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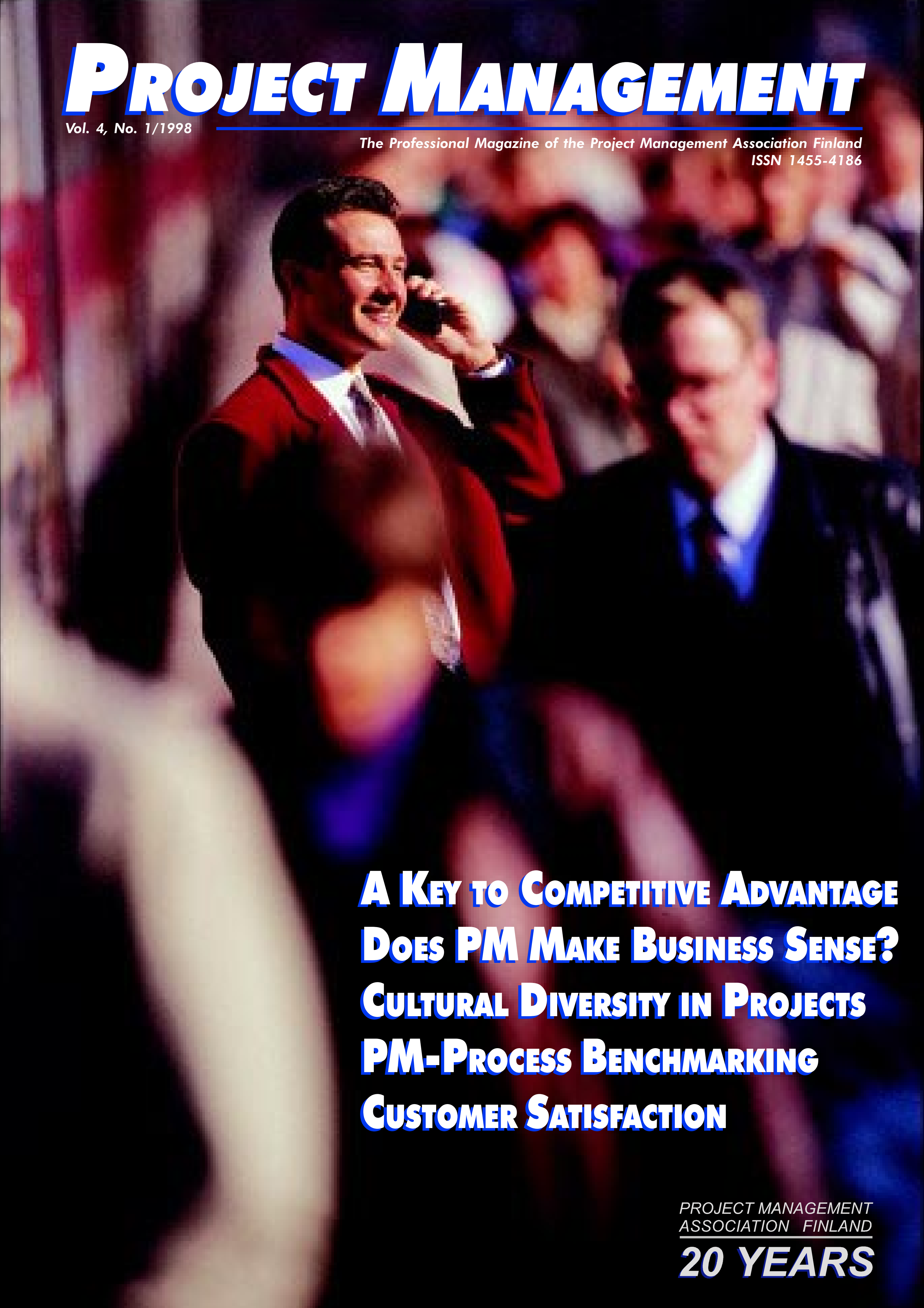

A Key to Competitive Advantage

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Cultural Diversity in Projects

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Customer Satisfaction

PROJECT MANAGEMENT
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20 YEARS

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Journal Policy

The Project Management (ISSN 1455-4186) is published by the Project Management Association Finland (PMAF). The mission of Project Management (PM) is to promote theory and practice in the field of project management and project-oriented business. It is the policy of PMAF to publish one issue of PM yearly, which will be distributed free of charge. The main distribution channels comprise circulation arranged by national project management associations to their members and distribution to the attendants of international events on project management in cooperation with the arranging organization. The circulation of the journal is 5 000 copies. The aim of PM is to reach extensively interest of project management experts and professionals worldwide in any sector both in academic world and industry, and this way to extend communication between all different sectors of industries including the public sector, universities and research organizations.

The PM seeks articles on any aspects of project management for publication. In addition to reviewed academic articles, it welcomes papers of more practical nature. Authors are encouraged to submit the following types of original manuscript: summaries of research results; surveys on current practices; critical analysis and developments of concepts, theories, practices, methodologies, application or procedures; analyses of failure; and case studies. In the selection of manuscripts primary importance will be based on the novelty value and the extend to which they advance the knowledge on project management. Those wishing to submit a paper or a case study should contact the editor-in-chief.

PROJECT MANAGEMENT ASSOCIATION FINLAND

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Shift from Project Management to the Management of Strategic Context in Production

Projects are to an increasing extent considered as vehicles that con tribute to the strategic context of management of a company. Many companies have adopted project oriented work methods in their businesses. Further, there is an incresing number of companies that deliver unique products to their customers and have organised their deliveries in project form. One major new challenge in future research and development will be to investigate how to organise project companies and what the successful management principles of a project company will be. The project company perspective includes aspects of e.g. project sales and marketing, project finance, and post-project customer processes that typically are more related to the management of a company rather than the management of a single project. Challences related to this field are reflected in the following by introducing aspects from the newly published study that provides development directions to project companies (Artto et. al. 1998).

Management of Uniqueness in Products by Project Networks

In the project business the order books vary along with the order books of customers and the general business outlook. Project companies have increasingly been forced to expand their customer base. As the number of customers grows the volume of business increases, but simultaneously the diversity and uniqueness of project products increases. As the uniqueness and variety of products increase, the number of fields of know-how that must be mastered has climbed. In order to smoothen fluctuations, companies have streamlined their own manufacturing activities, prompting an increase in the significance of subcontracting. Project companies increasingly operate in networks. Traditional networking and development of networking are fostered by advanced supplier-subcontractor networks. In project business, companies have consciously decided to band together and develop the activities of the overall subcontracting network producing a final product. Many modern and successful companies base their activities precisely on this mode of operation. Companies gear their activities toward functioning as a part of the network and may participate in several networks.

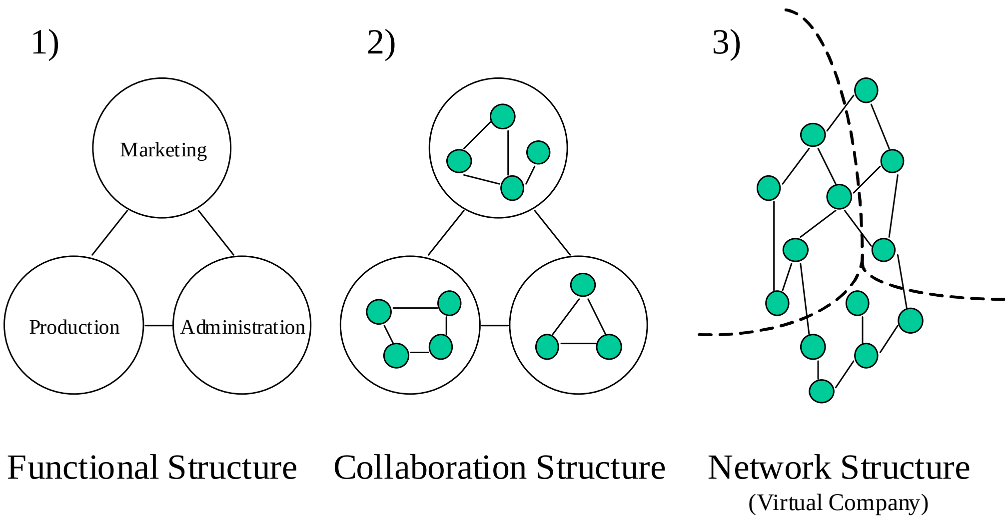

Figure 1. Shift of Company Structures and Respective Operative Logic toward the Network Structure

Evolution of Production Paradigm toward Network Structure

The networking approach is essential for project companies that produce and supply complex and unique products. The following discussion of evolution of production paradigm emphasizes the increasing strategic context of projects in production and in management of companies. The following discussion and figures are derived from Artto et. al. (1998); However, the discussion is largely based on the original work of Ranta (1993, 1997). Figure 1 presents the evolution of the company's organization structure and business approach with respect to networking company activities. The network structure can be compared to the concept of a virtual company. Projects are typically such virtual companies. In the virtual company different parties are grouped into an independent consortium functioning as a team, whereby production and supply can be carried out in the most efficient manner. The network structure is flexible. The structure can consist of companies best suited for the task at hand. The application of the network structure spurs structural changes in production activities. Ranta emphasizes that the networking structure facilitates local manufacturing during the transition to global manufacturing and that it enhances production flexibility. Flexibility can be augmented by, for example, application of mass customization in production. Especially important from the standpoint of the project business is to assess the impact of the network structure in manufacturing and the supply of individual unique products.

Figure 2 depicts the evolution of the production paradigm. The structures presented in the figure and their numbering correspond to those in Figure 1. The functional structure is indicative of a typical line organization-based business. The classical production line structure was the prevailing view in the beginning of this century when products were individual products (single product production in the horizontal axis of Figure 2). At that time production volumes were low (vertical axis of Figure 2). Ford's application of serial production in the automobile industry can be regarded as a shift from the functional structure (1) at the beginning of this century to the collaboration structure (2a) of the 1930s, where production began to use subcontracting organizations efficiently. There was simultaneously a considerable jump in the size of series and in the efficiency and volume of production. At first production using the collaboration structure was typically based on the American Tayloristic approach to production. Later the application of the Japanese production philosophy and lean production approach brought small improvements in production efficiency (from 2a to 2b, shift along vertical axis) and increased prevalence of more customized customer-specific products (from 2a to 2b, shift along horizontal axis) in production.

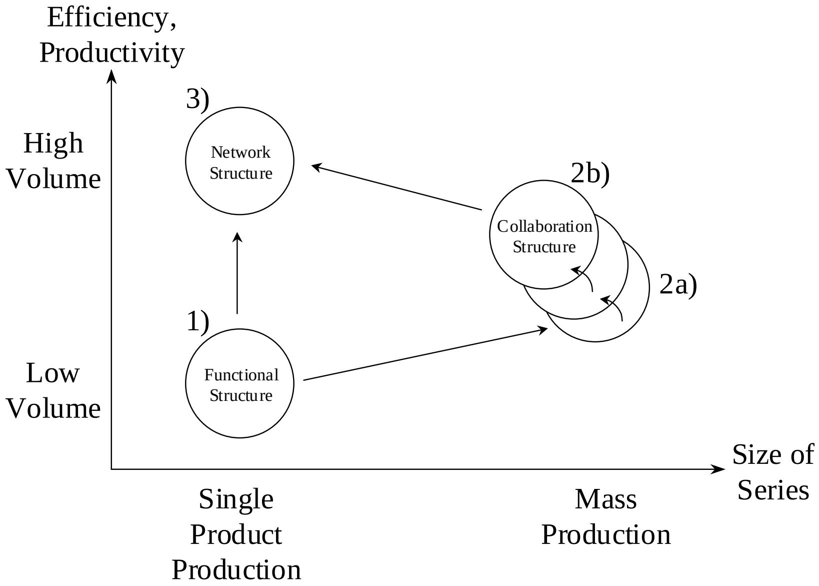

Figure 2. Evolution of Production Paradigm

The network structure and the related business logic can be seen as facilitating a rise in efficiency and increase in volume (from 2b to 3, shift along vertical axis), but it also fosters a shift toward more flexible production and supply of unique products in project form (from 2b to 3, shift along horizontal axis). For the time being the speed of production and flexibility aspects are of key importance. Many project companies are currently using network structures to upgrade their unique project products and develop their production and business approach.

Future Business Environment

As the markets and customers grow, the products and especially its coverage and scope are under strong pressures to change. From the standpoint of project companies, reacting to changes in the business environment occurs via specialization, differentiation and offering a full range of services to customers. Current trends in project companies and their customers include the following:

- the spectrum of required fields of knowledge will increase
- clients will grow and merge
- project companies will grow and merge
- the subcontracting by project companies will increase

In addition to the profound development and globalization of the business environment, the tools of international project business (information systems, telecommunication facilities) have changed, thereby facilitating new modes of activities.

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Customer-Based Project Success: Exploring A Key To Gaining Competitive Advantage In Project Organizations

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The successful strategic management of projects is based on an organization's understanding that an effective project is only as good as its capacity to satisfy customer requirements. In an increasingly competitive international marketplace, successful firms are typically those that have worked to establish a cooperative relationship with their clients, based on their desire to provide better service. This sense of better service typically refers to the willingness of these companies to evaluate their project management practices in terms of external, client demands along with the more traditional and internally-focused efficiency measures such as schedule and budget adherence. This paper reports on the results of a series of efforts by Aker Rauma Offshore Oy to develop a customer-based project success measure to ensure positive long-term relationships with customers.

Introduction

The pursuit of project excellence follows a path with no existing endpoint in sight. Project organizations routinely face almost insurmountable obstacles in attempting to develop and operate their projects, through working to satisfy large numbers of stakeholders, adhere to strict profit guidelines, maintain difficult schedules while conquering a series of technical challenges. However, when these firms critically examine their operations, they often founder on efforts to develop accurate measures of project success. Traditional views of success no longer necessarily capture the demands and constraints placed on firms operating in stiff, global competition. Put more simply, it is ironic that many project-based firms continue to view "success" through flawed parameters.

This paper examines the approach currently being taken by a Finnish firm with a clearer understanding of what successful project management means. In redefining concepts of project "success," this organization has chosen to go back to basics, believing that true success can only be understood when looked at through the eyes of the customer. In formulating this seemingly simple, but ultimately radical shift in operating philosophy, they offer a unique model that will likely become a bellweather for other project-based firms, abandoning out-dated views of project success in favor of a more clear-eyed vision (Pinto and Rouhiainen, 1998).

The Company

Aker Rauma Offshore Oy (ARO), a wholly-owned subsidiary of Aker Maritime, is headquartered in Pori, Finland. One of the company's key products is the Spar Hull and Mooring System. Spar is one of today's most promising deep-water offshore oil and gas development concepts. Currently, the largest market for Spar is the Gulf of Mexico. The four main components of the facility are: 1) the cylindrical hull that gives bouyancy to the facility, 2) the mooring system to keep the facility in the desired location, 3) topsides that contain the processing and drilling operations, and 4) riser systems that are used to transfer the hydrocarbons from the ocean floor well heads to the surface facility and back from the facility to the sea floor pipeline. In typical Spar projects ARO is responsible for delivering to the oil company customer the hull and mooring system, including project management, engineering, procurement, and fabrication.

The projects themselves are technically challenging and expensive: the spar hull can contain over 30,000 tons of steel framing and plating, the hulls are budgeted to take upwards of 18 months to design and fabricate and can cost over $100 million USD. In sheer dimensions, these spar hulls can be intimidating. The most recently completed hull measured over 200 meters in length and was almost 40 meters in diameter. Before lifting the Topsides facilities on the top of the hull at the final site at the Gulf of Mexico, the spar hull is fabricated in Finland in two pieces, transported across the Atlantic with a heavy transportation vessel, joined into one piece at the Gulf of Mexico yard, towed to the final site, upended and moored. By the time the total Spar project is completed, including drilling the wells, installing the pipelines for hydrocarbon transfer from the wells to the Spar facility and to shore, the total project can cost upwards of $1 billion USD. As these facilities are ordered by and for the use of major oil companies, ARO's role consists as that of a subcontractor to the overall construction effort.

ARO has been growing at a 40% compounded rate for the past six years, primarily since it embarked on a radical refocusing of project management operations to become more customer-driven in its strategic project management. At the same time, the organization has worked to develop a customer-based project success measurement device in order to better understand: 1) the specific needs of each customer, 2) how well those needs have been addressed, and 3) how the organization can improve the project management contracting process in order to maintain positive relationships aimed at future partnerships. This process has confirmed for ARO the importance of introducing, in addition to the traditional determinants of project success (Time, budget, and performance), a Client-driven model in which a committment to quality and customer satisfaction drives all strategic project decisions. This report will demonstrate that when such an external focus is encouraged, it will create an internal corporate culture conducive to competing successfully in the global marketplace.

Traditional Project Success Measurement

ARO, along with many similar companies, had traditionally bounded its project success measurement along the more well-known project metrics of time (adherence to schedule), money (adherence to budget), and performance to specification. While well understand and relatively easy to measure, these traditional measures also present some important difficulties, including (Pinto & Slevin, 1988; Wateridge, 1998; Shenhar, Levy, & Dvir, 1997):

1) <u>the tendency to sacrifice external concerns for internal performance</u>. In other words, when a company measures their performance in terms of <u>their performance</u>, the natural by-product is to discount or minimize legitimate customer concerns. For example, if a project manager gains maximum corporate credit for simply bringing in projects under budget, it generates a temptation to continually cut corners or make decisions leading to a poorer project in order to improve margins. The irony is that when using this model, it is possible to create a "successful" project that does not attempt to directly satisfy the customer. While the company will be pleased with the result, the customer could end up with a project that is sub-standard.
2) <u>the potential to develop adversarial relationships with contractors</u>. A common problem that underlies the "contractor-subcontractor" relationship is the desire of the various "subs" to squeeze every last drop of profit out of the contracted relationship. The irony is that this difficulty chiefly arises from prejudicial attitudes by both the contractor and the subs. When the up front assumption from the project contractor is that all subs are out to gain as great an advantage as possible, at the expense of the contractor, it causes contractors to go into a project relationship with a firm degree of distrust. From this point, any disagreements with subcontractors merely solidifies, in their minds, this preconceived attitude.
3) <u>the habit of treating all project relationships as "short term"</u>, rather than focusing on long-term partnership building. A common result from the traditional success approach is to treat each project as a discreet operation. To a degree, there is nothing wrong with this mentality - certainly projects are one-shot activities. However, the more important long-term relationships between customers and contractors are then often ignored. Once a subcontractor has completed their phase of the project, communication breaks down and both parties go their own ways.

As a result of the drawbacks with traditional project success assessment, ARO has shifted its focus to including customer satisfaction as a fourth success constraint. The inclusion of customer satisfaction acknowledges a fundamental truth in project-based firms: "successful projects" are only truly successful if they are seen that way through the eyes of the customer. The obvious benefit from this thinking is that it naturally moves ARO toward a externally-focused mindset, rather than reinforcing excessive concern for internal control processes based on simply adhering to the triple constraint.

ARO's Goals

ARO's interest in developing their customer-based project success evaluation system is derived from three important issues:

1) There is a perception within the organization that ARO does not possess enough real information on customer satisfaction. Generally, this information is informal or anecdotal, often going through several levels before reaching the management team at ARO. They need to get better, more timely, comprehensive, and objective data on satisfaction.
2) ARO wants to better understand customer needs. Through a more complete understanding of customer-based project evaluation, they can get a clear sense of the core dimensions that customers hold dear (as discussed with Value Chain Analysis).
3) Developing a well-performing

evaluation process will also have beneficial effects through establishing ARO more favorably in the minds of their customer base. In effect, this process will give ARO significantly more favorable "brand image" with clients.

The above points are based on ARO's perception that in a highly competitive industry, superior products go hand-in-hand with superior service. Their goal is long-term viability: something that can only be achieved through working to maintain positive relationships with present and past customers in order to develop future business opportunities. It was with this philosophy firmly in mind that ARO has set out on a unique approach to better understanding how project success and their success are inextricably linked to customer satisfaction.

Value Chain Analysis

In exploring ARO's motivations for establishing customer-based project success metrics, it is useful to refer to Michael Porter's (1985) Value Chain Model. Value Chain Analysis suggests that companies can compete most effectively if they clearly understand how they help create value to their customer's business activity cycle. To be successful, value chain analysis requires an organization to not only understand its own strengths and weaknesses, but those of potential customers. In this manner, they are better able to address and appeal to the most critical aspect in the customer's business operations. For example, ARO routinely engages in value chain analysis in order to tailor their project bidding to areas in which they can significantly enhance their clients' operations, through developing the delivery process of the spar hull and mooring system in a manner and for a price that gives the oil company an advantage over using alternative methods or competing contractor firms.

There are four distinct steps in performing a value chain analysis:

Step 1) Construct the value chain of the client

It is imperative that the subcontractor organization clearly understand their role in the customer's value chain. Each firm is composed of a sequence, or chain of activities, beginning with inputs bought from suppliers and ending with delivery to the customer, and after-sales support (See Figure One). Activities define the process by which a firm creates value through transforming raw materials into finished goods or services. It is important to note that it is possible to attain competitive advantage in any activity in the chain; it is not necessary that all activities be superior to the competition. Figure One shows a simplified value chain for an oil company customer of ARO. Note that ARO's contribution to this company's value chain lies primarily within its operations activities - ARO provides superior quality and lower total costs and risk by effectively managing the engineering, design and fabrication of the spar hull and mooring system used in offshore oil exploration and extraction.

Step 2) Identify activities and linkages that are superior compared to the competition

Activities in which the client has a cost advantage over the competition and activities that allow the client to produce a unique product or service are drivers of competitive advantage. It is important to discover whether the customer firm is driven primarily by low cost or product or service differentiation advantage. Understanding the customer's focus will enable the project organization to appreciate the project's impact and help guide choices which best fit the client's strategy. At the same time, project sub-contractors (e.g., ARO) need to engage in a straightforward assessment of their own strengths and weeknesses to ensure a close fit between what they do well and what the customer seeks. ARO has been highly successful in working with its customers to ensure that the operations and outbound logistics of oil field development are cost effective while maintaining a strong emphasis on quality.

Step 3) Identify activities and linkages that are inferior compared to the competition

These activities are a drag on the performance of the firm. For each inferior activity, a superior activity is necessary to offset the effect. Overall performance is enhanced when these activities are improved to, at the very least, meet the capability of the competition. Finally, it is important to note that a successful project need not create a competitive advantage. It can be equally effective through eliminating a disadvantage. As long as the client has a source of advantage in other activities, they will reap superior returns when the comparative disadvantage is corrected.

Step 4) Target activities and linkages with high potential for impact

Communicate to the client project options and alternatives, in order to "fit" the project to:

- improve activities to create a new competitive advantage(s)
- enhance existing competitive advantage(s)
- improve activities to eliminate competitive disadvantage(s)

Step 4 becomes the key starting point to developing a protocol for partnering with clients in order to enhance their business operations. The better able the project organization is at helping customers increase competitive advantage, the greater their own strategic position becomes vis á vis their competitors. In effect, ARO seeks to give other oil companies a compelling reason to select them as a sub-contractor.

One important key to ARO's success lies in their ability to offer the client organization competitive advantage through its own committment to project excellence. This is accomplished in two ways: first, by viewing project success through the clients' eyes, rather than based simply on historical parameters of time, budget, and specification. Secondly, ARO actively seeks to redefine itself as a partner, rather than simple subcontractor. This partner relationship is reinforced by the attention they pay to the overall project, rather than simply their contracted subcomponent. For example, in developing design and engineering aspects of the spar hull, ARO also looks to improve the overall project through close collaboration with other subcontractors (those developing riser systems, topside works, etc.) to give the customer enhanced value. This relentless pursuit of project excellence is based on a corporate philosophy which suggests that where the technology is to a great extent undifferentiated, what characterizes competitive advantage is often superior service through project development in active partnership with client firms.

The Customers and Their Needs

From ARO's point of view, the "Customer" is seen as a set of stakeholders consisting of multiple levels. The levels nearest to ARO are the site team and the project team. Above these are the project management and upper management levels. Behind these direct interfaces there is the end user who eventually will make use of the project. Typically ARO is communicating during the project with the site team, project team, project management group, and to some extent, with members of upper management. After the project has been delivered the contacts to the customer are limited to discussions concerning possible new contracts.

In discussing customer satisfaction, we will divide the project life cycle into three phases: 1) sales, 2) execution, and 3) operation. The project's life cycle will typically last from 3 to 4 years. The complete life of the product (drilling and production platform) is approximately 20 - 30 years. During the sales phase, ARO is normally competing with other firms in bidding the project. During this time customer expectations are built based on both the end product and the project execution process itself. Experience has shown that to win an order, in addition to having a competitive price, it is also important to reduce the customer's risk contingency by demonstrating the sophisticated project execution procedures employed. By the end of the sales phase, both these customer expectations have been built up to the point the contract is signed. During this phase there is an important step in the customer relations process: distinguishing between generating expectations and meeting expectations. One could reasonably argue that the goal of contract development is to create a set of positive expectations in the mind of customers - what the project can and cannot do, how we will do it, what performance criteria you can expect from us, and so forth.

There is a natural phenomenon present when establishing a project development relationship with a contractor. The phenomenon refers to the nature of customer expectations and attitudes across the project life cycle. Early in most projects, there is typically a positive relationship between all parties. The contract has been negotiated and signed and both the contractor and subcontractors settle in to develop the product. During this execution phase, disagreements often begin to surface. Confusion over the initial contract terms come out, goals start to conflict, and members of both the contractor and sub-contractors start to maneuver for maximum advantage vis á vis the other project partners. As a result, initial expectations, set so high, begin to crumble. Bickering and arguing set in and the project's atmosphere become more adversarial. While some readers would argue that this is a natural side-effect of contractor - sub-contractor relationships, ARO believes that there is a better way: working to maintain positive relations throughout the development process through strong communications and a commitment to customer satisfaction.

Customer satisfaction in the contract stage hinges on ARO's ability to create positive and reasonable expectations in the minds of customers. During the balance of contract performance (execution and delivery), the company's primary goal naturally shifts to meeting these expectations. Consequently, a key to good customer relations is to create a clear set of deliverables during the contracting stage that can be met during the project's subsequent life cycle. While this point may seem obvious on the surface, it is important to note that within many organizations, particularly when internal communications between marketing and engineering are poor, it is common to inflate initial expectations too high based on questionable promises. The project team then is doomed to spend the balance of the project fending off requests and complaints from an increasingly disillusioned customer who correctly perceives that they were sold a lie during the contracting phase.

Research Protocol

Creating a customer-based project success metric has involved several steps. ARO company members have been actively pursuing an agenda based on the following discrete phases:

1) Getting a list of key informants from the major customers. The list of key informants consists of those individuals knowledgeable enough and qualified to comment on the various activities of ARO and give their opinions as to the effectiveness of these activities. Some of these individuals may be high ranking members of the customer organizations and others are key project management personnel.
2) Asking these key informants about their decision process and criteria. ARO eschews simply holding post-project "lessons learned" feedback sessions in favor of a series of regular meetings with customers. While feedback conferences may yield good information for better project management in the future, their biggest flaw is that they allow no opportunities for process improvement to an ongoing project. ARO's preference for concurrent project control allows them to get answers to some fundamental questions, including: What are their key values and success criteria? What are their key concerns? How can ARO continue to satisfy their needs? What is ARO doing today that could be done better tomorrow? How does ARO operate to put itself at a strategic advantage with other competitors? These questions and their answers are key to understanding what specific decision criteria ARO's customers employ. Note that the intent of the questions asked at these meetings is not to simply adjudicate disagreements and "fire fight" current problems. Problem solving is important but the company also strongly feels that the best method for fixing problems is addressing and clearly understanding customer goals before misinterpretations lead to downstream problems.
3) Developing and refining the list of key issues. These issues are the key to ARO's continuing strategic advantage. They identify the areas that are important to customers, and ones they feel ARO performs either; a) well or, b) poorly relative to their competition. This list becomes the key starting point to developing an in-house Quality Assessment device that allows ARO to continually track future projects to ensure that they are being developed in accordance with customer needs and expectations.
4) Deciding on measurement parameters. Once the list of key issues (critical success factors) has been developed, the next step is to determine the various parameters of actual data measurement. The

key parameters revolve around the effective administration of the customer satisfaction measurement instrument. There are essentially three issues that required immediate attention:

a) Method - how should the data be measured? Should ARO employ a qualitative device based simply on interviews with customers? Should they use some "gap" measurement device to judge the difference between expected and actual results? It was subsequently determined that a combination of the two approaches was ideal.

   ARO is currently collecting data from customers that will allow a comprehensive questionnaire to be constructed for in-house quality control.

b) Timing - when should this information be collected? Clearly, it is necessary to do it at different points during the development process. There is little immediate benefit from getting the information about a finished project if it allows no opportunity for correction. On the other hand, it is also important to reflect on the appropriate points in the current project when this information is most useful. ARO's QA department can be most effective with this data if it is timely and "actionable" - meaning that the findings can lead to immediate corrective action.

   Part of the answer to the timing question lies in the length of the project undertaken. If, for example, a spar hull takes 12 months to design and fabricate, ARO will work with customers initially to address their chief concerns. Then, at various stages of project completion (e.g., engineering and design, procurement, fabrication), the organization assesses their own performance to date based on the identified key success factors. Likewise, these event points also allow the company to update customer expectations, answer questions, and strengthen communication links.

c) Feedback - how should the results be fed back to key personnel? As with the issue of timing mentioned above, it is vital that the data collected be done in a short period of time, that it be done concerning issues that are immediately relevant, and that it should be reported back in a timeframe that allows ARO to take corrective action, if necessary.

At present, the success measurement process is in operation. We are currently conducting the key interviews and assembling the important data that will be used to develop internal QA assessment protocols. The current timeframe calls for full development of the measure within the next six months and standardization of the protocol throughout the organization by the end of the year.

Discussion

Customer-based project success operates under a radically different philosophy from the traditional "triple constraint" approach to success assessment. While we have only been able to analyze preliminary findings based on interviews with one client firm, we have found some recurring themes. There are three important components of this philosophy:

1) The project organization must shift from a sub-contractor mentality to a partner mentality

This shift will be difficult for both parties. It will require the main contractor to look upon these contracted firms as full partners in the project, having a vested interest in working with the lead firm in a collaborative effort to make the project succeed. Too often in the past, "sub-contractor" mentalities translated into sub-contractor attitudes, leading many firms to cut corners, withhold important information, resist full disclosure, and save costs in order to get the maximum advantage out of the contractor - sub-contractor relationship. Inevitably, this leads to an adversarial relationship rather than a partnering one. The lead contractor cannot fully trust the subs to operate for the good of the project rather than their own good. The subs automatically assume that they are not trusted, resent excessive oversight from the lead organization and the result is endless bickering, negotiating, and mistrust. Once the job is completed, the atmosphere may have become so fouled that neither party wants to work with the other again.

Creating a collaborative partnership redefines the nature of the relationship. Now, the former sub-contractors are treated as equal partners in the project's implementation. The goal for both sides is maintaining the basis for long-term relationships. When relationships are the goal, the mentality of both partners becomes helping rather than advantage seeking.

2) When customer satisfaction drives the process, everything else falls into place

One of the biggest mistakes we continually make is to assume that schedule, cost, and performance will automatically create customer satisfaction. Our whole model is predicated on the idea that it is customer satisfaction that drives project development. Consider Figure Two. The traditional model, which we have argued against, suggests that the better organizations manage the project internally, the greater the likelihood that it will be viewed positively by the customer. While this statement is highly arguable, an alternative model suggests that if our underlying goal is "external effectiveness;" that is, working to satisfy the customer, the other internal metrics will fall into place. Put another way, if our main driver is to satisfy the customer, we will do everything possible to adhere to mutually agreeable schedules and budgets, working to ensure that both the product and the project execution process meet specifications that will satisfy the customer.

One objection that is sometimes advanced states that too much concern for the customer will actually throw the project behind as we open the floodgates for endless rounds of change order requests and spec changes. Actually, while this might happen to a minor degree, it ignores the fact that the customer also wants the project completed in a timely fashion. If we are working with them in a collaborative partnership, are maintaining open channels of communication, and are seeking to develop trust, we will be able to overcome the difficulties related to change orders. Ultimately, the customer will begin to understand project tradeoffs from our perspective (our schedule and cost challenges) and work with us to mutually solve them. The key lies in redefining the nature of the relationship. We are not adversaries, we are long-term partners.

The other benefit of such a partnering mentality is that it sows the seeds for long-term relationships. When customers understand our unique mentality of working to please them as our main motivation, they also begin to look on the relationship in a different way. Now, instead of constantly battling for percentages and minor advantages, both parties come to value the relationship itself, perceiving that in it lies the key to a longer-term, positive working climate.

3) The key to in-process course corrections is possessing "real time" data from customers

Too often, customer satisfaction consists mainly of post-project review sessions, such as "Lessons Learned" meetings. While the obvious benefit is that it gives us a chance to learn what we did wrong, the main drawback is that this approach gives the project organization no opportunities to correct these problems. To use an American idiom, it is the equivalent of closing the barn door after the horse has bolted. Yes, we can learn from these points for future projects but cannot do anything about them for the current one just completing.

ARO's goal of better understanding customer needs consists of generating real time data on project quality. Indeed, the customer-based project success model will be blended in with other quality control measures used at ARO to maintain their high standards throughout the development process. The benefit to ARO's customers is that it maintains a formal feedback and corrections channel as part of the ongoing project implementation. Customer needs, suggestions, and concerns are solicited on a continuous basis in order to make sure that good relations persist, the project is doing what both parties understand it should be doing, and formal and informal communications are maintained.

Conclusions

In an increasingly competitive business environment, organizations are seeking new and innovative methods for gaining advantage. Project organizations, faced with strong international competition and shrinking profit margins, must look for project management approaches that offer them a method for positioning themselves as both unique and offering a superior product. Customer-based project success is a technique that has been earmarked by ARO as a key to maintaining close and positive links to clients, not only for projects currently under development, but as a "leg up" for creating future business. While still in its early stages, preliminary results and reactions to their initiative have been very positive, with clients discovering ARO's willingness to go the extra mile for customer satisfaction.

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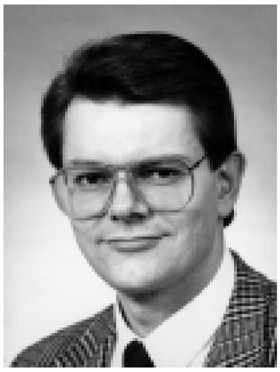

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Why Project Management Doesn't Always Make Business Sense

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The traditional view of project management is of a discipline dedicated to delivering "on time, in budget, to specification". This view is dangerously outdated. First, it ignores the great importance of properly defining the project. Optimising the project objectives is a critical part of the management process. Second, it does not sufficiently focus on optimising the potential commercial benefits of project delivery.

This paper argues that project management needs to be more commercially focussed. To do so it must concentrate on better front-end management and procurement, it must improve the performance of the people working on the project - throughout the whole supply chain - and it must take greater advantage of the benefits that IT is now offering.

Project management, traditionally not bottom-line oriented, has to change.

Project Management is a well-established discipline. Developed largely in the US defense-aerospace industries in the 1950s and 60s, it has slowly been spreading into most areas of business and social life (Morris, 1997). Since the mid 1980s it has enjoyed a particular boom, with professional project management societies promoting it and more and more companies adopting its central tenets as core to their business. It is now widely recognised that project management provides the fundamental discipline for achieving successful organisational change.

Yet project management sits oddly within business. As a discipline it is often decidedly un-commercial. There is little if any reference in the literature or trade writing to its impact on bottom line profitability. Some indeed argue that Business Process Reengineering is more effective as a means of delivering organisational change and improved profits (Cooke & Wolstenhome). Worse, there is actually a substantial quantity of data suggesting that the performance of project management is poor, and that all too often projects fail to meet their completion targets.

Classically, the definition of project management success is whether management delivers the project "on time, in budget, to specification." Yet, as was argued in The Anatomy of Major Projects, this is often not the best measure of success (Morris & Hough, 1987). Theoretically, you can be on time, in budget and to specification but still make a loss or produce something that does not perform as required. Profitability is an equally valid and in many ways a better measure. In fact there are several important financial measures. Indeed, the project team should in fact be focussing on a variety of product and process Key Performance Indicators - as we shall see shortly.

How long can project management continue to be so isolated from the reality of everyday commercial life? How can project management professionals make it more relevant, and valuable?

The answer, research and practice suggests, is to recognise that we are too often not focusing the project management effort properly, and that we are not drawing on the enablers that now really allow management to get bottom line impact. These are the arguments that this paper examines.

Research suggests that project managers do not focus sufficiently on the commercially key areas

The research data on project performance indicates, almost without exception, that the major causes of projects going wrong are poor definition and control (Morris & Hough, 1987). In particular, the data suggests that poor front-end definition is the area which is least well understood and managed and where many problems arise to cause subsequent problems.

- Poor definition, wrong expectations, and over-optimistic assumptions are frequently cited causes of error and difficulty.
- Inappropriate choice of technology and weak management of design have historically been major causes of projects going disastrously wrong.
- In certain types of projects, particularly infrastructure and public sector projects, "externalities" such as environmentalist opposition have caused major delays and extra cost.
- Poor control, particularly of changes, is a major source of cost and time overrun.

Of all these factors, amazingly,

probably only poor change control would normally be treated by most project management professionals as within the normal domain of project management responsibility. For project management to begin delivering successful projects, it has to address these areas of weaknesses.

If the front-end is one area that project management needs to focus on more, the way one acquires additional resources and builds them into a team is the other.

There are two issues here. One is procuring resources in a commercially realistic manner, with their work aligned to the sponsor's business objectives. The other is developing teams so that the right input is obtained in the optimal fashion. Procurement in fact is crucial, though it is generally under-recognised in the project management literature. The team aspect is much more widely recognised.

Let us turn first to the issue of front-end management.

The primary area of increased focus must be the project front-end

There is a view, hopefully becoming increasingly recognised as out of date, that project management begins only after Authorisation-for-Expenditure has been agreed. It has always been obvious that in reality setting up the project effectively is vital to project success. But with today's emphasis on optimising project definition for maximum value-for-money, actively managing this front-end definition stage is especially important - and difficult. The management of the front end can literally make or break the project.

Consider some current examples.

- The capital planning process of a global Fast Moving Capital Goods company followed annual corporate planning and budgeting timetables. There was no prioritisation or active management of particularly attractive proposals, no end-to-end management of the project process. Once project management was integrated on an end-to-end basis, competitiveness and IRR increased by up to 10%.
- In the same way the UK Government is currently looking at prioritisation and active management of its capital project budgeting.
- Product portfolio management has always been important in the pharmaceutical industries. GlaxoWelcome, however, is currently increasing the active management of its R&D front-end and integrating this into the downstream manufacturing stage of the project, even extending this end-to-end project management into the early stages of sales and distribution.
- The UK Ministry of Defence (MoD) is currently adopting a new "SMART" procurement practice. Core elements of this new practice include:
  - Greater emphasis on treating the project as a total system;
  - Greater investment at the front end;
  - Improved requirements management;
  - Improved estimating and predicting;
  - Incremental acquisition and concurrent engineering;
  - Improved commercial practices.
- Technology management is a significant element of the MoD's front-end work. There is considerable emphasis on Pre-Planned Product Improvement and greater use of commercially/readily available off-the-shelf technology. Risk management has been another key element of MoD's recent project management attention.
- Similarly in the auto and aircraft industries, amidst intense global competition there is currently huge emphasis, from the very earliest stages of product development, on working to shorten yet further time to market and cost through the use of integrated teams and information technology (particularly CAD/CAM).
- In the building and civil engineering industries, with the current move trend towards Design Build and Public-Private Partnerships there is growing recognition that there is inadequate understanding of the practice of design management. In projects in general in fact design management is increasingly being recognised as extremely important yet very poorly understood.

All these examples illustrate the importance of managing the front-end in order to achieve better project performance. Systemic planning, better budgeting, technology management, risk management, improved predictability, design management, better prioritisation - obvious though these areas are, management at the front-end is probably harder than at any other stage of the project. Not only are the judgements more important, they are usually made on less information. It is a genuinely difficult area.

And while the benefits of improved timing and end-to-end process management are potentially very large, there is equally great danger in rushing to judgement and making unnecessary or poor decisions. ("Avoid rush-to-code.") Good management at the front-end requires considerable experience and skill.

Procurement is the next obvious area of immediate bottom line opportunity

Procurement savings can go straight to the bottom line, often with corresponding impact onto shareholder value. Savings of 10 to 20% can often be achieved through the focussed management of procurement. Yet too often insufficient management attention is given to realising this level of return.

There are two common initiatives typically taken in procurement: cost reduction and partnering. Both are valid. Both should be implemented within a carefully thought out project procurement strategy.

- A major European oil and gas company has been able to achieve 15 to 25% cost and time-to-market improvement by treating procurement as a project in its own right. Clear savings targets are established, teams set up, and work tightly scheduled and budgeted. As a result:
  - The supplier net has been substantially widened;
  - Negotiations are better planned and conducted;
  - Contract management is tighter.

  When added to other initiatives on front-end processes and value engineering, overall savings have reached up to 40%.
- Nissan, along with most of the automobile industry, develops its

new cars on a project basis, with all its suppliers working on a partnering basis. All share in the reward and the risks. Performance is measured quarterly and annually for al members of the supply chain partnership; Key Performance Indicators cover quality, cost, delivery, management, and development.

- BP has proven evidence, for example its ETAP North Sea Oil field and Peni Petti Indonesian chemicals plant, that alignment of supply chain objectives coupled with high performance team building has resulted in extraordinary performance improvements. In many cases up to 30% cost savings have been achieved through the elimination of unnecessary contingencies and value engineering.
- Equally, there are other examples where this has not worked - generally where the risks have been poorly assessed and incentives inappropriately aligned. The Foinhaven project is an example. Determining the appropriate strategy is therefore an important activity, again often inadequately performed. What to keep in house; what to outsource. What to purchase on a commodity/low cost basis; what to undertake in partnership. How to allocate risk. How to optimise operating benefits (O&M/ILS)[1].

Like front-end management therefore, the way one procures resources requires a combination of considerable experience and skill. Hard commercial realism and good negotiating skills must be combined - where appropriate - with team building and leadership. After all, having just procured services in as commercial a way as is sensible, one now wants to have everyone working together as a truly motivated team, focussing on the owner's goals above all others.

Good project management has Front-End Definition and Procurement as integral to its overall practice

The argument being put forward is not revolutionary. Project management in the past has not been wrong. Rather, it is evolutionary. Project management has not been adequate. It needs extending right to the front-end. And more focused effort needs giving, within the project, to defining the appropriate strategy, aligning the project team and realising the cost savings and value benefits that are nearly always there to be had.

Consider the project management philosophy of Lockheed Martin, for example, one of the most successful of the large US aerospace and systems integrators. Lockheed Martin's summary of proficient project management comprises:

- Structured systems definition
- Total systems design and analysis
- Partnership based contracting
- Comprehensive integration, test and qualification
- Quality project management skills and processes
- Scheduling determination
- Forward looking risk management
- Real-time cost management.

The key point of this list is not the particular wording - capturing the essence of project management in a short list is bound to involve some questioning of precise words - but the fact that front-end definition appears in two out of the eight points, and that procurement is another.

Better focusing on people and processes offers huge scope for improving performance and hence profitability.

People and the way they perform are what make exceptional performance. Having the right people, working really creatively, make an enormous difference. We need to be prepared to look at new roles, new processes and ways of working, and new means of measuring and evaluating performance.

New Roles

It is increasingly being recognised that the owner organisation it has a key responsibility in setting up and managing its project. In particular, the role of the sponsor must be distinguished from that of the project manager. (The sponsor is the person who is responsible for the business success of the project. It is his money. It is his responsibility to ensure that the right targets are set, and where necessary are changed as the project evolves. The project manager is responsible to the sponsor for ensuring that the necessary things get done to meet the sponsor's requirements.) The key owner's areas of responsibility and decisions - for example, definition, safety, procurement route, and other factors affecting its business - need clearly defining. (The role of operations in project definition is another important area.)

Output focussed teamwork

Projects, almost always, involve teamwork. Generally there is very substantial teamwork, and the team's performance generally makes a very substantial impact on the output of the project as a whole. But leading project players are realising that we have only been scratching the surface.

Leading project based companies are now putting explicit effort on ensuring that teams are built and operate effectively. At one level this involves ensuring that the right people are members of the team. There is increasing use of integrated project teams - from as early in the project as possible. These should involve all key parties, including, as soon as appropriate, the contractors and suppliers.

At another level it involves aligning the teams' goals, attitudes, and ways of working, and liberating their energies towards the project's objectives. Alignment of objectives and working methods is key. Much greater attention is being put onto high-performance team building. The emphasis is on the team working as a whole not just to meet but to better the sponsor's objectives.

New procurement methods such as partnering and alliancing emphasise these features. All of them - ensuring the right team composition, alignment, and high-performance team building - for example are central features of BP's Alliancing method of procurement and project development.

Competencies

Traditionally attention was primarily on the qualifications that someone needed to perform a job. There is now great-

[1] *Operations & Maintenance and Integrated Logistics Support. Both represent the operation end of the product cycle after project management has built the product - current expenditure rather than capital. There is growing interest in understanding how project management can gain better input from this end of the cycle.*

er recognition of the benefit of focusing on the output performance requirements rather than input qualifications. Output performance is what competencies define.

One part of most competency frameworks is the appropriate professional domain. In projects, companies are turning to professional societies such as the (US) Project Management Institute (PMI) and the (UK) Association for Project Management (APM), to provide generic definitions of the areas in which a project management professional should be competent. The trouble is that both these societies' "Bodies of Knowledge" are currently a little out of date. Work has begun on both to update them. (The current set of elements being proposed of the APM Body of Knowledge can be found at www.UMIST.ac.uk/CRMP.)

Several companies are now making direct use of these professional Bodies of Knowledge to develop international programmes involving independent qualifications. British Aerospace, for example, uses the APM Body of Knowledge as its project management competency structure almost unaltered.

AT&T and Unisys use the project management societies' qualifications as external benchmarks of competency. AT&T, for example, uses the PMI PMP qualification as a rung in its project development ladder. Unisys combines APM's APMP qualification with the German Fachman qualification.

Processes and Performance Measures

Projects are prime examples of process orientated organisations. A project is based on its evolving life cycle, driving towards project completion. Project personnel need to understand the overall life cycle process structure so that they can see how their own contribution fits into the activities of others to achieve the overall project objectives.

There are now several examples of companies developing generic project process maps[2]; there are even whole industry generic sector process maps- the UK construction industry has one developed by the University of Salford (Cooper). Such process maps have the added advantage of clearly positioning review points where performance is measured - which brings us neatly to the issue of identifying the appropriate performance measures and ensuring these are reported against at the right time.

Too few project managers use the right performance measures

It is not just the focus of project management attention that needs realigning, it is also its measures. As we have seen, historically, project management has been defined in terms of accomplishing a task "on time, in budget, to specification." Traditionally, the trouble is, these targets were too often decided early in the project and may no longer be the best measures of real project profitability. Too often insufficient attention is given to maintaining measures that relate the impact of project delivery on business performance.

(The reasons for this are complex. Among them, perhaps the major one is that the business case for the project may have been prepared some time ago and that this then got formalised into some form of execution contract - and there is plenty of experience to suggest that changing specifications midway through a project can be a major cause of rework, delay and extra expense. A slightly less valid reason however is that the project sponsor - the holder of the business case - may not be tightly enough involved in managing the development of the project. Or equally, that the project manager has little or no motivation to think about how his project may be optimised to his customer's bottom line.)

The traditional measures of project success are clearly no longer sufficient. The best project management companies in fact typically uses a variety of performance measures, or Critical Success Factors. Product ones such as Business Success, Operating Efficiency, Competitive Position, Financial Return (IRR, NPV, cash flow), Risk, and Customer Satisfaction; and process ones such as Safety, Health, Environmental Impact, schedule, cost and cash. Modern best practice in project management would ensure that these various measures are tracked, at different levels of the project, as it evolves through its life cycle.

At key review points the project's Key Performance Indicators - including all these on product and business success - ought to be reviewed. Opportunities for performance improvement should then be actioned, providing that the risks of so doing outweighed the rewards. New measures might even be proposed to enhance the business case.

Where possible, some form of performance comparison should be undertaken. Benchmarking has become the fashionable word for this. Benchmarking implies comparing oneself against the "best in class" standard. There are various standards, and hence classes of benchmark: for example, intra company, intra industry, or cross industry. But beware of falling for the trap that there is some "best in class" standard which, once attained, means that you have achieved the desired outcome. As professor Francis Hartman from the University of Calgary, Canada has pointed out, benchmarks imply stability whereas in fact we are living in a world of "Continuous Improvement".

Organisational Learning has become increasingly important in today's environment of Continuous Improvement.

Projects are typically highly differentiated, many different organisations performing different tasks on extended and changing processes. Historically there has been little culture of collecting performance data and learning how to improve in the future. Today's projects, however, with their emphasis on alignment, teamwork, value for money, continuous improvement and Total Quality, are changing this. Learning suddenly becomes important - as an aid to improving, and indeed as a way of adapting to changed conditions and staying competitive.

Fortuitously, information technology has developed the ability to support organisational learning in ways that were not really possible just a few years ago. The most obvious example is the development of Internet technology. Video conferencing and other Computer Supported Work Sharing techniques allow information to be shared across the project in powerful and immediate ways. Distance learning and multimedia allow lessons learned to be put in learning format and guides to best practice to be developed and accessed on an as-needed, just-in-time basis.

These shifts, which I personally see as extremely important to the long-term development of project based practice, are mirrored by similar applications in training and knowledge man-

[2] *BAe (British Aerospace), BAA (British Airport Authority), BNFL (British Nuclear Fuels Limited), DoD (Department of Defense)*

agement. The combined use of multimedia, distance learning on an IS delivered platform (CD or intranet) suddenly changes the economics - and effectiveness - indeed the whole notion - of training for organisations that are physically dispersed. Similarly, IT tools are now able to capture, store and access information - knowledge - in ways which were not possible just a few years ago. Knowledge is increasingly being seen as a core organisational asset. Managing it more effectively for the project is a logical extension of managing it for the enterprise as a whole.

Information Technology continues to be a fundamental driver for improved project performance

Information Technology is a key enabler for most of the practices discussed in this paper.

Computer Aided Design and Manufacturing offers significant opportunities in front-end modelling. When combined with computer based product information, such as that represented by STEP and IAI[3] , the potential for estimating and pre-building accurately can be significant. The cost-benefit of applying the technology is crucial however. Preliminary research at UMIST shows that the stability of the design, one's position in the supply chain, and one's ability to predict and control the final outcome are all extremely significant (de Gusmao, 1997). Aerospace and automotives can optimise technologically much more usefully than building; a prime contractor can gain more benefit than a component supplier.

Even in procurement IT can be significant. Automated RFIs and RFPs (Requests For Information and Requests For Proposals) have been found to widen the supply net enough to lead to tangible cost savings. (Whether there are cost savings through electronic commerce is arguably still moot.)

While teamwork is one dimension of concurrent engineering/ simultaneous design, IT is undoubtedly the other. Simultaneous design is the activity of having design proceed in parallel, often in geographically dispersed locations. Concurrent engineering is this plus having the team drawn from representatives of all the parties who will influence the final outcome - manufacturing, marketing, operations, etc., as well as design. While the manner in which this team works is clearly important, there is no doubt that the extent to which data is held and shared between the team members is equally crucial. The contribution of IT in facilitating this through modelling, file sharing and effective communications contributes enormously to the effectiveness of the team working.

The same arguments apply right through the life cycle. Concurrent engineering tends to pitch the focus on the front-end but exactly the same applies later. Look afresh at processes: can Computer Supported Work Sharing then lead to significant performance improvements? There is little doubt that it does in manufacturing but even in construction recent research demonstrates that substantial benefits are available.[4]

Even in the seemingly softer areas such as organisational learning there is evidence, albeit so far not quantified, that IT can contribute significantly to organisational performance. Internet technology and multimedia have already been mentioned as ways of collecting information - for example on lessons learned from past projects - and of disseminating it more widely and in easier to absorb forms. Data mining, Case Based Reasoning, and intelligent programs (AI, Knowledge Based Systems, and expert systems) are examples of IT tools that help better represent information - as knowledge - and turn that knowledge and information into a profitable asset.

Conclusion

The practice of project management is changing. New technologies and management practices are giving managers new means to improve performance. There is greater emphasis on high performance teamwork. Information Technology is dramatically improving a wide array of areas, from communications and modelling predictability to knowledge management.

The real change however is the increasing recognition that the simple "on time, in budget, to specification" view of project management is not sufficient. Project management needs to be more directly concerned with the bottom line. A more sophisticated set of performance indicators needs systematically reviewing as the project evolves.

Greater attention to the front-end and procurement in particular will have a significant impact on project performance. Often neglected in the management literature, these two areas - quite different in nature and management difficulty - should now be receiving increased attention, both in research and practice.

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[3] STEP is the international Standard for Exchange of Product model data; IAI is the International Alliance for Interoperability.

[4] See for example the Elsewise research project : www.lbro.ac.uk/elsewise; see also the results of BRICC, MICC, and CICC: contact Bill Southwood at Ove Arup & Ptnrs, London

New Perspectives For Integration of Project Cost Control and Company Cost Accounting

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Keywords: Cost Control, Cost Accounting, Performance Measurement

The paper highlights the problem of the integration of project cost control and company cost accounting in project-based companies. Four different dimensions of the problem are pointed out: the multi-project environment, the relationship between accounting period and project portfolio planning horizon, the cost controllability and the relevance of cost maturity stages on economic control.

A different classification of costs, which makes reference to different levels of controllability, provides a model which allows to manage project costs at the most appropriate company level. Further, a 'layered' view of the project baseline is seen as a tool for effective project control - to monitor costs and to implement corrective actions - and performance measurement. Finally, the effect of project cost maturity stages - from commitment to expenditure - on the planning and control process is analysed.

Introduction

Adequete level of integration between company and project management processes is a strategically important factor in the success of project-based companies. For engineering and contracting companies the project is the main product/service and management by projects is the main 'production process'. Further, due to the progressive reduction in product/service life-cycle, caused by high levels of innovation and rapid development of markets, the management by projects is becoming more widespread even in manufacturing environment. Within this context, a low integration between company cost accounting and the control of project costs can cause significant problems. It is possible, for example, that although current projects show high levels of performance, they may register significant losses in the accounting period. One of the reasons is certainly the tendency to uncouple the reporting cycle of company economic results, related to the financial year, and the cycle of operational processes which refer to a project life-cycle generally covering a number of years.

While in recent years engineering and contracting companies have played a pioneering role in the development of project management methodologies and techniques, they have often adopted typical general industry accounting systems, based on cost centres, on functional departments and on short-term economic assessment.

Nevertheless the type of performance demanded of the company accounting system must be consistent with the characteristics of the project-based production (Söderholm, 1997). Typically, projects involve, at their starting point at least, production under fixed conditions of time, cost and technical performance of a still largely undetermined product. In other words, the product features are detailed as work progresses. Unlike repetitive production, product specifications and performance are more the output of the production process rather than its input. This is the main feature of project-based production, that should drive the company overall management approach.

This framework highlights three important implications for management control processes:

- An effective planning and cost accounting process must respect the company's typical operational cycle which is based on impulse rather than flow processes. The control reference point cannot, therefore, be a unit of time, e.g. twelve months for budgeting and monthly reporting, but should be rather the project life-cycle or the time horizon considering all the projects underway at a given time (project portfolio).
- Identification of the levels in the organisation to which the different types of cost and resources are assigned is critical not only for the assignment of responsibility, but, above all, to ensure effective

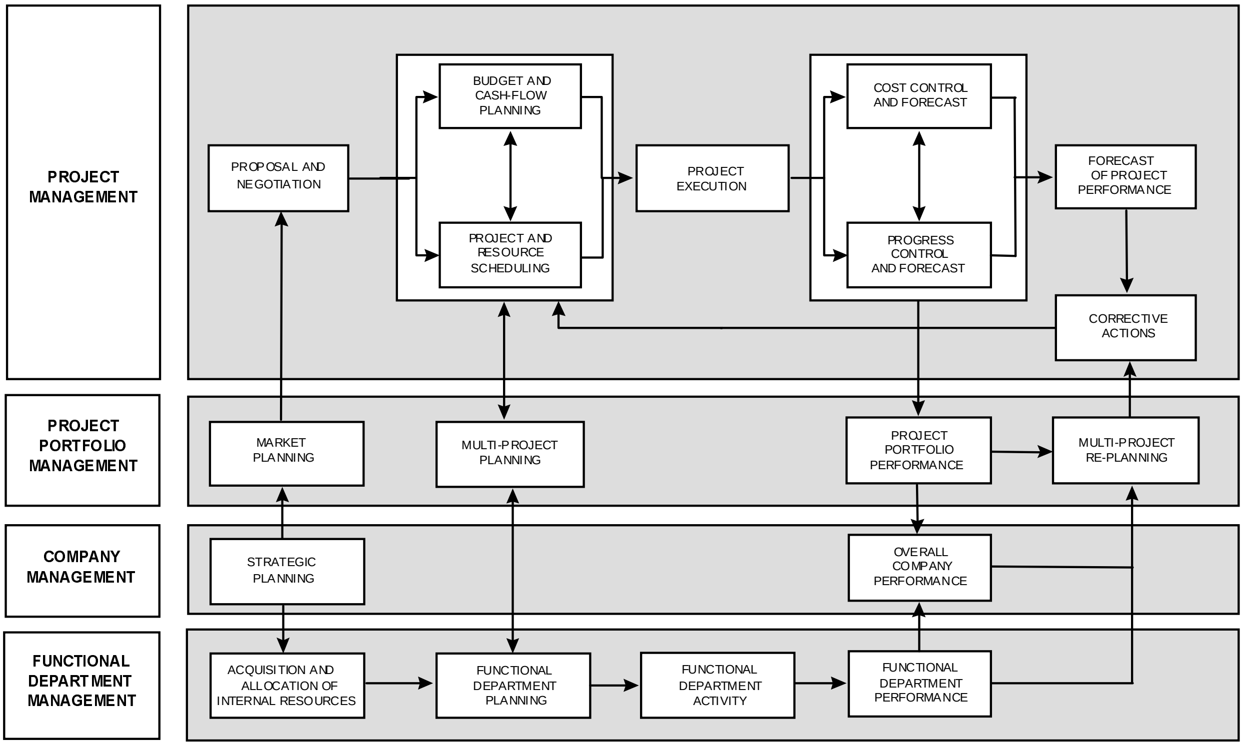

Figure 1. The planning and control process (Cagno et al., 1998)

planning mechanisms and corrective measures. The diagram in Figure 1 shows four management levels found in engineering and contracting companies and their dependence on each other in the planning and control process (Cagno et al., 1998):

- single project management;
- project portfolio management;
- management of functional department;
- overall company management.

- It is important to implement management control systems able to monitor and assess operational performance, in terms of effectiveness and efficiency, i.e. project management quality, and integrate these with the company's economic and financial results in the accounting period.

The problem has managerial importance, not limited to the mere identification of the most suitable performance parameters. Indeed, it is clear that a consistent assessment of results must be based on initial coherence between company budgeting process and project planning.

As observed by several authors (Turner & Speiser, 1992; Platje et al., 1993; Platje et al., 1994; Scheinberg & Stretton, 1994), managing the multi-project environment plays a fundamental role in project-based companies. The interdependence between the projects in a company's portfolio - projects in progress, at proposal or close-out stage - is always evident. In particular:

- dependence between project objectives with respect to company strategy;
- dependence in the use of common resources to attain company objectives to which all projects must contribute.

Various approaches to multi-project planning to manage the complexity of the inter-dependencies between projects have been developed (e.g. Cagno et al., 1998).

Main aspects of the integration problem

Within the above context, the integration between the company cost accounting system and the economic control of the project is certainly complex and requires that many different, strongly interrelated factors involving the entire company (e.g. organisational, managerial, technical, methodological, technological, etc.) are taken into account. There are, however, four fundamental aspects of this problem:

- the multi-project environment, i.e. the allocation of limited resources which are balanced on the basis of the progress level and the priority of the projects in the portfolio. This is a dynamic process, in which the consumption of resources evolves over time as a result of the rolling wave overlapping of the resource allocation 'profiles' in all active projects (cf. Figure 2);
- the view of the accounting period as a 'time window' within a planning horizon defined by the entire project portfolio (cf. Figure 3);
- the varying level of controllability of different project costs by the project team. This produces a 'layered' vision of the project baseline in function of the level of control that the project team can exercise over the different costs. Figure 4 shows an example of a 'layered' baseline dividing costs into specific (controlled by the project management team) and common (beyond the control of the project team) costs;
- the incidence of cost maturity stage - i.e. the classical sequence, committed, accrued, recorded and paid - on economic control, with particular regard to the accrual concept referring to when the corresponding resource is consumed (cf. Figure 5).

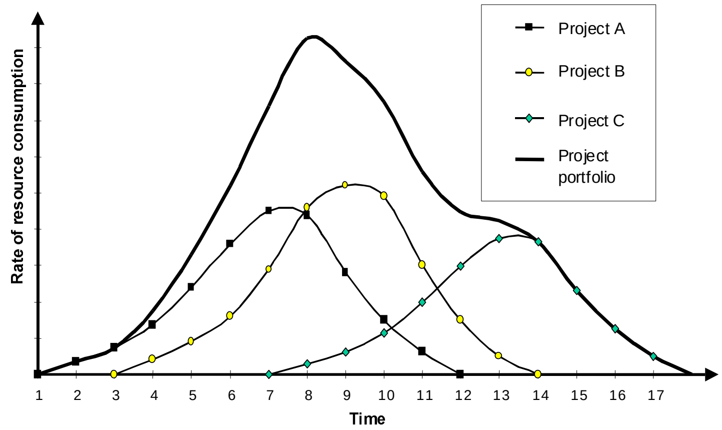

Figure 2. Development over time of the rate of resource consumption within the entire project portfolio

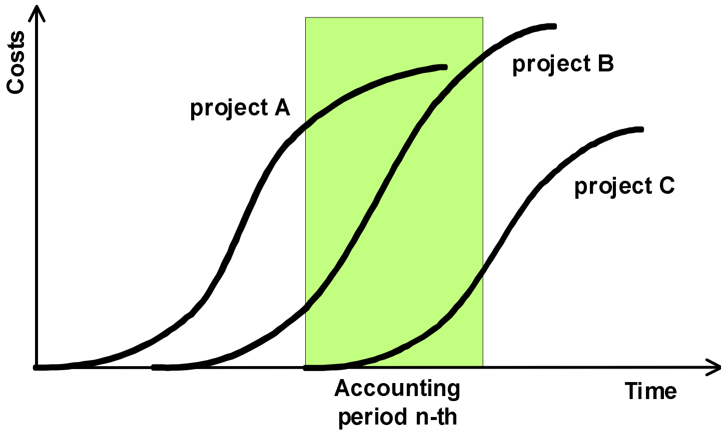

Figure 3. Relationship between the accounting period and project cost control

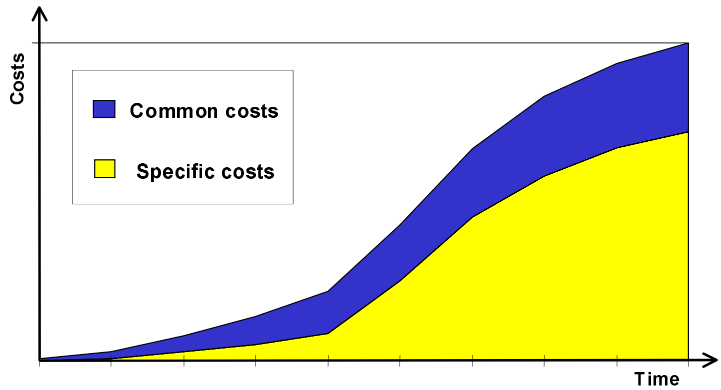

Figure 4. 'Layered' baseline of a project related to the level of cost controllability

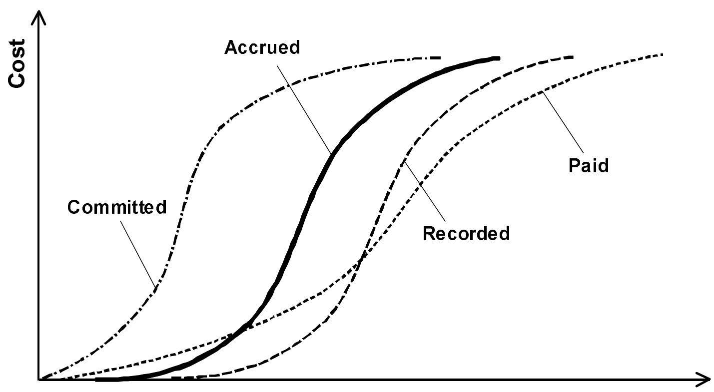

Figure 5. Cost maturity stage curves

It is within these four aspects that project-based companies find opportunities and restrictions in the development of effective cost accounting systems and tools. Integration of the company cost accounting system with project cost control means, therefore, integration of the above four elements in a management model which can then, in turn, provide specific operational tools.

Cost classification and project control

The definition of cost categories is of fundamental importance in the economic control of a project, as well as in company cost accounting system. From the point of view of an effective control of project costs, three aspects should be taken into account:

- The level of controllability of different cost items changes accordingly with the organisational levels: project team, functional departments, overall company (cf. Figure 1). For example, a company could implement an accounting system able to calculate the cost of invoicing for a project (e.g. based on the hours worked by administrative personnel). However, the project manager has little if any control over the way such personnel work. In other words, administrative activities (and costs) are not a means by which the manager can control project costs.
- Cost configuration means the body of attributes which provide an unambiguous interpretation of the significance of a given cost item and hence of its quantity and attribution (who consumes, who authorises, who oversees the expenditure/procurement procedure and with what level of control?). The choice of the best configuration for the cost should be function of the control objectives and the desired organisational behaviour.
- The incidence of cost maturity stage (committed, accrued, recorded, paid) on the economic control of a project, particularly in terms of when the corresponding resource is 'consumed', i.e. respecting the accrual period, and in terms of the different stages of planning and control process (cf. Figure 5).

The inclusion of these elements in the integration process between the overall company control system and the project cost control systems may be facilitated by two emerging factors. Today, the concept of 'strategically correct cost' configuration (Horngren, 1982; Horngren & Foster, 1987) is generally used when talking about cost accounting and management control systems. Going beyond the myth of the 'true' cost, which had been sought with ever more sophisticated methods, it is now accepted that there are various possible configurations of a given cost, while the applicability of each is related to the performance objective and the desired management behaviour. Besides, new architectures of information systems, based on data warehouse concept, are nowadays widespread allowing a multi-dimensional data analysis on the basis of company management levers. Both cost configuration and information system configuration, assume considerable significance in engineering and contracting companies with a typical 'matrix' organisation and thus with at least two distinct views: by functional departments and by projects. However, other dimensions might equally form part of the management analysis domain: business line, geographic area, maturity stage, type of resource, currency, etc. Note that in an integrated company information system, the general accounting dimension (balance sheet) is always present. Figure 6 gives an example of a possible model to classify the costs of a project-based company. Multi-dimensional analysis of company costs is certainly an important tool in integrating company management control and project cost control.

The classification of project costs therefore plays a crucial role. Indeed, referring to the strategically correct cost concept, it is not possible to assign an absolute preference to any one of the available classification schemes. The most well known and widespread scheme takes the level of connection between a given cost and the single project as the reference criterion, considering external (resources acquired specifically for the project, i.e. purchasing) and internal (company internal resources) costs. However, other classifications focusing on different criteria can be defined and profitably used. A classification may, for example, take the connection between a specific cost and project progress as the reference criterion, so obtaining three distinct cost categories:

- *Progress costs*, i.e. all expenses directly proportional to the physical progress of the project: direct materials, operational equipment, direct labour, etc.
- *Apportioned costs*, i.e. all specific expenditure for a single project although not directly linked to physical progress and divided into:
  - Costs apportioned to progress costs, e.g. costs to supervise construction, quality control of materials, etc.
  - Costs apportioned to the level of effort, e.g. making up delays in the supply of materials by intensifying expediting.
  - Costs apportioned to the duration of the project, e.g. fixed site costs.
- *Common costs*, i.e. all general overhead costs.

The project margin, given by the difference between contractual income and specific project costs (progress and apportioned), as shown in Figure 7, is therefore an adequate assessment index of the economic result of the project. The proportion of this margin used to cover common company costs and the proportion determining profit is a choice which goes beyond the scope of the project, being part of the overall company management control.

It is also possible to delineate a project cost classification which uses the level of controllability by the project team as the explicit and predominant criterion. The aim is to achieve a more effective model to control costs and assess results, as described below. The classification scheme can be derived from the simple representation of a generic cost item (C_{ik}):

$$C_{ik} = c_{ik} \cdot Q_{ik}$$

where for the project 'k', c_{ik} is the unit cost of the resource 'i' to which the cost refers and Q_{ik} is the quantity of the resource 'i' used for project 'k'. Note that financial incomes and charges can also

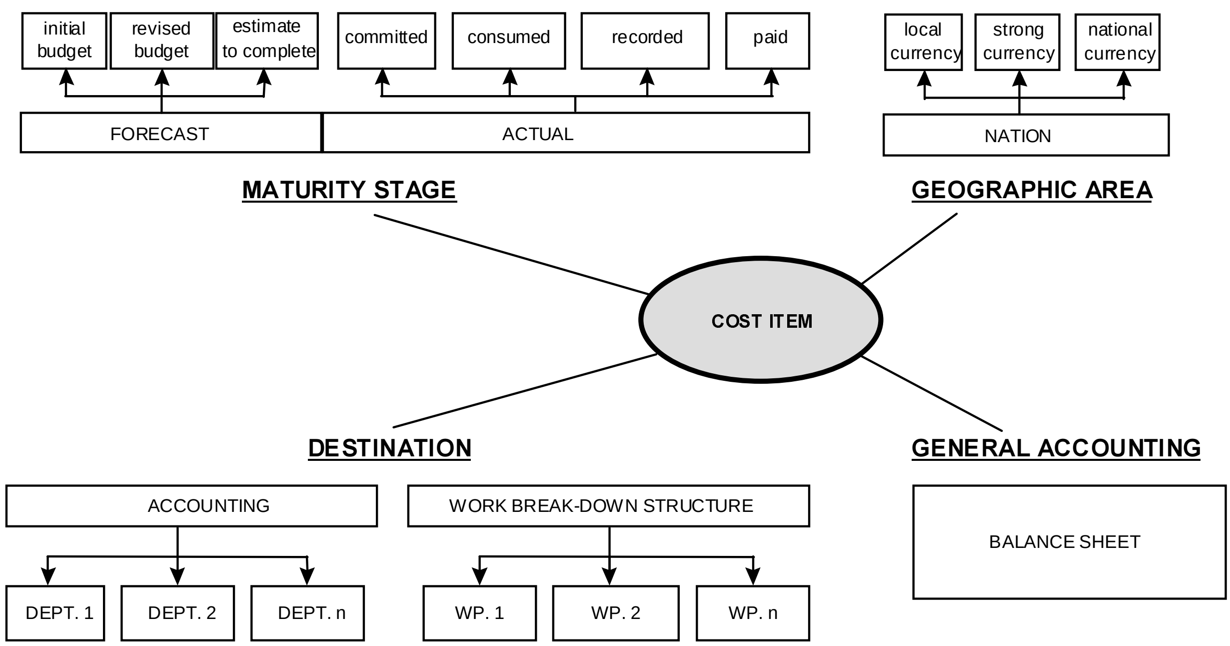

Figure 6. Example of a multi-dimensional cost structure

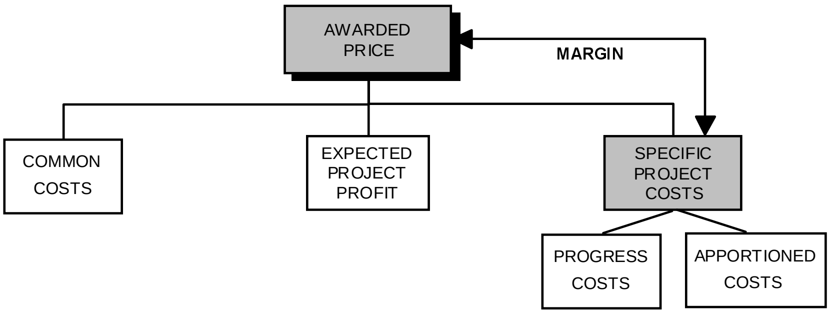

Figure 7. Calculation of project margin

be managed within this scheme. There are three situations of decreasing controllability:

- *Price-Quantity-based costs*: the project team is able to control both factors determining overall cost, i.e. unit cost and quantity consumed, e.g. specific external costs (materials, sub-contracts, outsourced services, etc.).
- *Quantity-based costs*: the project manager controls the quantity of resources used, while the unit cost is fixed at company level. This situation includes non-specific external costs (e.g. materials procured by a centralised procurement department) and specific internal costs (e.g. 'internal' engineering hours, 'internal' procurement hours, etc.).
- *Overheads*: the project assumes certain structural costs over which it has no control (e.g. administrative costs). These costs mainly depend indifferently for each project on the ratio between company capacity and current workload.

Cost maturity stages and project control

A cost evolves over time as the project progresses. This evolution is demonstrated by the four maturity stages which (e.g. in the case of the procurement process and utilisation of materials) refer to: commitment (purchase order), accrual (utilisation), recording (invoicing) and payment (cash outflow). Each of the four stages has specific relevance with respect to the different aspects of either economic or financial control of the project (Hamburger, 1986).

Following the principle of accrual period, economic control and the assessment of project progress would require that the cost is to be taken into account at the moment in which the corresponding resource is consumed (cf. Figure 5). This is what happens, for example, during the planning stage if the project baseline is derived from a CPM network on the basis of the time schedule of the activities, each scheduled activity corresponding to a given resource consumption and therefore to an operating cost.

To anticipate cost assessment as much as possible and so highlight any variance from the baseline immediately, it is possible, during the project execution, to use the committed curve comparing actual values with planned values. However, the possibility of significant imprecision when this method is applied indiscriminately to all types of resource should not be underestimated. Indeed, the period between commitment and use of a resource can vary considerably with the resource considered. For example, months may pass between the commitment and the installation of plant components produced by sub-contractors. Again, in the case of main plant components, the time between commitment and recording, shown on the graph as the distance between the committed and the recorded curves (Figure 5), is essentially a function of supplier delivery times. Given the length of this period in comparison to the time required to issue and receive the invoice, particularly in the case of critical components, the accrued and recorded curves should be quite close to each other. The time between invoicing and payment (i.e. between the recorded and the paid curves) depends on contractual agreements on payment terms. The forms of payment most commonly used envisage:

- a down payment, i.e. payment is effected, at least in part, before the corresponding resource is used;
- a credit payment, i.e. payment is made after use of the corresponding resource.

Down payment is used, for instance, for large sub-contracts with long delivery times, where the supplier receives a substantial advance payment in order to realise the work. Such outcomes are concentrated at the beginning of the project, meaning that the paid curve may precede the accrued curve (cf. Figure 5). However, as the project progresses, resources paid by credit payment tend to predominate, also because of the general application of a retainage on suppliers to guarantee the quality of supply. Figure 8 illustrates the importance of the different cost maturity stages in the different phases of planning and control process. It is evident that the recording (invoicing)

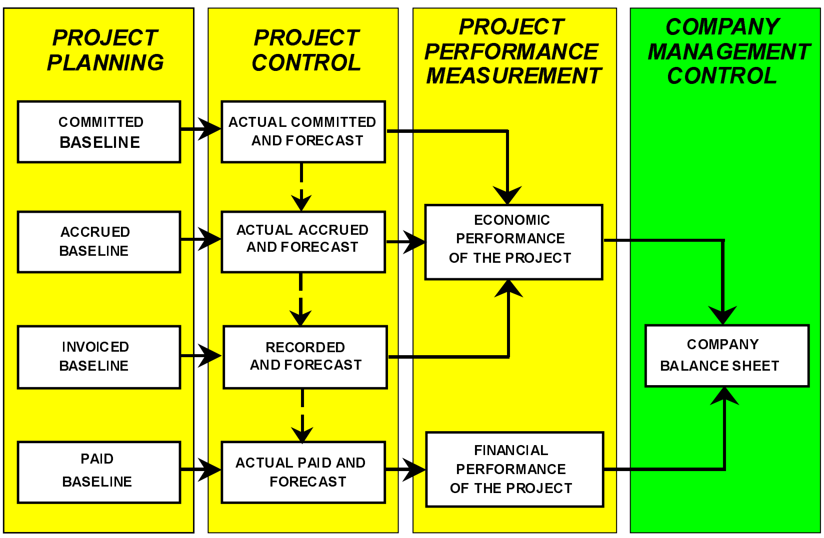

Figure 8. Project control process and cost maturity stages

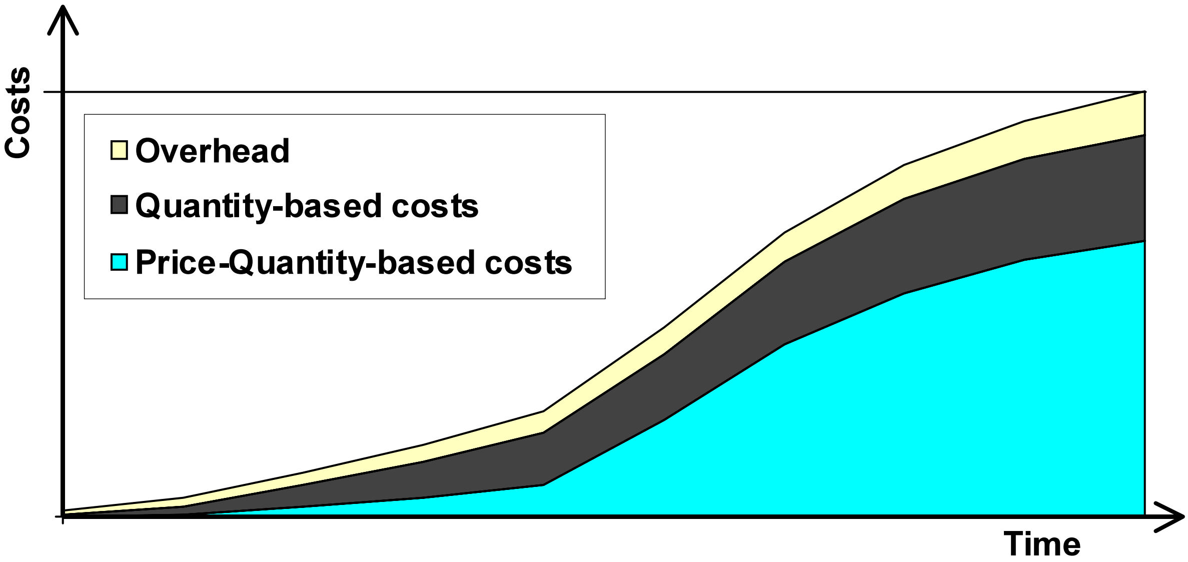

Figure 9. Example of 'Layered baseline' referring to cost controllability

phase is the basis for the definition of project cash-flows (a function of the payment terms of incoming and outgoing invoices), and can be seen as the hinge between the economic and the financial control of the project.

Assessment of the economic result of a project

The perception of the interdependence between the levels of control within a company is a fundamental factor in ensuring that objectives and responsibilities are coherent with the effectively available management levers in each of the identified levels. This coherence is indispensable in order to obtain management behaviour in line with objectives, and assumes particular importance with regards the economic control of the project. In facing the problem, two indivisible factors must be taken into account:

- the organisational configuration of which the project is a part;
- and the structure of the planning and control process.

Generally, a clear distinction between project-level and company (or single functional department) -level of controllability cannot always be identified, as a range of organisational grades (e.g. from a weak to a strong matrix) and different levels of detail in the assessment of the various types of cost (with the respective drivers) are possible.

Identification of specific areas of responsibility in the effective use of available resources to achieve the desired results facilitates a correct allocation of project and company costs. Here, too, project portfolio management is of particular importance. Referring to the planning and control model shown in Figure 1, a correspondence between the different areas of control and the type of cost identified is evident. Price-Quantity-based costs are entirely managed at project level. Overheads are managed by the single functional department or at the overall company level. It should be noted that the unit cost of the internal resource assigned to a given project is a company decision (in line with the concept of the strategically correct cost). Company decisions on which cost items have to be used to determine the unit cost of the internal resource have a strong impact on management behaviour and choices both for the functional departments and for the project team. In "make or buy" problem, different configurations for the unit cost can be set taking into account of just department variable costs, or department full costs, or company full costs (including overheads). The choice of a specific cost configuration can strongly affect the decision of "make or buy" problems.

A unit cost configuration which only includes department full costs leads to a cost for the use of internal resources comparable to what in manufacturing is termed the full industrial cost. In this way, the project is charged with company overheads in a direct and transparent way, rather than indirectly via the use of internal resources.

Two observations complete the picture which has been drawn:

- in addition to the type of cost, other factors influence the unit cost value of internal resources: resource reference quantity for the calculation of the unit cost (e.g. target or actual workload), reference to budget or actual cost, etc.
- much attention should be paid to ensuring that overheads are not assigned to a project twice, first directly via a quota fixed at company level, and second indirectly via the costs deriving from the use of internal resources.

With reference to different cost categories, deriving from a specific cost classification, a number of cost curves can be defined, rather than just a single project baseline.

Indeed, accordingly to the strategically correct cost concept, a specific cost classification should be choose with regard to the key factors for the project success and to the desired managerial behaviour. Thus, a 'layered' view of the project baseline allows to point out project critical costs and to manage them properly. Considering, for example, the different level of controllability of the single costs making up the total project cost, a 'layered baseline' can be set in function of the level of control exerted by the project team over the various cost categories (Figure 9). In this case a 'layered' baseline makes it possible to:

- focus on the portion of controllable cost obtaining a correct evaluation of project performance;
- highlight the unsettling effects

of any internal or external disturbance in the appropriate control environment;
- monitor the development during project progress of constraints which influence the economic result;
- obtain a more rapid and deeper understanding of the dynamics underlying the project progress;
- manage costs on the basis of the type of corrective action which can be implemented: reduction in the unit cost and/or of the quantity used of a single resource.

Conclusions

In the present context, effective integration between company cost accounting and project cost control is an important factor in project-based companies' long-term competitive positioning.

The main factors within which the problem must be treated in order to be faced correctly have been highlighted:
- a multi-project environment;
- relationship between project portfolio management and overall company management (a time window within the portfolio planning horizon);
- different management approach as a function of the level of controllability of each cost item;
- management of project cost development over time, i.e. the cost maturity stages.

Future development involves the realisation of management control models and systems able to monitor and assess even operational performance parameters. Indeed, it is increasingly important to concentrate efforts in the continual improvement of project management quality, i.e. project effectiveness and efficiency. To this end, operational parameters - e.g. physical progress, amount of repeated work due to the late emergence of non-conformities, technical performance etc. - must be identified, which integrate with the economic and financial parameters, describing project and company performance. This objective necessarily demands ever greater integration between overall company control and project management (internal integration), as well as in relation with customers and suppliers (external integration). Both conditions are indispensable to ensure that:
- technical and management factors monitored at operational level reach, appropriately filtered, the management control level, so extending its scope beyond solely economic data;
- customers' expressed and implicit needs are included in the main contractor's control system and are, in turn, transferred to sub-contractors.

The ultimate aim is to enlarge companies' strategic and management horizon, exploiting medium and long-term competitive factors, rather than merely short-term economic and financial results.

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Inside The Looking Glass - Cultural Diversity in Global Project Teams

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Today's global comtanies face tremendous challenges integrating the diverse cultures prevalent in the modern workforce. As projects become increasingly global, project teams must deal with a new range of challenges from language barriers and time differences to religious diversity and differences in eating habits. A Project Manager faced with an international array of customers, suppliers, and team members needs to be aware of these cultural differences and take special care to avoid the potential risks and pitfalls associated with them. For many Project Managers, particularly for Americans with little or no international experience, this can be a daunting challenge.

But with proper communications, this challenge can seem more of a minor inconvenience than a major obstacle. In fact, communication is the most critical success factor in overcoming these cultural obstacles. By recognizing the needs and perspectives of the various people supporting the team, the Project Manager can develop and implement an effective communications plan that supports the project objectives. This plan must be based on more than just the personal experiences of the Project Manager - it must consider all cultures and all environments involved with the project.

This paper highlights some of the significant communications issues facing a global project team and suggests some practical steps to help the Project Manager build an effective team in a multi-cultural environment. Further pre-research for understanding cultural issues is important.

The Importance of Effective Communication

This paper focuses on one key element a Project Manager must consider in dealing with this situation - the establishment of an effective Communications Plan. It cannot discuss in its brief few pages all of the critical aspects of global project management.

On the other hand, effective communications can go a long way in building a project team that is prepared to deal with other management challenges, so it seems a logical place to start.

In the article, "A Leadership Profile of American Project Managers," which appeared in the Project Management Journal March 1998, Zimmerer and Yasin surveyed senior Project Managers across the United States.

Zimmerer and Yasin identified that the two most critical roles of successful Project Managers are as Team Builder and Communicator.

In planning communications with the project team, it is essential that you consider all of the participants in the project - including clients, stakeholders, project team members, partners, suppliers, regulatory agencies, and your own organization. By explicitly considering the cultural backgrounds of each of these participants you can identify the potential (or probable) risk factors that can inhibit effective project communications, and can develop appropriate mitigation strategies.

Failure to take into account the significant cultural differences of your project team, and a stubborn insistence that this varied mix of people can adapt to "your way" of doing things, is a recipe for disaster.

Getting Ready for Your Adventure

When a Project Manager is posted to a new international assignment, he or she must be prepared to face the adventure. Here are some suggestions for initial preparation based on the author's experience in deploying people to far-flung corners of the globe:

1. Make Contact Early. Contact the existing team in the new location. Seek input on the current situation, information about the local cultures and any difficulties that might be encountered upon arrival.
2. Learn about the Players. Learn about the players on your new project team from all available resources. Request a list of all project participants that indicates each individual's cultural identity. Request resumes on key players to learn about their background and experience. Check with your contacts in the business who may know the people you will be working with before you arrive.

If the new posting is to a region

where there are no current operations, then there is no existing project team to learn about. In this instance, it is crucial to have an agent or a representative at the location to assist in getting established in the new culture.

3. Search the Web. Many excellent resources are available for information on the cultural aspects of the region. The U.S. State Department and several other U.S. government agencies offer extensive information on regional cultures. Table 1 provides a listing of several Web sites that are useful in preparing for a new international assignment.
4. Check your Local Library or Bookstore. Check your local bookstore or library for publications on the region or cultures involved. There is a tremendous wealth of published information on virtually any location and any culture in the world
5. Learn the Language. Learn some basics of the host language. Greeting your host or your new customer in his or her native tongue, no matter how limited your abilities, is a gesture that is universally appreciated. When done tactfully, it indicates a willingness to accommodate their needs and a genuine desire to respect their culture.
6. Meet the Locals. Upon arrival at the new project site, take time to familiarize yourself with your new surroundings and make an effort to meet some local residents. The first order of business is to find a residence for your yourself and your family. Use this opportunity to get to know your new city and to make some local contacts. Perhaps a trip to a local bank, grocer or other retailer will offer additional insights. These people are living models of the project team you are going to be dealing with, and they can help you to be prepared before your initial encounter with your team.

Building a Communications Plan

The next step is the development of a Communications Plan. This plan, distributed to the entire project team, addresses the complete spectrum of communications within the project.

At a minimum, the Communications Plan should address what needs to be communicated, to whom and by whom, when, and in what format. The Communications Plan also needs to address specific cultural influences that are applicable to the current situation.

In developing your plan, consider the following kinds of issues:

- Holidays -- Recognize that during Ramadan, progress will be affected in Islamic countries. Understand that during August in Germany, much of the workforce will be on holiday. Accept that Rio during Carnival will not be as productive as other times of the year.
- Working Schedules -- Many of the Mediterranean countries take an extended lunch break, working late into the evening. Some countries limit the hours that can be worked in any given day, and Arabic countries may work Saturday through Wednesday.
- Sensitivity to Formality -- Many cultures, particularly those of Asia, have a distaste of formal correspondence and prefer that communications be more informal, on a face-to-face basis. Given this situation, specify those items that must be documented (change proposals and records, limited contract correspondence, approval sign-offs), but be flexible and accommodate the need for more personal contact. Use a low-key approach rather than excessive formality.
- Sensitivity to Protocol -- Some European cultures frown on discussing business during a meal. Many countries in the Middle East and elsewhere have a process of discussion, usually starting with informal discussions about family or special interest items (sports, entertainment, etc.), then talking about minor business issues before getting into the crux of your agenda.

A Communications Plan is worthless if it is developed in a vacuum, or if once it is developed it sits on a shelf collecting dust. The best advice for formulating an effective communications plan is to involve representatives of the various cultures in your planning process. Ask them what works, and what doesn't. Ask them to help you put together a plan that is sensitive to cultural differences in the team.

Treat the plan as a living, breathing, changing document. Don't be afraid to modify it as you gain more experience with the project team members. Most importantly, make sure the plan itself is properly communicated and understood throughout the project team.

Conclusion

Today's Project Manager has the opportunity to plan for, and overcome, many of the cultural obstacles that are encountered when building and leading highly effective, high-performance project teams in the global marketplace. Effective communications is one of the most important aspects of this process.

In order to build and implement an effective communications plan, project managers must prepare by learning as much as possible about the people, cultures and environments involved in the project. Next, a communications plan should be developed with active participation from members of the team representing the diverse cultures involved. Special care must be taken to accommodate cultural norms and expectations. The resulting communications plan should be fully communicated to all members of the team and should be continuously improved based on experience. With the development and application of an effective communications plan, cultural diversity can become a strength to be celebrated rather than an obstacle to be overcome.

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INTERNATIONAL IT DIRECTORY

The General Services Administration, through its Office of Inter-governmental Solutions (OIS), is a focal point to ensure that the information technology experiences of some are learned by all. OIS is in a unique position within the worldwide IT community. Access to key officials within the Federal government as well as in the international, State, and local IT communities creates this unique centralized position. This particular page is "A Guide to Information Technology Officials in Governments and International Organizations"

http://policyworks.gov/org/main/mg/intergov/nationhd.htm

CURRENT EVENTS

Cable News Network (CNN) site that gives international happenings coverage daily and also helpful regional information and links.

http://cnn.com/WORLD/index.html

GENERAL INFORMATION

This web page is a collection of sites for general international information, as well as historical and ancient facts on various regions around the world. This site specifically gives information on the following regions: Canada, Africa, Asia, Australia & Oceania, Europe and Latin America. Population information is also included.

http://www.edenhance.com/people.htm

INTERNATIONAL HOLIDAYS AND EVENTS

This web site contains a current Holiday Calendar for 217 countries and includes 1488 individual holidays.

http://www.classnet.com/holidays/

EDUCATIONAL COUNTRY TOURS

An EF Educational Tour is an opportunity to discover new countries, languages and ideas through group travel. In essence, nothing makes education more vivid than firsthand experience. For over 30 years, EF has introduced foreign cultures and lands to people worldwide.

http://www.eftours.com/standard.html

UNITED NATIONS INTERNATIONAL STUDIES

This online series of information is provided by the Federal Research Division of the U.S. Library of Congress under the Country Studies/Area Handbook Program sponsored by the Department of the Army. It presently contains studies of 85 countries.

http://lcweb2.loc.gov/frd/cs/cshome.html

TRAVELING AND WORKING OVERSEAS - STATE DEPARTMENT NOTES

Links to State department advice covering just about everything to do with travelling abroad!

http://www.state.gov/www/services.html

WASHINGTON POST INTERNATIONAL EXCHANGE RATES

International exchange rates - updated 5am, noon and 7pm every trading day.

http://www.washingtonpost.com/wp-srv/business/longterm/stocks/currency.htm

CDC TRAVEL HEALTH INFORMATION

Center for Disease Control and Prevention - what shots to get for which countries! Where to drink water and where not.

http://www.cdc.gov/travel/travel.html

COUNTRY COMMERCIAL GUIDES

Guides prepared by the local US Embassy giving overviews of entire commercial environments of each overseas territory. Important for anyone staying overseas for an extended period of time.

http://www.state.gov/www/about_state/business/com_guides/index.html

U.S. STATE DEPARTMENT TRAVEL ADVISORIES

Advisories about travel to countries worldwide.

http://travel.state.gov/travel_warnings.html

Table 1. World Wide Web Resource Directory

CATEGORY: RESEARCH & INDUSTRY CASE

Planning and Scheduling System For Distributed, One-Off and Complex System Projects

Miikka Kotamäki, Helsinki Institute of Physics & CERN, Switzerland
Ari-Pekka Hameri, Helsinki Institute of Physics & CERN, Switzerland

The paper describes an approach and a prototype to build and maintain the schedules needed to manage time, resources, and progress in a large-scale and globally distributed project. The approach is based on the decomposition of the project into work packages, which can be each considered as a complete project with its own structure. The prototype promotes the distribution of the decision making and responsibilities to lower levels in the organization by providing a state-of-the-art system to formalize the external commitments of the work packages without limiting their ability to modify their internal schedules to best meet their commitments. The planned system lets the project management focus on the interfaces between the work packages and alerts the management immediately if a conflict arises. The proposed system simplifies the planning and management process and eliminates the need for a large, centralized project management system. The underlying case for the work is a global collaboration project to construct a complex large-scale particle detection system, which will be operational by the year 2005 at CERN, Geneva.

Introduction

Large-scale projects with objectives beyond conventional solutions make nice reading (e.g. Morris & Hough, 1987) on how things get complicated when distributed and collaborative efforts are used. The problems related to major projects are not different from the ones we confront in any daily project (Hameri, 1997):

- ignorance of what other project teams are doing;
- lack of discipline in design change control;
- diverse views on what are the objectives (time, costs, quality, technology) of the project;
- rigid project planning and scheduling routines, which results in poor reactivity to sudden changes in the project environment;
- unforeseen technological difficulties.

To put this in perspective a study of more than 8,000 projects found that only 16 percent were able to satisfy the time, budget and specification constraints set for the project (Frame, 1997). Looking more carefully these problems, one realizes that communication and sharing information between collaborative parties is very fundamental prerequisite for the succgss of all kinds of projects. The focus of this paper is on planning and scheduling, but also on integration of this information with the work and task level descriptions, and how to collect, manage and share this information.

The underlying case of the article is the Compact Muon Solenoid (CMS) project at the European Laboratory for Particle Physics (CERN). CMS-project is a large project involving more 1,800 than researchers, more than 150 institutes, laboratories and companies from more than 35 countries. Each of participating organizations has its own way of working influenced by their own standards, (business) culture and habits. Some are used to plan and schedule all their work in advance while some rely more on ad-hoc management and regard strict planning and scheduling as something that limits their creativity and prevents them from achieving the optimal result. Since the CMS project will be pushing not only the limits of scope and performance, but also of cost and time, it is extremely important that the project is well planned and tracked. One should also note that the project is not only operating in physically distributed manner, but also decisions related to funding and technical details are being made in distributed manner. The customer of the project is the research collaboration itself, which leaves significant amount of trust to collaborative and supplying parties of the project.

All major projects need to have simple and clear guidelines on how the planning should be performed, who should do it and when, and how the plans should be updated, integrated, verified and disseminated. Independently of the project there is a need for smart but simple and easy to use tools for both the technical managers and the project management. The scheduling system of a large and distributed project must support the effort of having the decision making at lower levels in the project organization and to allow the groups to use their own internal planning systems with which they are already acquainted. This provides the project management with better focus on monitoring and controlling larger entities and the interfaces between them. Further, the scheduling system should be able to handle uncertainty and change in the tasks and relationships among them, and finally, when implemented it should contain a World Wide Web interface to make it accessible throughout the world.

These requirements are familiar to all scheduling activities. The project management literature is full of books and guidelines on how to schedule the work and how to analyze the time related task networks. As most of the large-scale industrial projects are driven by prime contractors, usually by dedicated consulting companies, with their own routines stemming from past projects, the applied planning and scheduling means still are somewhat conventional and base on strict milestone based management with various means of financial enforcement. The underlying case may somewhat be a peculiar one, but it highlights the problems of distributed management operations in large-scale projects with intensive design phase and offers a solution with novel insight and procedures on how to establish feasible and flexible planning routines for major projects.

The paper studies and provides a description of an operational scheduling system for a large-scale project. In doing this, the paper presents first the various scheduling and planning levels identified in the case at hand. Then the process to build a central coordination schedule for the project is discussed as it sets the skeleton for the rest of the planning and scheduling activities. Then the procedures for detailed planning are documented, before the actual management system is treated. Finally, conclusions with implications and relations to industrial projects are drawn.

Schedule Levels

In the CMS project, two levels of schedules will be used: The coordination and the detailed level (Figure 1.). A separate coordination schedule is generated for each subsystem covering the entire duration of the project. A more compressed view of the coordination schedules can be compiled by rolling up

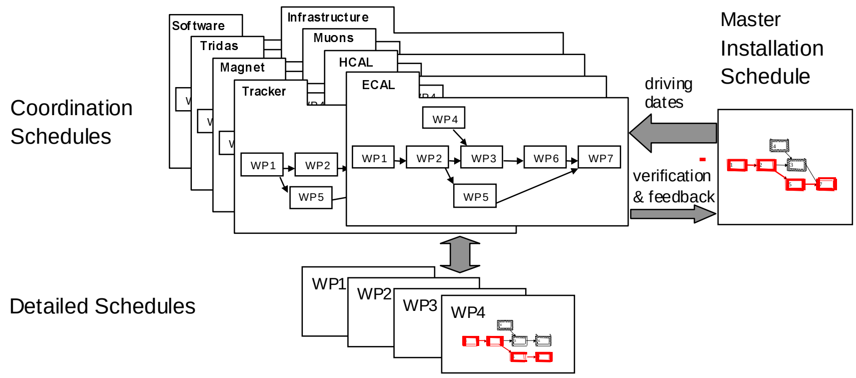

Figure 1. Schedule levels in the case project. Each coordination schedule refers to certain subsystem of the project.

the coordination level tasks into higher level tasks. These rollup schedules can be consolidated into one "global schedule", which by definition is not a driving schedule but provides the management with a possibility to analyze, verify and to comment the coherence of the scheduling status of the whole project. The ultimate driving dates for the sub-project schedules are retrieved from the installation schedule, which is, in principle, at the same level as the coordination schedules. At the second level, the work packages are, when necessary, decomposed into detailed schedules containing detailed tasks.

The coordination schedules form the core of the planning and scheduling system since they will be used for the time and cost management of both the subprojects and the whole project. To make this possible, the schedules must be built complying with the set of common guidelines. The subproject managers are responsible for building the preliminary versions of the coordination schedules. The general procedure for building a coordination schedule is shown in Figure 2 and is as follows:

1. Work out the Product Breakdown Structure (PBS).
2. Build the Work Breakdown Structure (WBS) by decomposing the work to be done into work packages.
3. Schedule the work packages. Retrieve the driving dates from project's installation schedule.
4. Let the work package managers build their respective detailed schedules, allocate the required resources and complete the work package data sheets
5. Refine the coordination schedules to meet the detailed planning targets.

The WBS is generated by following a specific set of rules and decomposing the project into chunks of work to a level of detail that need planning and scheduling. The elementary activity of the coordination schedule is a work package (WP), i.e. the lowest level of the work breakdown structure, needed for building the coordination schedules, contains the work packages. The decomposition of the work into work packages is the most critical part of the planning process because it guides the remainder of the planning activities (see e.g. Globerson, 1994; Reijniers, 1994).

The base for the WBS is the Product Breakdown Structure (PBS) in which all parts of the final product are defined (Lewis, 1993). It should be noted that the PBS may not be completely known in the beginning of the project and its final form may not be known until the detailed design phase is over. The transition from the PBS to the WBS is done by asking the following question for each part of the PBS: What tasks must be accomplished in order to produce the part? This identification process can be done by applying the standard tasks shown in Table 1 for each part of the Product Breakdown Structure. In principle, each work package should be associated with only one part of the PBS and to only one standard task. However, to reduce the number of work packages it is strongly recommended that several standard tasks are combined to a single one whenever appropriate. Thus, the standard tasks should be used merely as a checklist to ensure that no essential task is forgotten.

In the case project each of the

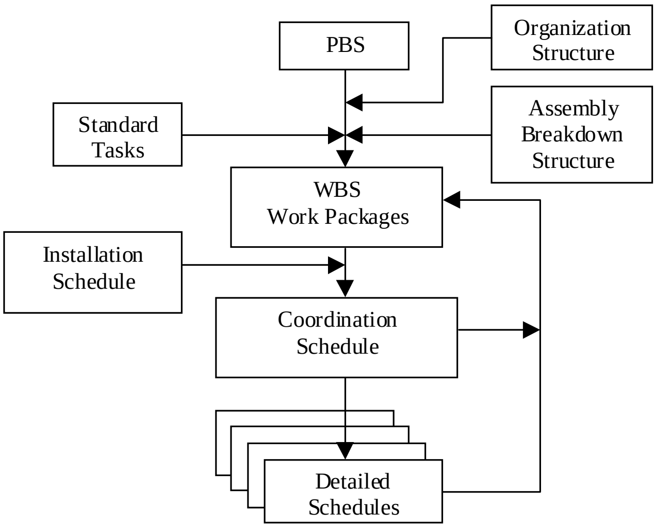

Figure 2. The process of building and refining the coordination schedules.

eight subprojects produce round 200 - 300 work packages. No work package is allowed to be a part of another work package, and the work packages should be defined in such a way that they cover the whole project i.e. no work may remain outside them. Also, one should not confuse the work package and work package data presented in this context with the production data acquired during the production. The decomposition into work packages is done only from the planning and scheduling point of view. For example, the work packages are not meant for decomposing a mass production of parts into production batches, and then for collecting and saving the production data of each batch. A separate system should be used for that purpose.

One of the main problems is to decide the level of detail required when defining the work packages. The same problem actually arises already when defining the PBS: What is the level of detail of PBS needed for building a WBS of appropriate granularity? As a general rule, the WBS must be defined in a way that the sub-project manager can manage the project. However, although the sub-project managers are free to develop their respective WBS according to their needs, the common guidelines must be followed so that the project office is able to manage the project as a whole. Since later changes of the WBS are allowed, neither the WBS nor the PBS needs to be final. During the definition phase only the highest level standard tasks should be used as a basis for a work package and when possible one should combine them if appropriate. On the other hand, the assembly phases often need to be broken down into several work packages and the use of the second level standard tasks might then be useful. For many PBS parts it is sufficient to define only a single work package containing all the work needed and thus all the standard tasks, from design to finished part, without further decomposition. After decomposing the work into the appropriate level of detail, each work package should be checked for the following requirements:

1. **Each work package has a responsible person (WP leader) or at least one supplying partner in charge for the work.** This is extremely important because the WP leader will be fully accountable for the cost, schedule and performance of the work package's elements.
2. **The work package has a deliverable or several deliverables.** The deliverable should also be needed by another work package, otherwise the work package is useless. A deliverable can be on one hand a physical part, equipment or system, and on the other hand a service, plan, specification or an activity, which is consumed by some other work package(s).
3. **Start and end events should be clearly defined.** Once the start event has occurred, work may begin on this work package. The production of the deliverables will most likely be the ending event, which signals the completion of the work package.
4. **Time and cost can be estimated.** The project's time and cost are mainly managed at work package level. The first estimates are later refined to meet the detailed planning of the work package.
5. **The work package is an independent unit with its own independent procedure.** This means that once work has begun it may continue without need to get additional input or information until the activity is complete.

If the defined work packages do not fulfil the above requirements, they should be decomposed and checked again. There may be exceptions with regard to the last requirement, which in some cases might be difficult to fulfil. Planning system contains a function, which makes it possible to handle longer work packages with intermediate outputs (deliverables) and intermediate inputs (receivables). Therefore, the last item can be considered more as a non-obligatory requirement.

After decomposing the project into work packages, the subproject manager defines the contents of the work packages. The procedure with each work package is as follows:

D Design	**F Fabrication & Tooling**
DC Conceptual Design	FT Tooling
DB Basic Design	FM Component Manufacturing
DD Detailed Design	FD Delivery
DR Redesign & Change Integration	**A Assembly & Installation**
P Prototyping	AO Off-Site (Pre) Assembly
PD Prototype Design	AC At CERN Assembly
PC Prototype Procurement	AI In-Situ Installation
PF Prototype Fabrication	**T Testing and Commissioning**
PT Prototype testing & Reporting	TO Off-Site Testing & Commissioning
C Tendering & Contracting	TC At CERN Testing & Commissioning
CM Market Survey	TI In-Situ Testing & Commissioning
CT Tendering Process	**M Management**
CV Vendor Evaluation	MC Configuration
CF Finance Committee Dossier	MQ Quality
CC Contracting Process	MS Planning & Scheduling
	MB Cost Management

Table 1. Standard tasks.

1. **Give a title.**
2. **Make a short description of its contents.**
3. **Issue a unique work package code in accordance with the guidelines.**
4. **Make an estimate of its duration.** Some preliminary detailed planning might be needed to make a reliable enough estimate. The estimate is later refined when the true detailed planning of the work package has been done.
5. **Identify the responsible person, the work package manager.**
6. **Identify the predecessor work packages.** This is needed for determining the required sequence of tasks for the preliminary schedule.

Detailed planning of the work packages

The work package manager is fully responsible for the correct spending, scheduling and outcome of the work package. This means that he or she is also responsible for its detailed planning and scheduling, which is not only needed to refine and complete the work package data, but also to enable him or her to make the external delivery commitments. It serves also as a means to show the project management that the work package has all the required resources to complete the work. At the beginning of the project, details of all the work packages, some of which will not start before significant time has elapsed, are not known. However, a detailed plan is feasible in the short term, and as the project proceeds the details of the rest of the work packages emerge. To further define the work packages the following actions are to taken by the manager:

1. Breaks the work package down into detailed tasks and builds the detailed schedule.
2. Estimates the cost, labor and other resources needed to accomplish the work package.
3. Defines the required input products, their deliverers, and the dates when they are needed.
4. Defines the output products - intermediate and end results, their receivers and the dates when they are available.
5. Completes the work package data sheet.

The person who is most familiar with the nature of a specific task should make, or at least comment and/or approve, the task duration estimates. Each separate task should be estimated as precisely as possible. However, the work package manager should create a small "management reserve" line in the work package plan. This is like contingency in budgets, but the management reserve is not money but time. Now, any delay in the detailed tasks will cause the start date of this management reserve to slip proportionately. The management reserve can then be used to bring the activity back on schedule. The management reserve or "risk limitation float" should be proportional to the estimated risk of the detailed tasks

The work package manager is responsible for building and maintaining the work package's cost and work force estimates. In the first phase, only the summaries of these estimates, i.e. the estimated total cost, work force and external services are entered into the work package data sheets. The entries are not only used for estimating the total project cost, but also to form the project's spending and manpower profiles.

Each work package should have a deliverable or several deliverables. There must be a receiver for each deliverable otherwise the deliverable is not needed. One of the main concerns in project planning in general is to accomplish an agreement on the deliverable and its delivery time to which both the deliverer and receiver commit themselves. To accomplish this the work package managers must define not only the output products and the required input products of their respective work packages, but also the receivers and deliverers and the desired delivery dates. The data is entered into the work package management system, which will be utilized in finding the right receivers or deliverers and to form the delivery contracts with them (Figure 3).

For each work package a data sheet shown in Figure 4 will be filled. The subproject planning coordinator fills at least the fields shown in bold already when building a preliminary coordination schedule. Later, after the detailed schedule has been compiled,

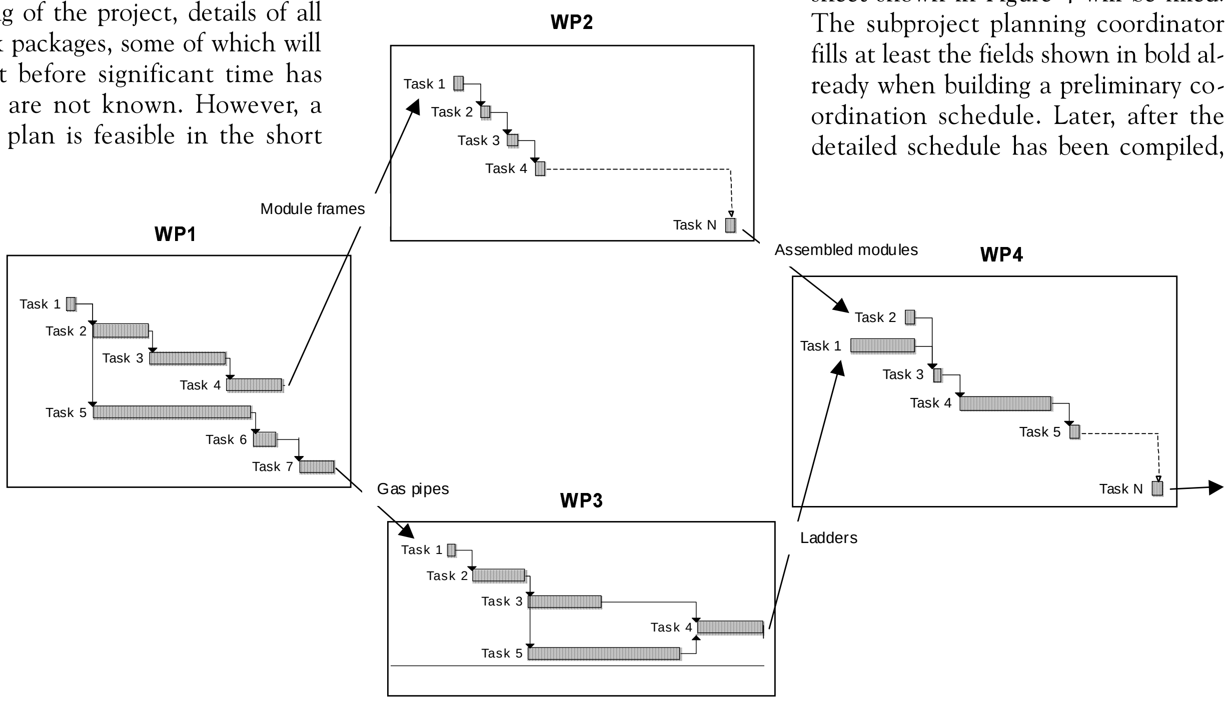

Figure 3. A simplified example of a network of four work packages. Work package WP1 delivers a product to WP2 and a product to WP3. Both WP2 and WP3 deliver a product to WP4. The work package managers have created their own detailed schedules.

the work package manager fills the remaining fields and also double-checks the preliminary values. The work package data will be entered into the work package management system through a World Wide Web interface. The filling of the work package data sheets might first seem to be more bureaucratic than useful. However, one should regard the work package description as an insurance policy. If for some reason the work package manager is unable to continue with the project, how will someone know the status of the work package, what has yet to be completed, and how it is to be completed? If the work packages gain legal status in the project, i.e. they serve as official commitment documents, then they could also be used as means to pursue compensation in case of problems.

WP Title	Module assembly					
WP Code	WP2		**System**	Tracker		
Responsible	Supplying Company					
WP manager	Mr. Turner					
Email	turner@supply.com		Telephone	+77779	Fax	+71234
Scope of work	Assembly of 100 modules. Testing of the modules. Packing and delivery to CERN.					
Starting date	15/1/1999		**Completion date**		2/4/1999	
Predecessor WPs	WP1					
Risks, Assumptions and Reserves						
Total Cost of the WP (USD)	$$$		Cost book reference number		2.x.x	
In-house manpower (months)	4		Hired manpower (months)		2	
Input products	Deliverer	Receiver Agree	Deliverer Agree*	Date Needed	Date Available*	Status*
Module Frames	WP1	Y	Y	15/1/1999	15/1/1999	Agreed
Output products	Receiver	Receiver Agree*	Deliverer Agree	Date Needed*	Date Available	Status*
Assembled Modules	WP4	Y	Y	15/3/1999	2/4/1999	Date not Agreed

Figure 4. An example on the contents of the work package data sheet.

Work Package and Coordination Schedule Management

The work packages and the coordination schedules are managed by a work package management system. Figure 5 describes the relationships between the different parties of the project and the work package management system. Work package managers use the system regularly to review and update their work package data and delivery agreements, thus it always contains the latest information of the work packages and their scheduling. The system produces several types of reports for the project management: Status reports of the work packages and their input/output contracts, cost calculations, spending profiles, workforce profiles and special zoom schedules containing only a given set of work packages. The main planning office and the subproject planning coordinator analyze the subproject's progress and status by importing the scheduling data from the system. In principle, only the work package managers should be allowed to make changes to the work package data, i.e. neither the planning office nor the subprojects planning coordinators change the scheduling of the work packages but communicate the required changes to work package managers via respective subproject management.

The work package management is based on a well-known database and the system exploits World Wide Web interface, which provides cross-platform compatibility and access for the global user community. User authentication is applied to maintain security and prevent violation of vital information. The systems scans for loose links and work packages with deliveries without receivers and vice versa, i.e. following problems have been detected:

An interface between work packages has not been identified or has been incorrectly identified, i.e. a work package lacks the required input, or is planning to deliver something that is not needed, or the managers of the delivering and receiving work packages have not been agreed on the deliverable.

A task is not feasible as planned requiring changes not only to the work package, but also to the entire work breakdown structure.

A task is late delaying the planned deliveries of the work package.

To prevent such conflicts or at least to minimize their consequences the work package managers need to identify their interfaces between other work packages. Secondly, the system allows them to formalize their external delivery commitments without limiting their ability to modify their internal schedules to best meet their delivery commitments. Thirdly, the system alerts the project management immediately if a conflict arises. To accomplish an agreement on the deliverable of a work package and its delivery time, to which both the deliverer and receiver commit themselves, we adapt a so-called "Rec/Del" system of the Customer-oriented Management Information System (CMIS, 1998). CMIS was developed in Caltech's Jet Propulsion Laboratory for managing NASA's Cassini project. The purpose of the system is to provide us-

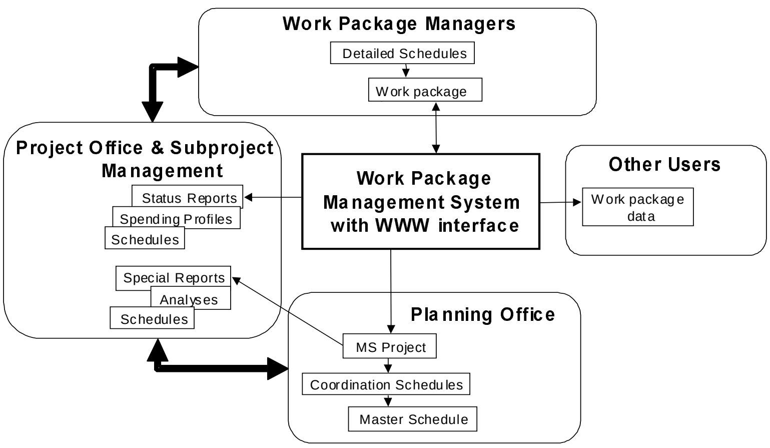

Figure 5. Work package management system and its interfaces.

ers with interactive capabilities of creating, monitoring and updating agreements made on the work package deliverables and their delivery times. The system relies on five simple conventions (CMIS, 1998):

1. All project products have to be one work package's output product (deliverable) and another's input product (receivable).
2. Once the work package managers of a delivering work package (deliverer) and receiving work package (receiver) reach an agreement on the need for, and delivery date of a product, a contract is formed.
3. Each contract is tracked and stored in a database.
4. Only the receiver can decide whether a product delivery has been successfully completed.
5. Any person of the project is able to determine a product's (contract's) status at any given time through WWW.

Contract ID: * 000001			Product: MODULE FRAMES		
Current Due Date: * 15/1/1999		Delivered Date:		Baseline Date: * 15/1/1999	Status: * Agreed
DELIVERER			**RECEIVER**		
WP Code: WP1	Agree: Y	Date Available: 15/1/1999	WP Code: WP2	Agree: Y	Date Needed: 15/1/1999
Contact: Jim Smith	Phone: +77777	Email: jim.smith@cern.ch	Contact: Ville Peltonen	Phone: +77779	Email: ville@hip.fi
Notes: 100 MODULE FRAMES			Notes: MUST BE ACCORDING TO SPECIFICATIONS IN CMS-XX-1234.		

Figure 6. The data of a product or deliverable form. The fields marked with an asterisk are automatically filled in by the system. Also the contact information is automatically copied from the work package data sheets when the work package codes are entered.

Output products	Receiver	Receiver Agree*	Deliverer Agree	Date Needed*	Date Available	Status*
Module Frames	WP2	Y	Y	15/1/1999	15/1/1999	Agreed
Gas Pipes	WP3	Y	Y	30/1/1999	30/1/1999	Agreed

Figure 7. The "input/output products" section of the work package WP1's work package data sheet. The work package does not have any input products registered. The output products are visible as input products in their receivers' work package data sheets (see Figs. 4 and 8).

Input products	Deliverer	Receiver Agree	Deliverer Agree*	Date Needed	Date Available*	Status*
Gas Pipes	WP1	Y	Y	30/1/1999	30/1/1999	Agreed
Output products	Receiver	Receiver Agree*	Deliverer Agree	Date Needed*	Date Available	Status*
Ladders	WP4	Y	Y	1/3/1999	1/3/1999	Agreed

Figure 8. The input/output products of the work package WP3 as seen in its work package data sheet. The WP1's output "Gas Pipes" is here visible as an input product.

Input products	Deliverer	Receiver Agree	Deliverer Agree*	Date Needed	Date Available*	Status*
Assembled Modules	WP2	Y	Y	2/4/1999	15/3/1999	Date not Agreed
Ladders	WP3	Y	Y	1/3/1999	1/3/1999	Agreed
Output products	Receiver	Receiver Agree*	Deliverer Agree	Date Needed*	Date Available	Status*
Assembled Ladders	WP5	N	Y		15/5/1991	Product not Agreed

Figure 9. The input/output products of WP4. The output products of WP2 and WP3 are here visible as input products. "Assembled Modules" are needed earlier than suggested by their deliverer. The planned receiver of the "Assembled Ladders" (WP5) has not agreed on the product, i.e. the work package managers have different ideas of the product and thus they should discuss and find an agreement.

The work package manager defines the input and output products, their deliverers and receivers, and the proposed delivery dates by filling out the respective fields of the work package data sheet shown in Figure 4. The other party (the deliverer of an input product or the receiver of an output product) is then automatically notified of a new product, which is then visible also in his work package data sheet. He then decides whether he agrees or not on the proposed product and dates, and fills the respective fields in his own work package data sheet. He can also jump to the product form (Figure 6), which contains the complete data of the product or deliverable in general, and make the modifications there. The receivers can change only the receiver part of the form while deliverers can change only the deliverer part.

In Figure 4 the fields marked with an asterisk are automatically retrieved from the other party's work package data and cannot be modified here. The input/output product names contain URL links to the corresponding product forms. Similarly the work package codes of the deliverers and receivers contain URL links to their respective work package data sheets.

A product may have one of the following statuses:

- **Product not agreed.** Either the receiver or deliverer disagrees on a product's existence or description
- **Date not agreed.** The receiver and deliverer disagree on the delivery date.
- **Agreed.** The receiver and deliverer agree both on the product and the delivery date.

Once the status is changed to 'Agreed' the product form is considered as an agreement between the deliverer and the receiver. If one party changes an agreement the change must be reviewed and accepted by the other party. All changes to a once agreed delivery date are tracked by the system to measure the performance of the plan. Figures 7 - 9 show the input and output fields of the imaginary work packages presented in Figure 3. The corresponding fields of the work package WP2 are shown in the work package data sheet in Figure 4.

The system generates automatic messages to remind the users of the deliveries due in a specified time. When the due date has passed, the receivers are automatically contacted for confirming the reception of the planned receivables. The completion status of the product is thus one of the followings:

- **Under work.** The agreed delivery date has not yet passed.
- **Received.** Product received and the contract thus completed.
- **Missing delivery.** Product not received or did not meet the specifications.
- **Missing status.** The receiver has failed to confirm the delivery as "received" or "missing delivery".

The system will regularly produce reports containing the list of products with "Missing Status" or "Missing Delivery" to give the project management an immediate warning of possible problems. The system acts as a tool for delegating decision making and responsibilities to lower levels in the organization, thus allowing management to focus on monitoring and controlling of the interfaces between work packages rather than on individual work packages. However, in the installation phase, the system may prove less useful because the different phases are much more coupled and dependent on the same resources, such as space, cranes and other tools.

Conclusions

The paper has described the structure of the planning and scheduling system for the CMS project. The system mainly relies on procedures generally used in the management of large-scale projects. However, it also contains some recently developed and innovative, but less known, features to distribute the decision making and responsibilities to lower levels in the organization. It provides effective tools for managing the interfaces between the activities of a large-scale distributed project, and thus simplifies the planning and management process and eliminates the need for a large, centralized project management system. The system is more applicable to the construction phases of the subprojects than for the installation phase of the project, which requires a more centralized planning.

Final conclusions on the applicability of the distributed work package management approach are too early to be documented as the prototype is about to enter production use. Yet, the results from the piloting have been encouraging and sets the future prospects high. The intuitive nature of managing work packages through their natural links via the deliverables to be produced has been accepted. As the underlying project is globally distributed the natural medium to manage the information is World Wide Web (WWW), which makes the system accessibly through various platforms. As the WWW is based on links the basic routine to manage the work packages exists inherently in the system, yet the connection with proper data bases have been built to provide adequate storage and search facilities.

From the industrial point of view the case presented sets an interesting approach for projects which have not been repeated earlier, i.e. they are customized, complex, large-scale, distributed and one-off. Apart from projects aiming to construct massive and highly sophisticated scientific instruments, the major infrastructure works and new product development projects are most likely the ones that could benefit the approach or parts of it. Also the applied procedure with its self-organizing nature to connect work packages provides the management with a mean to analyze the interrelationships among various partners and this way to improve the lead-time of the project by pinpointing concurrent and parallel tasks more easily.

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International Research Project PM-Benchmarking: Benchmarking of The PM-Process

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If project management is perceived as core competence of the project-oriented company, project management-competence (pm-competence) has to be continuously improved. Within the Research Program: Best PM-Practice a process-oriented project management-approach is developed. Project management can be perceived as a business process consisting of the sub-processes project start, project controlling, and project close-down. The quality of these processes can be described and deliverables can be measured. Project management-benchmarking is applied as an instrument of the further development of the pm-competence. This paper summarises results of previous projects within the Research Program: Best PM-Practice and introduces the International Research Project: PM-Benchmarking.

Introduction

Since April 1996 the Projektmanagement Factory at the University of Economics and Business Administration, Vienna and Projekt Management Austria, the Austrian Project Management Association representing Austria in the International Project Management Association (IPMA) have performed the Research Program: Best PM-Practice.

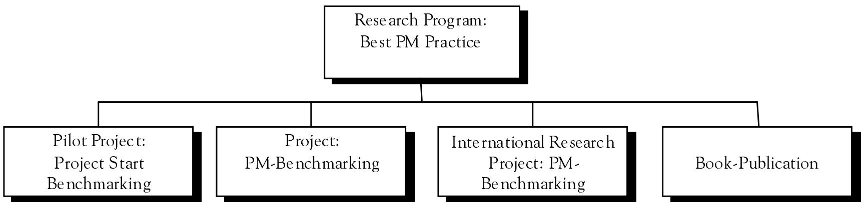

Figure 1. Structure of the Research Program: Best PM Practice

The objective of this research program is the development of a process-oriented project management approach. In a pilot-project a model to benchmark the project start process was developed. Considering the experience gained in this project, the project controlling and the project close-down process were developed. The benchmarking was performed in 1997 and 1998 with the following companies: Asea Brown Boveri AG, Austrian Energy GmbH, CA-IT GmbH, Digital Equipment Österreich AG, Fachhochschul-Studiengänge Vorarlberg, Interunfall Versicherung AG, Trodat Werke Walter Just GmbH & Co KG, Unisys Österreich GmbH, Voest-Alpine Industrieanlagenbau GmbH.

Objectives and Structures of the International Research Project: PM-Benchmarking

The objectives of the International Research Project: PM-Benchmarking which was launched in March 1998, are the benchmarking of the pm-processes of the benchmarking-partners, emphasising the project start, project controlling and the project close-down process. The pm-competence of the benchmarking-partners is compared with the "Best PM Theory". This will contribute to the further development of the pm-competence of the benchmarking-partners as the methods and tools applied support organisational learning of benchmarking-partners. Moreover the process-oriented pm-approach is further developed and an international data-base of pm-competence is established.

As benchmarking partners project oriented companies or business units from all industries and from public administrations interested in the further development of their pm-competence are invited. In order to make benchmarking-results more evident, systems with the greatest homogenous pm-culture are defined. In the case of huge enterprises only a restricted business unit is considered. When dealing with benchmarking-partners with a homogenous pm-culture the whole enterprise is studied.

Benefits for the benchmarking-partners are the improvement of the competitive advantage by further developing the pm-process, learning about the process-oriented pm-approach, the

2) How often does the project controlling process take place?
(Please complete all boxes.)

always = 1 often = 2 sometimes = 3 seldom = 4 never = 5	medium complexity	high complexity	
Every 3 weeks			(390/391)
Every 6 weeks			(392/393)
Every 8 weeks			(394/395)
If required			(396/397)
Other (please add: ....) (340)			(398/399)

Figure 3. Example of the benchmarking-questionnaire

"Best Theory" and application of the systemic-constructivistic research approach. The benchmarking-partners receive feedback to their pm-documentation and can cooperate with leading project-oriented companies in the benchmarking-week.

The cooperation is organized in different team structures as shown in the project organization chart Figure 2. The role of the project manager is the overall project coordination and moderation of the pm-benchmarking weeks. The benchmarking-team is responsible for the development of the pm-benchmarking tool, the analysis of the pm-documentations of the benchmarking-partners, the evaluation of the benchmarking results and the preparation of benchmarking reports. Each benchmarking-partner is represented by 2-4 pm-experts (owner of the pm process, project office manager, senior project manager, ...). The benchmarking-partners provide pm-documentation and participate in the benchmarking-week and reflect the benchmarking-results.

The project manager, the benchmarking team and one coordinator of each benchmarking-partner form the project team to coordinate the overall project. The communication in the project team is organized in workshops and is supported by e-mail and tele-conferencing.

Research Approach, Working Methods and Tools Applied

The research approach applied focuses on the perception of projects as social systems. The social system theory implies the use of qualitative research methods, such as documentation analyses, self-assessments, workshops, and reflecting team work. (Projektmanagement Factory, 1997; Projektmanagement Factory, 1998). The focus is on the generation of hypotheses regarding the performance of the pm-process and their interpretation rather than on hypotheses testing. The validity criterion for constructions of reality and therefore also for scientific models is "viability". It can not be the extent up to which the model matches reality as the latter can not be perceived entirely. Viability does not mean "true" or "false", but comprises the explanatory and prognostical potential for the research question itself and the potential for further development in the sense of new questions or application in other research areas. Viability itself is also a social construction. The validation of scientific models is a matter of consensus within the scientific community. Research there-

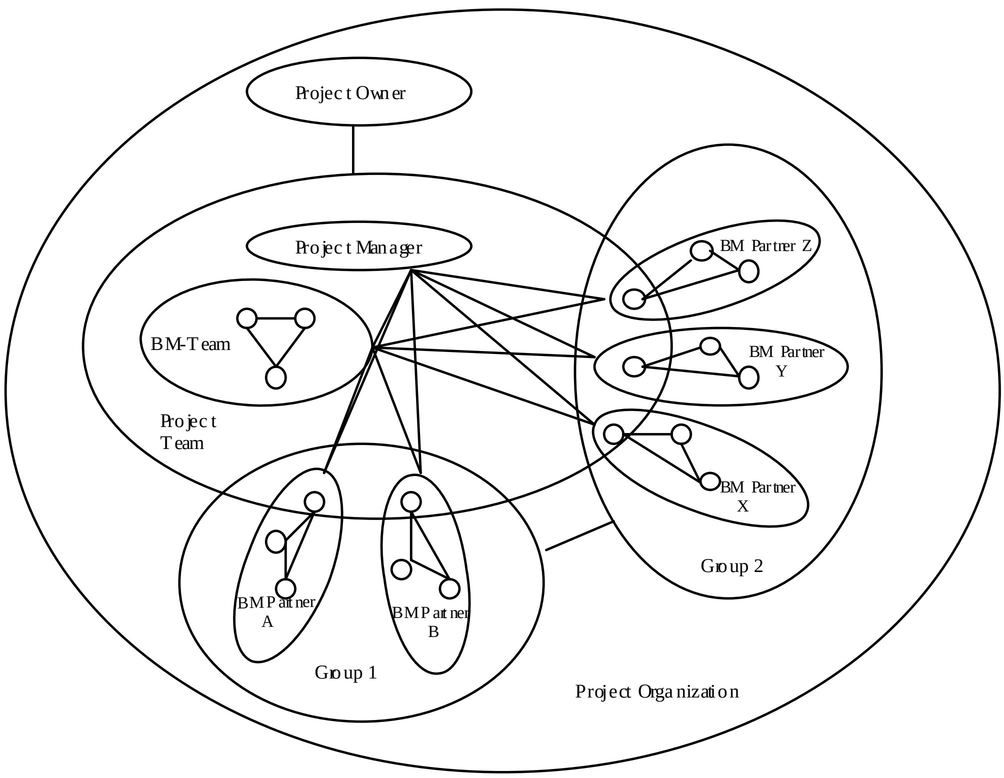

Figure 2. Project organization chart of the International Research Project: PM-Benchmarking

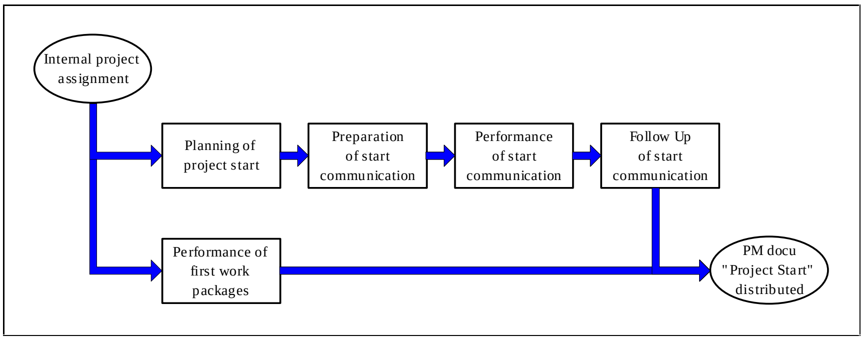

Figure 4. Structure of the project start process

fore requires the exchange within the scientific community.

While traditional benchmarking-approaches tend to neglect the possibility of an open mutual learning of organisations, the benchmarking-approach applied tries to support the organisational learning attempt by using interactive methods and different team structures (Huemann, Winkler 1998). Only working forms that support communication of the collective support organisational learning. Senge (1994) states "Unless teams can learn, organisations cannot learn". For data collection and analysis qualitative research methods are applied. Central tool is a questionnaire, containing measurement criteria for the results and the design of the pm- processes.

The questionnaire serves as the basis for the self-assessment of the benchmarking-partners. The self-assessment is observed by the researchers using the reflecting team method. Further information is gained in analysis of project management documentation and participating observation. In workshops the pm-practices of all benchmarking-partners are compared with each other and reflected according to the "Best Theory".

Process-oriented Project Management

If project management is considered as core competence of project-oriented companies, it has to continuously improved. Project management can be perceived as a business process, consisting of the sub-processes: project start, project controlling, project close-down. The quality of these pm-sub-processes can be described, resulting outputs can be identified. Thus pm-quality can be measured! Further more project phase transfer, project crises resolution may be part of the pm-process.

Following the project start process is described as an example. The project start has to be planned, start-communication, such as kick-off meetings, start workshops with the project team and with the project owner, have to be prepared and performed, the project plans have to be documented and distributed.

In the project start process following objectives are pursued: The project is established as a social system, a common "Big Project Picture" is constructed. The know-how from the pre-project phase has to be transferred to the project. Adequate project plans and adequate project organisation have to be designed. The project team is established and adequate project culture is developed. Project objectives are agreed on. A project management documentation is drawn up. First project marketing activities are planned and performed. Finally, an efficient performance of the project start process should be ensured.

The design of the project start process determines the results. Those have an impact of the project results and in further consequence the benefit caused by the investment initiated by the project. The design of the project start process depends on the complexity of the project and not on the type of the project or the industry of the considered project-oriented company.

The "Best Theory" in Project Management

To make the project management of different project types like contracting projects, engineering projects, IT-projects, organisational development projects, marketing projects, comparable, it was agreed to use complexity as category. The benchmarking-partners were asked to consider two categories of complexity (medium and high complexity). Criteria used for constructing complexity from the researchers' point of view are: strategic relevance, interdependency and variety of work packages, dimensions (costs, duration), openness of results, relations to environment and risk of acceptance.

How a project is perceived in a company, whether it bears medium complexity or high complexity influences project management, for instance, the use of project management tools, the selection of the project manager, communication forms of the start-process. But as complexity is a matter of construction, it might be perceived differently from company to company. In order to make evident how the various benchmarking-partners preceive complexity, they are asked to describe typical external and internal projects of their enterprises with medium and high complexity and name their basic criteria of complexity.

To offer the benchmarking-partners a benchmark to compare with, the "Best Theory" for performing project management processes was developed. The "Best Theory" is a construction created in a communication process of the participating researchers. On the one hand findings from literature and on the other hand project management and consulting experience were considered. Objects of consideration were all possible types of projects, a differentiation in projects of medium and high complexity was made. The Best Theory distinguishes in must criteria, can criteria and absolute no-no criteria.

Exemplary Results of the Research Program: Best PM-Practice

The International Research Project: PM-Benchmarking can build up on results and experience gained in previous benchmarking projects carried out within the Research Program: Best PM-Practice. The evaluation was carried out following the structure of the benchmarking-questionnaire. In the evaluation of benchmarking results, interpretations regarding each benchmarking-partner as well as interpretations regarding the industry are made. The interpretations according to industry only consider the benchmarking-partners and do not make a valid statement about the whole industry.

Following the evaluation of three questions considering projects of high complexity are described briefly, (Projektmanagement Factory, 1997; Projektmanagement Factory, 1998).

Question: Which documents of the project organisation are results of the project start process?

- The internal project assignment is almost always a result of the project start process. The frequency of preparing documents of the project organization increases according to project complexity.
- Project organization chart, description of project roles, responsibility matrix are partly not drawn up in the start process, but standards written down in the pm-guidelines are used.
- Benchmarking-partners from the constructing and IT-industry more often prepare documents of the project organization. The frequency of preparing documents of the project organization depends primary on the pm-culture of the enterprise.

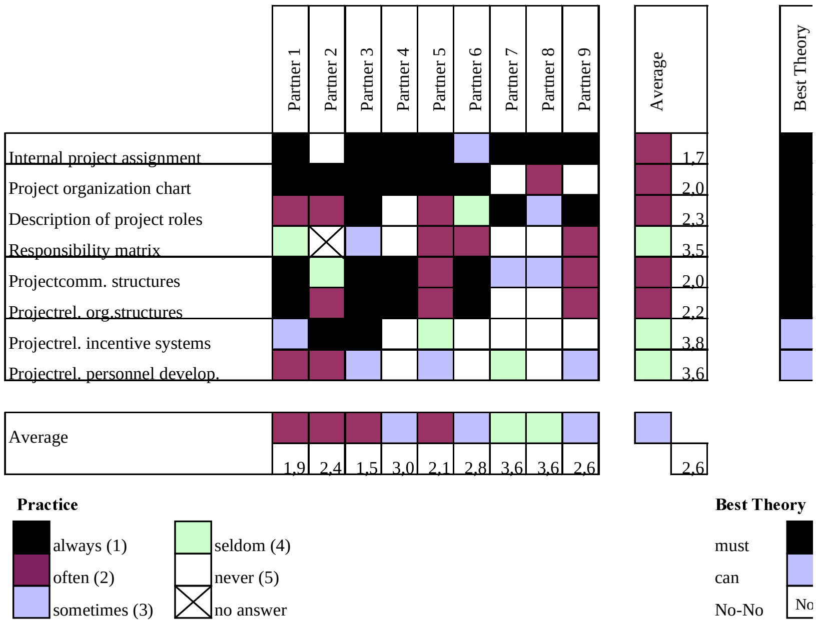

Figure 5. Exemplary result of the project start process (project organisation)

Question: Which project planning documents result from the start process?

- Considering projects of high complexity the listed plans are on average often (2,3) results of the project start process of the benchmarking-partners. Considering projects of medium complexity the listed methods are on average sometimes (2,8) used.
- Some methods (project mile stone list, project list of dates, project gantt chart, project cost plan) are used "always" to "often" (1,5 - 2,0) by all companies where as other "softer" planning methods (project scenario analysis, CPM diagram) are "sometimes" to "never" applied. Considering projects of high complexity there are deficits in the application of "soft" planning methods in comparison to the "Best Theory".
- Benchmarking-partners from the constructing industry generally apply more methods in comparison to other industries, especially in comparison with service industry.

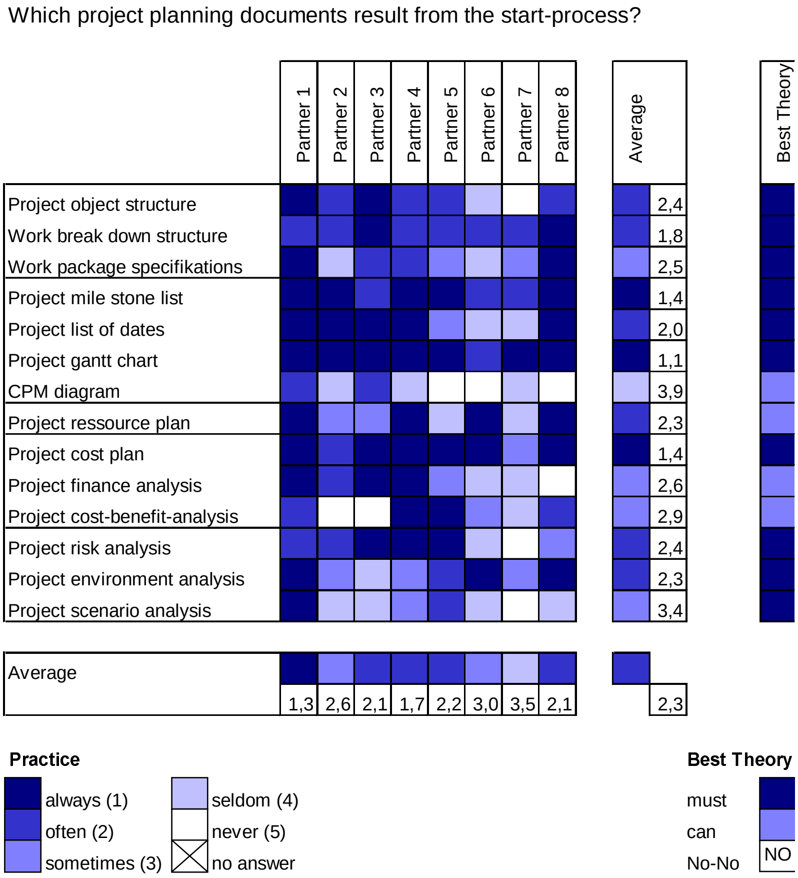

Figure 6. Exemplary result project start process (planning documents)

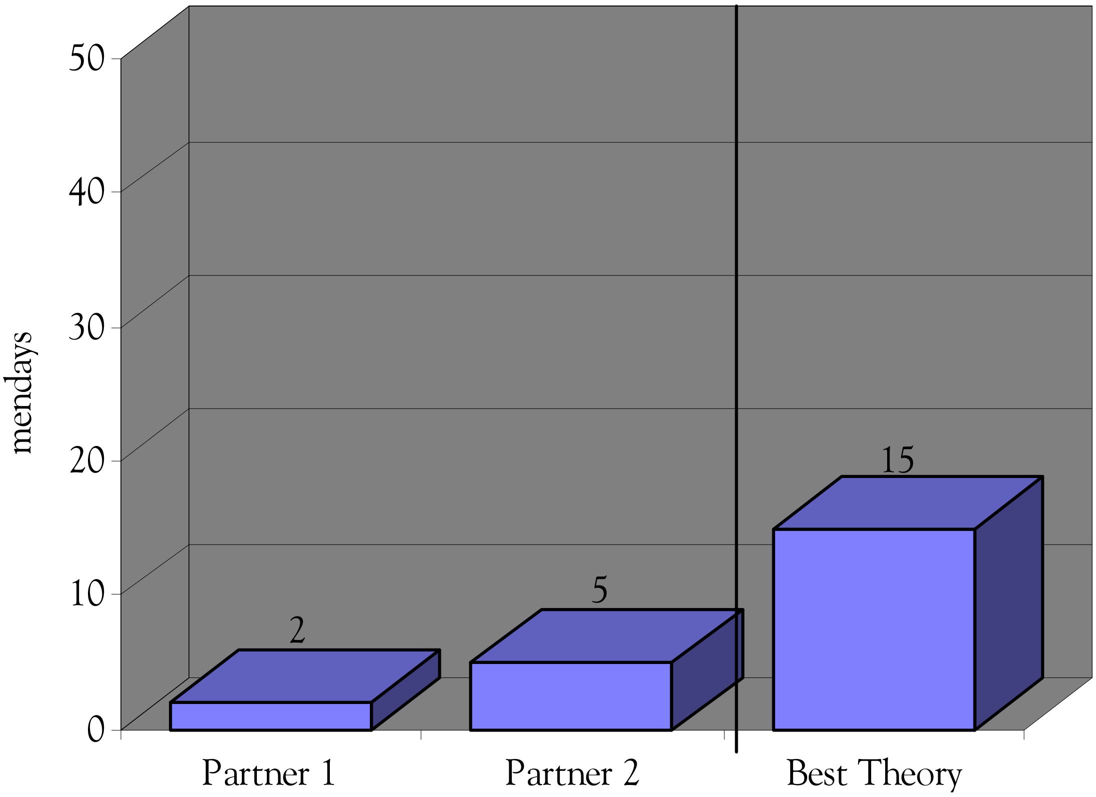

Figure 7. Exemplary result project controlling process

Question: How long does the project controlling process take?

The differences to the "Best Theory" can be caused by a different understanding of the project controlling. It is argued that there should be more team work in the controlling process while the benchmarking-partners do not have such a high involvement of personnel relying almost only on technical support possibilities.

Summary of Central Findings

Following summary of the most significant findings provides an overview of the benchmarking-results of the research (Projektmanagement Factory, 1997, Projektmanagement Factory 1998).

Findings Regarding the Project Start Process

- Regarding project planning methods, the benchmarking-partners primary use methods for project cost planning and project time planning (gantt chart). Project environment analysis and scenario analyses are seldom used. In projects with a high project complexity there are partly deficits to the "Best Theory", which recommends the use of "soft" planning methods.
- Regarding the project culture, the benchmarking-partners concentrate on the use of a project name. Social events and a project logo is more often used in projects with high complexity, but not often enough compared to the requirements of the "Best Theory".
- Explicit project marketing is only very seldom performed by the benchmarking-partners. The tools are often limited to informal communication or the use of standardised communication structures. "Creative" tools such as project presentations or project exhibitions are seldom used. The project marketing activities are primary addressed to internal target groups and customers.
- As forms of communication in the project start process primary single meetings and kick-off meetings are organised. Workshops for developing a "Big Project Picture" are in projects with medium complexity rather exceptions.

Findings Regarding the Project Controlling Process

- The benchmarking-partners primary collect time and cost related data for the project controlling, while social data (project culture or relations in the project team) are seldom considered.
- The project owner is integrated in the project controlling process. Objectives are agreed on with him, he entrusts the project team with the project controlling process. The role "project owner" will gain further importance in the benchmarking-partners' companies in the near future.
- Documents concerning objective, performance, time, resource and cost planning are very often adapted in the project controlling process, while documents for designing the project organisation are rarely adapted in the project controlling process. An exception is the project handbook, which is always adapted.
- The communication and the collection of the data in the

- project controlling process are mainly organised in single work forms. Team work enriches communication only from time to time.

Findings Regarding the Project Close-down Process

- Assessment of the project team members and the project owner is mainly made by feedback of hierarchically higher ranked persons or it is not made at all.
- The emotional project close-down is always performed as a social event (e.g. close-down-dinner), even in projects with medium complexity.
- A final project report is always drawn up and in most cases adapted for different target groups. The final project report is kept short but enclosures and reports of the project contents are often added to.

Relationship between the Project Management Sub-Processes

Based on the evaluation of the questionnaire following findings concerning the relationship between the project start, project controlling and project close-down were perceived:

- Investments in the project start process have to be perceived as investments in the whole project! A higher expense and use of capital and resources in the project start process to draw up the documents for project planning and organisation create benefits for an efficient performance of the other project management processes. E.g. if a detailed project environment analysis is result of the project start process, it can be well used in the project controlling and the project close-down process.
- The results of the project start process are the basis for the project controlling and the project close-down process. The project start process can therefore be perceived as the most important process concerning the impact on the further performance of the project.
- In the project start process a conscious differentiation between projects of medium and high complexity is made. Here the differentiation is made by the different use of the methods or the use of different methods.

Conclusion

Within the Research Program: "Best PM-Practice" the Projektmanagement Factory of the University of Economics and Business Administration Vienna and Projekt Management Austria have developed a process-oriented pm-approach. The pm-process consists of following sub-processes: Project start process, project controlling and project close-down process. These sub-processes are seen as interrelated, whereby the start process can be perceived as the most important one. By defining the deliverables of the pm-process, pm becomes measurable and thus the pm-competence of the benchmarking-partners can be further developed.

Organizational learning of the benchmarking-partners is supported by using interactive methods, by building win-win situations for the benchmarking-partners to give mutual learning chances and by providing a theoretical input, which is called "Best Theory".

The difference to the "Best Theory" can be perceived clearest in the project start process. The project controlling process is often performed by the benchmarking-partners following the "Best Theory", in the project close-down process again more differences are visible.

Further benchmarking projects are planned to further improve the process-oriented pm-approach and to develop a pm-competence model.

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Project Management by Results

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Keywords: Project Objectives, Technical Result, Management by Results, Forecasting

The focus of project management is analysed. The basic lead is a principle of management by results. The simple idea of managing the few basic results by updating forecasts is emphasised. The term technical result of a project is defined in a novel way to conform to project product. The customer requirements specified in a contract are a simple result-oriented notification of the basic goals for the project to aim at.

Project management should be a future-oriented and proactive way of planning, controlling and forecasting of the technical results of the project and to deal with time and costs as framework and constraints within which the technical result needs to be achieved.

A power plant project case is analysed where the presented principles of project management practices have been used with good results.

Introduction

The purpose of this article is to analyse and clarify what project management should focus on. The basic lead is a principle of management by results. The simple idea of managing the few basic results by updating forecasts is emphasised. Further, corresponding principles with good results in case of a major Finnish power plant project is introduced, highlighting problems and development needs with current project management practices that are in accordance with the suggested line.

Over the about last ten years remarkable progress in developing the project management practice has been made by producing quality guidelines (ISO, IEC, BS), by elaborating relevant knowledge areas by project management organisations (PMI, AIPM, IPMA, APM) and not the least by producing vast number of articles in various magazines specialised in both theory and practical cases of project management.

The authors of this article don't want to underestimate the potential impact of many interesting extensions and modifications of the project management discipline, but on the other hand the authors require a search for a plain and simplified methodology sticking to forecasting and managing the end results of a project. On the background of this suggestions is the authors' feeling based on their experience that project management standards (e.g. PMBOK 1996, ISO 10006, 1997) or project managers' certification bases (e.g. PMAF 1997, APM 1996) represent a risk that:

- A newcomer faces a major problem in trying to find the clue in project management. Processes emphasised from various viewpoints seem to hide the clue that only the results in the end matter,
- A less experienced project manager may also lose the clue by managing his or her project with a set of processes not pertinent to the required results. We have to remember that a project always represents a change in the organisational structure despite whether the structure of the originating organisation was project oriented or traditional line organisation. A project manager needs to find clarity in the jungle of various organisational views; management processes and result requirements both those of the originating and the project organisation. Should the project manager be unable to guide his or her project onto the right track in the very beginning then it mostly turns out to be fatal in respect of the outturn results.

Another classic solution also exists to the above problem; to find the right path in a jungle, find out what the customer requirements are. Mostly, the contract contains rather clear requirements to what needs to be accomplished; scope and the relevant specification with quality and performance requirements, allowable costs and time frame. This applies also to company internal projects and makes also the point that you should have a contract with your internal customer although the company tradition or current practice did not require it. The contract is always a simple result-oriented notification of the basic goals where to aim at. Focusing on results by using the contract as a yardstick enables laying a glimpse to the future with a strong emphasis on customer orientation inherent. The target defined by the contract may then be used as a basis where continuously produced forecasts during the project life cycle can be compared to.

A review is needed about the current status of the management processes and techniques in respect of whether they overcome the hurdle; forecasting the outturn result and management by end results and are thereafter qualified for long term use. Also ISO 10006 (1997) lack proper emphasis on this requirement.

Focus on Results to be Achived

The new international standard ISO 10006 (1997), Quality Management - Guidelines to Quality in Project Management, defines a project as an "Unique process, consisting of a set of co-ordinated activities with start and finish dates, undertaken to achieve an objective conforming to specific requirements, including the constrains of time, cost and resources". Further the standard defines that "Project management includes the planning organising, monitoring and controlling of all aspects of the project in a continuous process to achieve its objectives".

The project product is in the standard defined as "That, which is defined in the project product scope and delivered to the customer". The scope-related processes are:

- concept development
- scope development and control
- activity definition
- activity control

In ISO 10006 the ultimate result of the project, i.e. the project product is managed by procedures called development and control of the scope. It is said that "the characteristics of the project product should be identified and documented as completely as possible in measurable terms for use as the basis for design and development".

The standard presents ten groups of project management processes that corresponds to the knowledge areas of other presentations of the overall context of project management such as that of Intercert International, Association for Project Management APM in UK and Project Management Institute PMI in USA. Planning and controlling are emphasised in the processes, all of which, in general terms, focus on the review on the present status of the project and the conformity with the plan in terms of time, cost and scope. In general, the project management literature describes the project management in a similar way.

The authors' opinion - based on practical experience in project management - is that a key core process structure of project management should rather be the more future-oriented and proactive way of planning, controlling and forecasting of the technical results of the project and to deal with time and costs as framework and constraints within which the technical result needs to be achieved.

Technical Result

Definition of a New Concept of Technical Result

The importance of managing by the end result or objectives related to the project end product were emphasised above. We define the term technical result of a project to conform to project product. The technical result is determined by the scope of supply, the product quality and the product performance. The quality includes the conformity of the product with the requirements of environment, safety, availability and maintainability.

Project Technical Result Objective

The ultimate results of the project on the finish date when time and cost are known are covered by the objectives within the technical result. These requirements are (see Figure 1): scope of supply, product quality and product performance. The final quantitative scope of supply is usually described in the as-built documents. Product quality includes the conformity of the product with the requirements of environment, safety, availability and maintainability. The performance of the product is usually of primary interest of the customer. The performance will be measurable at the end of or after the finish date of the project. The ultimate technical result should be of primary importance in the project management processes of planning controlling and forecasting during the execution of the project and the forecasting should be emphasised.

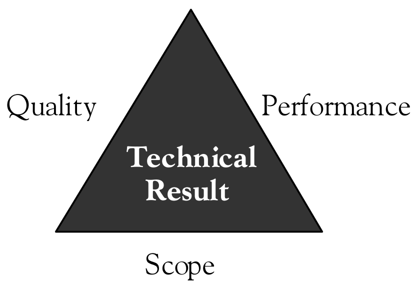

Figure 1. The technical result: scope, quality and performance

As a new concept of technical result was introduced and defined above, it is obvious that the new concept and related management procedures may get intermixed with some other resembling and well-known, but still different concepts and methodologies. According to the authors' opinion it is worth noting that the term configuration management should not be used for planning, controlling and forecasting the technical result. The use of configuration management in this context would be misleading, because the term configuration management in general refers to management practices related to change control of technical or other specifications combined with documentation control practices. For definition of configuration management, the interested reader is advised to consult e.g. Turner 1993, Archibald 1992, Cleland 1994, Dinsmore 1993, Kerzner 1995, Kezsbom, Schilling, Edward 1988, Morris 1994 and the basic documents such as US Air Force Systems Command Manuals AFSCM 375-1 1965.

Project Constrained Objectives

The project management and the project objectives to be achieved are illustrated by the technical result of Figure 1 supplemented by another core triangle: constrained objectives triangle, Figure 2.

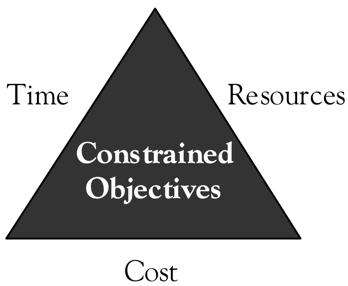

Figure 2. The constrained objectives: time, cost and resources

The time, costs and resources objectives are considered as constraints in project management standards (e.g. ISO 10006). The time objective is typically present as a time window, the start and finish dates of the project or even as a target subjected to penalties. The cost objective might also be present as a maximum acceptable cost limit. Then the forecasting tasks concerning the constrained objectives - i.e., time, cost and resources - will be to fulfil the boundary conditions of time and cost by using the right amounts and quality of different resources. Essential for the reliability of forecasting the constrained objectives is the quality of the project management processes.

The general empirical experience and experienced cases of several real-life projects are in the background of the above-introduced concept of the objectives and how they should be interpreted and used in project management. The proposed concepts and principles are first analysed from a theoretical perspective in the following. Then, a case project is later analysed to show the applicability of the concept and to shed light to the suggested principle of managing the technical result. Further, the aspect of simultaneously managing of the constrained objectives is discussed.

Technical Result and Constrained Objectives in Relation to Existing Theory

The overall construction of project objectives introduced in Figures 1 and 2 are analysed in the following by comparing it to how project objectives are outlined in existing basic literature.

Kertzner (1995, pp. 5-6) states that project management is designed to manage or control company resources on a given activity, within time, within cost, and within performance. Time, cost, and performance are the constraints of the project. If the project is to be accomplished for an outside customer, then the project has a fourth constraint: good customer relations. Kertzner focuses on the control of the company resources. The interesting concept in Kertzner's terminology is performance, which is not specified further in the context of the discussion, referred to. As Kertzner raises the term 'technology' while discussing performance, it is obvious that Kertzner might include aspects of project end product characteristics to what he calls 'performance'. In such case, Kertzner's performance might include some aspects of our concept of technical result analysed in Figure 1. However, it is obvious that Kertzner's performance includes aspects of efficacy of project work as well. We would like to conclude that the presentation is not clear in respect to our framework of project objectives in Figures 1 and 2. However, Kertzner's way of defining constraints differently brings the managerial focus on project process - or managing company resources - to a focal point, whereas our focus in defining the project objectives and project management rather emphasised the technical result as the end state. In our model own company's and partner's resources are utilised by the project along with the other constraints of cost and time to achieve the final technical result.

Turner (1993, p. 11) argues that project management is based on managing five project objectives. The five objectives are scope, organisation, quality, cost and time. Turner states also that the traditional approach focuses on the quality, cost and time objectives, which are traded against each other to achieve the optimal outcome. Turner illustrates the interrelation of the five objectives with a pyramid with organisation as the object which integrates the four other objects of scope, quality, cost and time. Turner (1993, p. 8) defines project as "an endeavour in which human, material and financial resources are organised in a novel way, to undertake the unique scope of work, of given specification, within constraints of cost and time, so as to achieve beneficial change defined by quantitative and qualitative objectives". We agree with the definition of constraints of time and cost. However, the interesting point to analyse is to compare Turner's definition of the scope and quality objectives in relation to our 'technical result'. Turner's 'scope' clearly includes aspects of the 'scope of work' and 'technical scope defined in the specification'. The latter relates to our 'technical result' concept, but our overall objectives model determined by Figures 1 and 2 assumes not 'scope of work' (project process) being any separately defined objective. Turner's 'quality' refers on the other hand to technical scope (the quality of the project product), which is included in our technical result concept, but on the other hand Turner's quality refers also to scope of work (project process). Although we consider project process of how the work is done important, this aspect of quality is not included as a separate objective in the model of overall objectives. The project process with all quality aspects inherent is assumed to be included in the constrained objectives side.

Finally, Turner (1993, p. 11) states that "the term performance is sometimes used to cover scope and quality" which refers to the fact that the technical result and project work is intermixed and defined jointly under same objectives without disseminating apart these objectives that clearly are of different nature. This controversy could be noticed also from Kertzner's definition discussed above. We argue that the 'technical result' concept is justified as it is important to separate these different end product and work related concepts in project objectives. Our solution is to present the work related concept in the constrained objectives side of project objectives. Further, with the 'technical result' more result-oriented implications can be conveyed to project management practices than in the scheme where the project work is intermixed with the result.

The technical result oriented project management is supported by the recent studies of Jaafari (1998) and Jordanger (1998). Both authors criticise managing the project by traditional objectives of time, cost, and quality. Jaafari suggests a proactive project management approach for today's commercial environment. The approach is based on having life cycle objective functions in management. Examples of such objectives are net present value and total life cycle cost (LCC). Jaafari suggests an application based on a managing of the project scope or configuration by terms of functions, properties, and interdependencies. Jordanger's suggestion for a project management practice also emphasises life cycle perspective, suggesting that net present value be used as a yardstick. Further, Jordanger's study puts customer's value chain in a central position with a priority in the operation phase and life cycle cost of the project product. The conclusion drawn here is that both Jaafari's and Jordanger's life cycle aspect and customer's value chain aspect are reflections of the technical result. The economic measures of life cycle cost (LCC) and net present value reflect in economic terms what can be gained with aiming at and producing an appropriate technical result by the project.

Implications to Project Management

It was suggested above that primarily the technical result should dictate and boost proactive and future-oriented management principles and the constrained objectives should be considered as framework in this scheme. The implications and aspects of applying such management principle are analysed in the following.

Project Management Institute's (PMI's) definition about project management knowledge areas describes project management practice in terms of its component processes (PMBOK 1996). These processes have been organised into nine knowledge areas. Also the recent project management quality guideline (ISO 10006, 1997) provides ten project management processes similar to that of PMI. The project scope management and quality management - or scope and quality related processes - could be thought of to cover at least some aspects of the management by results area intended in this article. However, description of these areas in ISO and PMBOK still lack the focus and implicated management practice introduced here, which makes it difficult to evaluate the position of this management by results in the overall project management discipline defined in those standards.

Given several project management knowledge areas and processes introduced in standards such as e.g. ISO and PMBOK, criticism exists that in practice too much focus is put to especially time but also to cost management area. Turner (1993) considers historical and other background factors that might cause the phenomenon why project managers may have heavy focus on time; According to Turner, the reasons might be the following:

- The systems for controlling time (networks) are the most advanced
- Project managers have greater control over time than cost or quality
- Time is the most visible objective
- Time is inherent in the make-up of people who make good project managers.

Some projects are especially critical in terms of time. In such projects, timely planning and time management becomes important. A good example of time criticality is that many new product development projects have introduced time-to-market objectives. In many traditional branches - e.g., in construction - cost management and cost engineering with low price solutions come to the first place.

The authors suggest a key core process structure of project management should be the proactive way of managing the technical end result of the project. Implementing forecasting results to responses which often means that changes in design and planned scope occur during the project implementation. Thus, change management is a significant process related to the management of the technical result. Change management includes design reviews and freezes and handling of change requests.

Meri-Pori Power Plant Project

The Project

Meri-Pori Power Plant project was implemented during the years 1990-93. Meri-Pori is a coal fired 565 MW power plant situated in the west coast of Finland, Figure 3. The plant and the project have in 1994 been honoured with a power plant award "For evolutionary improvements in conventional steam-cycle technology with state-of-the-art emissions control, and full recycle of SO2-scrubber by-products into other industries". The technical result of the project was better than originally required by the customer. The constrained objectives time and cost were achieved and in case of cost even lower than the original requirements of the customer.

The power plant project was a joint investment of the power companies Imatran Voima Oy (IVO) and Teollisuuden Voima Oy (TVO). IVO is state-owned and TVO is owned by the Finnish industry, mainly the pulp and paper industry. The project was supervised by the investors and governed by contracts between IVO and TVO and by contracts between the parties customer and supplier within the company IVO. The Engineering division of IVO was the supplier, performed the EPC-project, and the Energy division of IVO the customer together with TVO. The supplier acted with turnkey responsibility. During the project the Engineering division was organised to become a separate EPC-contractor company on the international market.

A new power plant is a huge investment. The implementation time must be short and the specific costs low to get a feasible project. It should be noted that according to the statistics of Unipede/ Eurostat/ Sener the electricity prices in Finland have remained the lowest or close to the lowest for a long time.

Constrained objectives

Time

The master time schedule of the Meri-Pori project was developed during the feasibility phase and was fixed when the main equipment was ordered and the implementation phase started. The time-related processes of the EPC-project were straightforward: The mas-

Figure 3. Meri-Pori Power Plant

ter time schedule with all the important milestones was frozen and the detailed schedules needed for the time management were developed within the fixed time frames of the master time schedule. The schedule control 'activities on schedule' and the forecasting how identified risks might influence on the schedule were related to the milestones of the master time schedule. Forecasting was emphasised, which mainly was the estimation of the duration of the remaining activities to be able to achieve the ultimate date: start of production.

Cost

The specific costs of the power plant, investments FIM/kW and production FIM/kWh (Finnish currency FIM to the power rate kW and to the energy rate kWh) were basic requirements of the customer for the project and input data for the technical development of the plant concept during the feasibility phase. The requirements were transferred to the implementation phase and to the original budget of the EPC-project and subject for the forecasting. The customer and the supplier handled the costs as 'open book', so the savings in the budget were not added to the profit of the supplier, but improved the profitability of the new plant for the investors.

The Meri-Pori project established a platform for the cost-related processes: implementation plan, WBS, list of planned procurements and a time-phased budget with a task structure corresponding to the previous items.

Forecasting future costs was one key-issue of the monthly meetings of the project team. The progress and the remaining works were evaluated in a way similar to the earned value method, but only by defining the interrelations between time, cost, and achievements by reasoning. A practical tool was a graphical project cost status report on different levels of the WBS. The discussion, mutual understanding and commitment by the project team of the cost status and forecast are important. The cost status reports in time scale and in combination with the evaluation of the progress of the works and the risk response development were the basic information and tools used by the project team members for the forecasting of the final costs. The specific investment cost without interests of the Meri-Pori plant was about 600 USD/kW, which was a low figure and 15% under budget (an accurate figure is difficult to calculate, because main parts of the costs were in FIM, DEM and JPY). The result of the objective cost confirms the importance of forecasting in project management.

Costs are related to the technical result. The technical result will be discussed in the next section. Two kinds of costs shall be forecast: investment cost and operational costs. The fuel costs can be seen as input data for the calculation of the specific costs and then forecasting is focused on the performance (efficiency) of the plant. The other costs of operation and maintenance (O&M), e.g. personnel needed, are object to forecasting. The total staff of the Meri-Pori plant is 37 people - even the double would be a low figure.

Resources

The resources must be managed to be able to run a project 'on schedule, under budget'. Also here the forecasting was important in the project. The work within the company was executed according to the implementation plan and thus easier to predict than the works executed by subsuppliers. The quality of the work and management processes of the own company and of the suppliers and the skills of the persons are more important issues than the quantities to be considered in the forecasting. Compared to the original budget the Meri-Pori project used 20% less in-house working hours.

Technical Result

Meri-Pori is a condensing power plant. The product is electric energy supplied to the 400 kV grid. Net power output, efficiency and ability for efficient O&M are the essential parameters of the plant. In the Meri-Pori project the assessment of savings and additional costs in relation to the technical result was based on Life Cycle Costs (LCC). Performance and O&M related features were taken into account cost wise.

The requirements for the technical result were developed in the feasibility phase. Availability and maintainability and environmental requirements were included. The main technical parameters for the plant and for the main equipment were specified in a brief document named Technical Specification. The figures of this key document were confirmed by the customer and were attached to the contracts between the parties. An important issue was to have a thorough discussion with the stakeholders, to decide which are the driving parameters for the Meri-Pori project in order to freeze the figures for implementation. For the forecasting of the technical result it was necessary that the design bases and LCC criteria were decided on and keep unchanged. A more detailed specification of the equipment and plant processes was described in the documents: plant description, technical specification for purchases and in the implementation plan.

Forecasting of the Technical Result

The realisation of the technical result was achieved finally by deriving the results by design, procurement, construction, erection and commissioning activities. Similar activities were performed both by the own organisation and by the organisations of the subsuppliers. In the frame of a tight time schedule it was necessary to have overlapping activities.

The work of the feasibility phase must be properly performed. The technical specification and the plant description presented above served as the technical baseline for the project. The key issues were identified, which had an essential influence on the technical result. They were followed up and the final result was forecast in reviews during the project. Design reviews with freezing and change management were the main procedures to control the works.

Scope

The scope was briefly a well functioning plant, which fulfils the requirement developed in the feasibility phase, and engineering, procurement, construction, erection and commissioning of the plant. Essential tools for the forecasting of the 'well functioning plant' are the System Descriptions and the descriptions of the Operating Requirements.

Quality

Quality is a large range of technical requirements, but it will be only briefly presented in this article. The quality of the components and subsystems were planned, controlled and forecast with the target 'right level' to be in accordance with the requirements of e.g. performance and availability but also investment and O&M costs.

Performance

Deviations in the net power output were in LCC calculations of the Meri-Pori project valued four times higher than the specific investment costs. This means that 1% plus or minus in the performance of the plant was a very big figure. The performance depended of the quality and the proper design of the processes, equipment, mechanical systems, electrical systems and the automation of equipment, systems and plant level. There was simultaneous work on different technical disciplines in several companies. The management of interrelationships and interrelated technical systems and other entities was emphasised.

Forecasting the performance is a complex matter. To illustrate this, we take the plant efficiency and the turbine plant as an example. The plant efficiency is the electric power to the grid divided by the fuel power input. In Meri-Pori the turbine-generator set with auxiliaries including a turbine driven feedwater pump set was purchased as a package. Thus the turbine plant was a complete system, where the performance could be defined and measured according to international standards. The forecasting of the plant efficiency and net power output could however not be based on warranty figures only. For example the uncertainty of the results of the performance warranty measurement of the turbine plant could be about 1%, which is a bigger figure than required for the accuracy required for the forecasting. The project team using own calculation tools and information of the state-of-the-art of steam turbine technology evaluated the efficiencies of main components of the turbine plant delivery. In the same way the other main processes were analysed and the final performance forecast several times during the project.

The measured performance of the plant, even after three years operation has been better than the original requirements. The plant efficiency is 44% when the original requirement was 43.5%. However the performance warranty measurements of the individual main equipment have shown figures close to the unacceptable limits. We must admit that the accurate forecasting of the technical result was not an easy task. Deep technical knowledge is needed for the engineering judgement. This was however successfully performed in the Meri-Pori project.

Conclusions

Analysis of project objectives is conducted by resulting to a decomposition of project objectives where the technical result plays a central role. The technical result is introduced as a novel concept and its relation to constrained objectives is outlined. The technical result comprises scope of supply, product quality and product performance and the requirements of environment, safety, availability and maintainability. It is stated that the technical result is of primary importance and the constrained objectives of time, cost, and resources should be considered as framework objectives. The motivation for this suggestion is based on the fact that the technical result is the key issue of the customer. Project management should focus on the forecasting of the technical result. The constrained objectives of time, cost, and resources are also important and should be managed by professional planning, control and corrective actions.

Suggested 'project management by technical result' implicates customer orientation and strong orientation to proactive project management with the aspect of managing the future outcome rather than reviewing current state or past achievements. Thus, the importance of forecasting the result is emphasised in the suggested project management practices.

The Finnish Meri-Pori power plant project case was analysed. The case provided empirical evidence that the suggested project management scheme could be implemented with successful results.

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Disturbances In The Boundary of Product Development and Production Ramp-Up - A Case Study

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Key words: Technology Management, Product Development Integration, Project teams

The aim of this case study[1] is to find out reasons for projects' timetable failures and difficulties. For this purpose, disturbances were analysed during a specific new product development project and its production ramp-up stage. The project was analysed retrospectively by group and individual interviews. The study shows the process' critical incidents. The acknowledged problems in the project are classified as 1) disturbances in the project process and as 2) intergroup boundary problems between development and production teams. Although the approach of the study is purely descriptive the connections of empirical findings to theoretical constructs are also discussed. A method for product development audit to analyse and model strengths and weaknesses of realised projects is recommended.

Introduction to the field of study

The speed and flexibility of product development and its implementation have been regarded as important factors contributing to the economical success of the new product. Decreasing the time spent for introducing new products requires the management of several different functions (e.g. product design and production) simultaneously to the same direction. Very often product design projects, however, fail to keep their timetables and achieve the speed wanted. It seems that much of the delay in product development comes from the difficulty in co-ordinating the efforts of various groups. In a study of boundary activities (Ancona & Caldwell 1990), it was found out that high-performing product teams interacted more frequently than low performers with manufacturing, marketing, R&D, and top division management during all phases of product development. Another study (Nihtilä 1996) reviewing earlier studies on successful and unsuccessful new product design projects highlights the importance of integration between R&D and customers, between R&D and marketing as well as between R&D and manufacturing. Other factors mentioned in earlier studies were: understanding customer needs and adequate bi-directional communication channels both within the project team and between the team and rest of the organisation. The overlap between the different development phases and the cross-functional team approach were regarded as two fundamental and intertwined elements of integrated new product design (Nihtilä 1996).

Large R&D departments are typically matrix organisations, hybrids of functional and project organisations - such is also the case under scrutiny. Each individual is linked to others according to both the project they work on and their function. Hayes et al. (1988) call two variants of the matrix organisation the heavyweight project organisation and lightweight project organisation. A heavyweight project organisation contains strong project links, and the project manager has a high authority, for example over the budget. A lightweight project organisation contains stronger functional links, and the project manager is more a co-ordinator. The project reviewed here can be characterised as a heavyweight organisation.

Projects consist of teams. A team is a small number of people with complementary skills who are committed to a common purpose, set of performance goals and approach which they hold themselves mutually accountable (Katzenbach & Smith 1993). By bringing people with diverse skills together, product managers hope to increase effectiveness and adaptability in projects. Numbers of factors are necessary for team level innovations. Training is important; putting contrasting personalities in the same group without adequate training causes easily conflicts. The clearly defined objective enhances teams' functionality. Equally important, however, is that team members participate in the setting of those objectives. High participation, i.e., a lot of interaction amongst team members, open information sharing and shared influence over decisions, enhances innovation. Task orientation or preparedness of teams to engage in constructive controversy and conflicts is also underlined. (West & Altink 1996)

The larger the project the more there are teams responsible for achieving sub-goals of their own. The teams

[1] *This study is a part of the research project "Teamwork and reward systems in R&D" at the TAI Research Centre, Helsinki University of Technology. The project is co-financed by Technology Development Center Finland (TEKES) and participating companies. The project aims at the enhancement of the product development process by improving teamwork, process management and compensation systems.*

and people supporting them form the organisational context around the product development process. Teams should work together and co-operate their activities to achieve the common goal, i.e., the project completion in time. Co-operation and communication between teams and among their members, however, often fail. (Vartiainen et al. 1996)

The case and orienting approach

About 200 employees designing power electronics are working in the field of product development in the company. Over 30 employees worked in the studied project. The aim of the project was to realise a new generation product utilising new technologies, a new platform product. The two year project was officially finished one year before the analysis.

The project was organised into several functional teams headed by team managers who themselves formed the management team. The project used and followed an internal product development model. The model consisted of typical product development phases: concept definition, product definition, design completion, verification, field trial and lessons learned, all of them tailored for the company's internal use. Functional project teams proceeded simultaneously in their own areas of engineering. The progress of the project was monitored in management reviews after each phase. Design reviews were the official co-operation form between development and production teams.

Several employees from product design and production were responsible for the ramp-up phase. Part manufacturing was made by several subcontractors worldwide while the factory's own production line was for assembly. A new assembly and testing line was simultaneously built for the product. In this paper, production is used as a synonym with assembly. The factory itself had a history of producing customised products with low volumes. The new product was the first representative of high volume standard products in the factory.

After the project, it was found out that the product design phase was one year late and the ramp-up phase turned out to be painful with a very low volume compared to the target. So, there were great needs to understand reasons for the timetable failure and difficulties during the ramp-up. This descriptive analysis focuses on two important problem areas: The delays during the design were in a great deal caused by unexpected technical difficulties and their management, i.e. the process. In the case a situation where the product is handed over from one team to another is investigated. There were reasons to presume that the main reason for difficulties during the ramp-up can be found in the co-ordination and communication processes, i.e. the intergroup boundaries. Thus, the objects of the analysis are also the border between the product development process and the production process, i.e. the ramp-up phase, and the disturbances between the production and development teams.

In this study the researcher came from outside of the studied process and the company but had earlier studied the company's product development management.

Methods

The development process was analysed retrospectively by examining the realised project. The analysis was supported by a product design process chart that was used in group and individual interviews. The process chart was shown to the group or a person discussing about its validity. Then each person was asked to write down five problems or conflicts during the development process that caused problems for the ramp-up phase: what happened and in which phase? Then each problem was placed in the specific stage of the process where the source of the problem existed. Each person then explained his statement and the researchers had the possibility to ask for clarification.

The analysis started with a group interview (n=3) of production representatives. The group was asked to mention as well five successful factors at the project.

The individual interviews (n=6) of both development team and production team representatives dealt with the following additional questions:

- Why? What was the reason for the problems?
- What could be done? Development proposals?
- What were the strengths of the project?

After interviews the researchers made a literal description of the project and the interviewees checked it. The problems found were grouped into four categories: 1) manufacturability and quick ramp-up, 2) responsibilities, 3) procedural justice, and 4) intergroup boundaries. In addition, the development proposals were collected.

Results

Manufacturability and quick ramp-up

The project ended up with several problems as a result of technical problems together with insufficient management (Fig. 1). The relationship between causes and consequences in the stories of subjects interviewed were not always clear. However the 'mother of all problems' seemed to lie in rushing. The information of the product and project timetable reached the selling companies early. The purpose of this was to get as much information from the customers as possible for the definition phase. This turned out to be a problem because the information spread could not be controlled, and the selling started early. After that the project met technical difficulties, and because of early selling to customers, was forced to launch an incomplete product. When selling had started, the incomplete product was brought into production. Pilot programme and 0-series production were left out and the first products were delivered to the customer. The feedback from the field came late resulting changes to the design while the production had already been started. The disturbances followed and were strengthened by several other problems.

The company's core competencies are software and hardware design. The project had some lack of knowledge in mechanical design. Assembly line specifications were late. Manufacturability was not considered as important and therefore manufacturability analysis was late. As a result the product was difficult to assemble with many different parts and tools.

The assembly line was specified and designed according to the original product specifications. Design and production teams were separate and not enough information from the design changes went to the production team. The product and assembly line compatibility was not checked. As a result the decision on the assembly line layout did not correspond to the final product.

The core technologies were not ready for the ramp-up and a lot of resources were needed for further development. As a result was changes in design. The project was not sufficiently prepared for EMC requirements which caused oth-

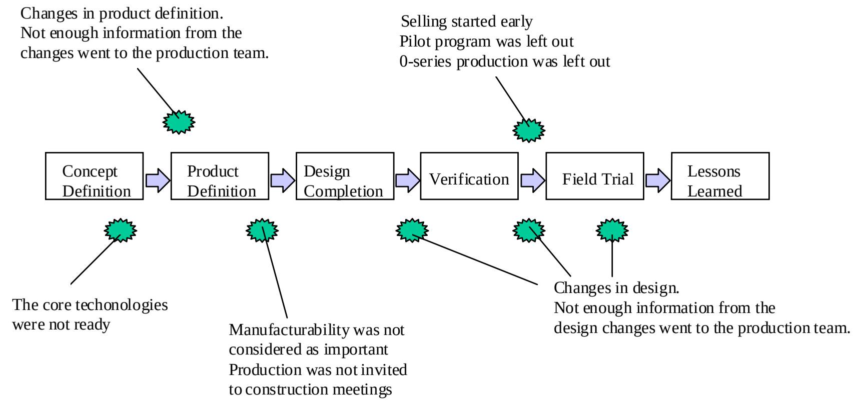

Figure 1. Factors of product development process that caused problems for the production ramp-up in the case.

er changes in design in a late phase. Only a few information if any of the design changes went to the production. Because the product design was not completed at one go, the construction and parts were continually changing during the ramp-up.

Responsibilities

Unclarity in responsibilities and work distribution caused misunderstandings, and some of the tasks were left undone. This unclarity was especially troublesome in designing and building the testing line where no one had the main responsibility of co-ordination. In addition, all the literal agreements with testing equipment subcontractors were missing. Other essential unclarities mentioned were following:

- It was not clear who - development team or production team - is responsible for organising the design reviews.
- For some parts supply responsibilities were not clear - development team or production team?
- After the design change iterations it was not clear inside the development team who is responsible for bringing the whole product into the production. In the beginning each functional team was bringing its own design changes to the production. This caused some extra work for the production.

Procedural justice

The concept 'procedural justice' can be defined here as the subjective evaluations of fairness in decision making or resource allocation procedures as contrasted with the experienced fairness of outcomes in these encounters. The basic principle is that all actors should have voice - i.e. they should be given opportunity to influence - in decisions and allocations in which their interests are involved (see Lind & Tyler 1988 and Leventhal 1980).

While the development team representatives mentioned only single experiences of injustice, especially the accounts of the production representatives can be examined as violations of procedural justice principles as follows:

- The production was not asked for delivery times when the selling was started.
- The reviews were accepted too easily even if some of the design problems were not solved. This gave the marketing organisation a picture that the project had proceeded further than it actually was. "In the end the production is always in trouble".
- The production representatives were not invited to the construction meetings.

Intergroup boundaries

There was a shared understanding of production and development teams' high intergroup boundaries as a problem. Production and development had separate or even opposite targets as well. Production team's target was to have a high volume for the old product while the new product with all its difficulties was rather a nuisance. Development team's target was to solve, as well as possible, the technical problems occurred in the new product, like EMC requirements. The boundaries were highlighted as follows:

- The official language of reviews and documentation was English. All the production representatives mentioned this as a problem in a way or another. "In the reviews, the English language made the 'quiet' production even more quiet."
- The design reviews between the production team and the development team had a destructive spirit. Design team members described it as an occasion of pointing mistakes in product design. Production felt that the reviews were the last chance to delay the uncompleted product's coming to production.
- Since production representatives did not participate in the design meetings information was not distributed sufficiently. This point is linked to the procedural justice viewpoint as well.

Development proposals

The most common development proposal concerned production representatives' participation in design process. Other proposals were rare compared to the presented problems and no common view seemed to be for developing the process. When one was calling for a stronger management, the other for participative approach and the third for a proper prototyping and pilot programme.

Discussion

Reasons for timetable failures

The main reasons for the one year timetable delay and painful rump-up period seem to be many-sidedly linked to the responsible social system and its teams. The social system's ability to use reviews after each phase and correct operations respectively failed. Somehow a shared knowledge of the present problems and procedures to overcome them did not arise. Were the design teams too functional? Could they not therefore understand the needs of the production team? This would not be a new conclusion. It is well-known since the start of Taylorism that too specified jobs lead to difficulties first between employees and management and then, in the age of teamwork, between teams that do not see and comprehend the benefit of the whole process.

The situation in the studied project was highly sensitive to intergroup disturbances and conflicts. There were two functionally separate teams - design and production - working for the same objective. However, the project did not form one unity but the organisational setting highlighted differences between the two teams. First, there was a clear power difference/distance between the teams in which development team had the dominance. This was illustrated in the stories of production team members about common meetings and decision making procedures. For example, the language used in the meetings was often English so that production staff did not understand as mainly Finnish speaking what was going on. They also felt that they had no real voice in the important decisions. This, in turn, created experiences of procedural injustice (see Leventhal 1980, Cohen 1986). The symbolic boundary between the teams was stressed leading to clear in-group versus outgroup categorisations. The literature on group dynamics (Brown 1988, Hogg & Abrams 1988) clearly demonstrates that the situation of design and production teams described above almost certainly generates in-group favouritism and outgroup hostility resulting in conflicts.

On one hand, innovations usually occur through disturbances and conflicts in the social system; it is possible to learn from experiences gathered during past and more or less succeeded projects. On the other hand, it can be argued that high intergroup boundaries and antagonistic setting tend to direct conflicts to nonconstructive issues. It is also essential how the conflicts are managed. Dominance and avoidance in conflict situations are certainly not the best ways in teamwork. How teams manage their boundaries affect projects' performance. Boundary management refers to interactions teams must undertake in dealing with other groups and up in the division upon whom they are dependent for information or resources or with whom they co-ordinate to complete the assignment. The conflict management strategies impede co-operation that is vital in project organisations. (see e.g. Thomas 1976, Raven and Kruglanski 1970.) Resulting distortions and disruptions in the development process cause delays during later phases of the product implementation and manufacturing.

Comments on the method

The process chart provided a firm basis for individual restructuring of the process' critical incidents retrospectively. It can be recommended to build such a chart when analysing past events in projects. A lesson learned is that it is very beneficial to analyse carefully the strengths and weaknesses of the past projects. The open questions in the interviews also worked well. A criterion for this was that after certain amount of interviews no more themes and problems came out. A problem of the questions was their 'negative' emphasis, bias on problems and disturbances. This resulted only few development proposals from subjects although these were asked during the interviews. Altogether, the method used to reconstruct and model a finished project worked relatively well. Still, it has some shortcomings in scientific precision and needs further development and reflection. Our aim is, however, to collect more data on realised projects. It seems fruitful to collect more cases by using our approach.

The development dimension of this study will be to use the lessons learned in creating discussion and dialogue between development and production in future projects. This is supposed to increase understanding of mutual problems and common goals and interests of the development and production teams. Bringing the two teams closer to each other should lower boundaries between teams involved and facilitate the vital co-operation of project units (Brown 1988). The boundary management is necessary for the speed and flexibility of new product development.

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Customer Satisfaction Through Employee Satisfaction

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The basic tenets of total quality management (TQM), as we all know, are: customer satisfaction, continuous improvement and a quality culture through training/development. These are also central to human resources management (HRM). TQM further promotes the concept of internal and external customers. This covers the interaction among individual employees, among functional groups, and also between workers and management, as customers and suppliers.

Introduction

Management, which has commitment to quality, considers the employees as primary customers, while serving as a supplier of jobs and job satisfaction. It keeps them well-supplied with opportunities and training to grow, in addition to equitable pay and benefits. Most importantly, it facilitates their working together to a better than satisfactory level, with business guidelines, policies and procedures. If this really happens, the collective day-to-day performance is bound to produce quality results and satisfy the external customers. This has relevance in management of projects as much as in company organization management. While the project sponsor is the project manager's client, his team members are his suppliers. Examining the aspect of mutual satisfaction in the management of human relations might be of interest to project managers.

Customer satisfaction is going to be of paramount importance for conducting business and running projects in the coming years. This article is an attempt to identify a strategy to meet this inescapable reality, by examining the potential TQM-HRM partnership, based on practical experience. It considers as a major factor the management's dependence on the human talent, which must be carefully searched, nurtured, encouraged, challenged, and above all, satisfied.

People, the Foundation of Quality Management

Emerging Role for HRM

We have witnessed so far a transition from personnel administration to personnel management to employee relations to human resources development (HRD), with varying shift in the focus in each case. Further transition from HRD to HRM is also almost complete. Such transition, often not too clear, gradual and overlapping with a previous one, invariably incorporates changes in social attitudes towards work, worker needs and demands, and the realities of the business world. It reflects the overwhelming realization that people are the foundation on which organizations are built. The quality of people determines the quality of management and the effectiveness of company business.

The emerging new transformation for HRM is with the value-added dimension of TQM and Business Process Re-Engineering (BPR). We could perhaps call it: Total Quality HRM (TQ/HRM). BPR and TQM both have the same focus on quality, and on improvement of products, processes, procedures and services. Since only people can bring about such improvement, the people-biased HRM function is a natural contender to cover TQM/BPR as its integral part. HRM's emphasis on developing, training, and managing people has to be reinforced with a TQM outlook, which makes them natural partners.

TQMization, that is, introducing and implementing TQM, may begin with potential improvements in the HRM function itself.

In order to meet the TQM challenge, human resources (HR) managers need to implement an integrated organizational strategy, one that enables staff to achieve the required performance standards and fulfill personal development objectives in the process. They, indeed, have to launch TQMization as a project. Organizations need to add value to current HRM approaches and better prepare the organizations, work groups, and individuals for sustainable survival and development in the increasingly competitive global environment.

TQM brings a new meaning to the human resource function. Increasing complexity of today's business brings an escalating pressure on human resource professionals to either play proactive, strategic partnership roles or be left behind as marginal contributors. The imminent challenge to develop a world-class work culture that integrates quality HR and strategic business plan has to be met. Organizations that do not succeed in the integration of strategic management, TQM and HRM will eventually face extinction.

It is essential to develop a powerful HR methodology such that we can start from the process of individual change for better, and build outward to better relationships among functional groups to make the total organization a homogeneous and harmonious entity. HR managers who can act as change agents, facilitators and coordinators for quality improvement efforts on companywide basis best accomplish this process. They have to assist management in strengthening the linkage between business strategies and management practices. Today's management is experimenting with new approaches already, such as, TQM, boundaryless or flatter organization through BPR, self-directed work teams, and so on. HR, as a spokesman for all people, can act as an internal management consultant for such innovations.

TQM Finds a Home in HRM

The main stumbling block for TQM implementation is to find a place for it in the organization. Every organization may have its own idea about whom the TQM manager should report to. TQM does support Quality Assurance/Quality Control (QA/QC) for process improvement to produce final genuine product. However, its focus is not on the product but rather on the management of the entire business organization. There is a tendency to let it be a direct report to the CEO, but that makes it too distant from where the action is. A case may be made to place TQM within QA/QC, or Marketing/ Business Development, due to its customer orientation. Or, maybe even in Information Systems, due to its role in integrating functional databases. Experience has shown that Human Resources is the ideal candidate to provide a home for TQM within the corporate organization.

If we value and trust our employees, treat them well, empower them, and make them feel important, they can achieve the seemingly impossible. Combining TQM with HR provides the opportunity from day one to impart the company's quality culture to the employees. Through proper selection of personnel in the recruitment process, and training them to improve their skills and develop a career for them, it is ensured that the organization has a motivated and energetic workforce. HRM and TQM prove to be natural partners in creating the quality culture and in building an effective organization.

HRM has always been a key staff function in any organization, being involved with people from their entry through exit. The line functions need HRM's support, and HRM needs inputs from them to help them in turn. This is a situation where the internal customer-supplier concept inherent in TQM application comes into play in a most profound way.

TQ/HRM, the TQMized HR function, extends beyond the traditional role. It links itself with overall management of the business, including setting up the goals of the organization in order to proactively and systematically respond to current/future internal and external customer needs. Management realizes now that developing the company business depends upon the development of HR. The organization's success is not possible unless improvement in people management practices takes place, and good employee relations remain a number one priority with management. The new role of the TQ/HRM function is to build a quality culture within the organization focused on complete satisfaction of every employee. Among the added responsibilities of HR professionals are:

- Participation in developing business plans
- Upkeep of policies and procedures
- Formation and coordination of quality improvement teams
- Evaluation of individual/functional/company performance and similar TQM related activities, which culminate in employee satisfaction
- Ensuring that employees get appropriate recognition from management for improvements made.

The rationale for attaining TQM by its partnership with HRM includes common elements of concern, such as: (1) mutuality of people relations, (2) creating corporate culture, (3) training and development, (4) company policies and functional procedures, (5) attainment of quality through personal/personnel indulgence, (6) continuous improvement in the company's products, processes, procedures and services, and (7) customer satisfaction through employee satisfaction.

Quality in Management as a Motivator

Commitment of employees is always expected in any organization. But it is not automatic, and cannot be taken for granted. A broader emphasis on employee motivation must be considered if we want to have a committed quality organization. Involvement of employees in the management of their respective work processes plays a major role in their motivation level. This translates into the success of the TQM program. If we believe that more satisfied employees are more motivated, and hence more productive, then the responsibility to make that happen rests with the HRM function. This means that the responsibility and pressure on the TQ/ HRM function start from the selection of the individual in the organization up to the time of his departure. It requires cooperation from all functional managers.

A major ingredient for TQ/ HRM's success is the involvement of top management. It is essential that the CEO leads the whole organization towards the goal of quality. Failure of companies to implement TQM is almost invariably attributable to the lack of top management involvement, and lack of direction to steer the organizations with a clear vision and necessary support.

TQM will never be accomplished and implemented successfully if the top people in the organizations do not adopt it from the beginning and monitor its progress closely. Their interest in TQM must be genuine, and their support wholehearted. The employees must be assured that top management is really serious about TQM. It should be actively demonstrated by managers and supervisors at all levels that they are not just interested but are actually enthused about the ideas presented by their employees for improvement of things.

Quality in management's attitude and actions must become so obvious that everyone within the organization begins to react to it positively. This is reflected in the promptness of decisions and fairness in dealing with employees' needs as persons and professionals, in celebrating when work teams or individuals show results in meeting/exceeding expectations, and rewarding good performance without any bias or preferential treatment. Good management is quality management, and that is what serves as a real motivator for employees and the supervisory staff. If at any later stage, people discover that the initial rha-rha and hoopla have only generated a TQM rhapsody, and that it has degenerated into a mere lip service, they are frustrated and demotivated. Hypocrisy, favoritism, nepotism and discrimination are an antithesis to TQM. They are also the greatest demotivators. Remember: No Quality Without Equality!

An executive steering committee consisting of senior staff and chaired by the CEO may be formed to establish long term TQM objectives and lead the organization towards achieving them. It should: (1) develop the philosophy and methodology for quality, (2) launch initial and periodic, in-house TQM campaigns, (3) focus on establishing a quality culture based on equality, (4) support training activities, and (5) overcome any obstacles that stand against smooth implementation of the program.

Once the employees are convinced that their own managers are honestly, consistently and zealously pursuing TQM, they will be highly motivated. They will enjoy coming to work under quality management of the company, and give their best. Next, let us see how realignment of the HR function itself can better support the realignment of people management practices, and of the business strategy.

The TQ/HRM Phenomenon

Traditional HRM

The international Society of HRM (SHRM) in USA has implicitly reserved a place for TQM already within the HRM module called "Management Practices"! The SHRM Learning System, an educational program developed by the Society, incorporates following modules, and attaches relative weightages for testing in the "Professional in HR (PHR)" and "Senior Professional in HR (SPHR)" examinations conducted by its HR Certification Institute. The increase in emphasis on items 1 and 5 for the Senior Professional is worth noting.

The traditional role of HRM is understood to involve: (1) Recruitment, (2) Benefits, (3) Training & Development, (4) Office Administration, (5) Public/Labor/Industrial/Government Relations, and (6) Other Services (Travel, etc.). Traditional HRM, through the transitions it has gone through in past 2-3 decades, has expanded its role such that the HRM professional is, indeed, becoming a change agent or a facilitator of changes attempted companywide. TQM and BPR call for fundamental changes in the organization culture and company operations. HRM has already been playing a part in this. It is, in effect, best poised now to be the most natural candidate for partnership in TQMization.

TQ/HRM as a System

If business management can be looked upon as an open system to manage all resources (time, money, manpower, and materials), the TQ/HRM System becomes an essential component of it. Typically, a system model calls for predetermined inputs, a known procedure or process to utilize these inputs, and desired end results or outputs. A simplified, self-explanatory view of a typical TQ/HRM system may be shown in Figure 1.

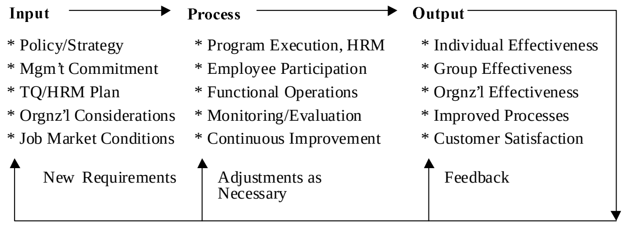


Figure 1. A typical TQ/HRM system

Note:

(1) Policy/Strategy: Company vision and mission, TQ/HRM philosophy & guidelines, criteria for effectiveness.

(2) Individual Effectiveness: Personal/creative output, loyalty/commitment/dedication, personal growth, motivation, influence on others.

(3) Group Effectiveness: Group productivity, morale, team spirit, adaptiveness to changes.

(4) Organizational Effectiveness: Overall productivity, responsiveness to environment, values-beliefs-attitudes of managers, employee/union relations, employee empowerment, turnover.

The TQ/HRM Plan must incorporate the most essential provisions for a Training and Development Program and a plan to prepare, implement and audit Policies and Procedures for all functional groups. Since there are no easy tangible items (as in Engineering, Construction, or Manufacturing) associated with TQ/HRM inputs and outputs, one has to contend with subjective and quali-tative rather than quantitative considerations.

The TQ/HRM System, to be effective, has to address the total organizational needs, functions, and ultimate success of the business. By its very nature, the system outlook leads one into an examination of its internal and external environments in their entirety so that the system components can be defined/identified and their interrelations established.

		PHR	SPHR
1.	Management Practices	22 %	29 %
2.	Selection & Placement	20 %	15 %
3.	Training & Development	12 %	12 %
4.	Compensation & Benefits	21 %	18 %
5.	Employee & Labor Relations	18 %	19 %
6.	Health, Safety & Security	7 %	7 %
		100 %	100 %

While actual TQ/HRM activities may be the responsi-bilities of a TQ/HRM Manager and his staff, the TQ/HRM outlook has to be cultivated by functional heads of all management areas, without exception. This outlook entails the ability to understand, appreciate, explain, inform, generate and monitor the wishes-desires-aspirations, opinions-criticisms, abilities-limitations-motivations, actual performance, compromises and sacrifices of every human being in the organization.

Everyone in the organization, by virtue of merely being there, has a common stake in the organization's well-being. He or she has to contribute by participating in decision-making/executing in a manner relevant to his/her position. By incorporating TQM into the HRM system, the need to improve all services performed by the HRM group, and to set an example for others in TQMization, is experienced readily. Successful operation of the TQ/HRM will be reflected in effectiveness output of the individual, group and overall organization as mentioned above.

Special Focus Under TQ/HRM

Policies & Procedures (P&Ps)

This is a major area of activity not always made a part of HRM. Adding the policies and procedures activity along with TQM related training to the responsibility of HR has proved to be a major advantage to the success of TQM. Once developed, P&Ps need to be continuously reviewed for practicality and relevance in light of ongoing changes in organizational structure, business strategies and priorities, and work processes. A periodic (annual) audit for compliance with procedures and potential improvements is called for in the TQMized HRM. TQ/HRM could easily provide coordination for preparation and upkeep of P&Ps of all functions.

Typically, the TQ/HRM system may include the following areas of activity, or subsystems, for which preparation of relevant P&Ps are worth considering:

- Benefits
- Recruitment

-Employee Relations
-Training & Development.
-Safety & Security
-General Services
-TQM Plan

TQMization, with its inherent requirement of P&Ps provides an excellent basis for pursuing ISO 9000 Certification for internationally accepted quality standards. It may be noted that the essence of ISO 9000 is to have a companywide quality management system implemented by adequately detailed P&Ps and work instructions. ISO 9000 Certification is available only after independent audits to verify proper documentation of work processes such that "You do what you say, and you say what you do!". ISO standards are being applied now in service industries as much as in manufacturing or construction industry.

Fitness Reviews and Improvement Teams

It is important that the organization monitors the progress and success of the TQ program thoroughly on a regular basis. The effectiveness of such a program can be assessed through what may be called total quality fitness review. Like a personal clean bill of health following a physical fitness program, this provides an indicator of corporate fitness or well-being. It is a TQM awareness survey generally conducted each year by interviewing a randomly selected cross-section of employees to identify and provide their inputs on various key areas (or, "conditions of excellence") such as: human resources, customer satisfaction, and communication.

Upon completion of all interviews, a final score can be quantified with an established weightage for every area that was discussed. Based on that, determination is made of the organization's strengths and weaknesses (i.e., opportunities for improvement!) as perceived by the interviewees. This is formally presented to top management for necessary consideration. An action plan to improve weaknesses is then formed with quality improvement teams (QITs) representing concerned departments in the organization. Projects for potential improvements are identified, and multifunctional QITs are formed to address selected issues. No QITs are considered for issues that fall within normal responsibilities of the responsible functional groups.

Issues of lasting interest, such as, procedures improvements or effective statistical process control, may require permanent, on-going QITs. Team members and leaders in such cases may be changed annually with a view to get maximum employee involvement, to generate overall team spirit, and also bring in a fresh perspective of processes and problem issues. Special leadership training is organized for assigned team leaders. It includes indoctrination to the tools and techniques employed in TQM projects.

TQ/HRM Training

Emphasis on developing, training and managing people is of real importance to both HRM and TQM. Training and development (T&D) is the essential process to ensure employee motivation as well as satisfaction. A total systems approach for a T&D program would consider the craft skills, technological skills, techniques/procedural skills, human relations/communication skills and conceptual-analytical- decision-making skills, to be acquired by personnel at appropriate levels of operation.

The philosophy and practice of TQM and HRM are amply defined, refined, tested and proven separately so far. Combining the two entities into one operation or undertaking is the essence of the transition to TQ/ HRM. Training becomes a part of the TQMization project. To give a real TQ/HRM orientation to that, the program developer/ expert has to have lived in the TQM world in some capacity or another, and has to possess a thorough knowledge of its uniqueness, the underlying philosophy and practices.

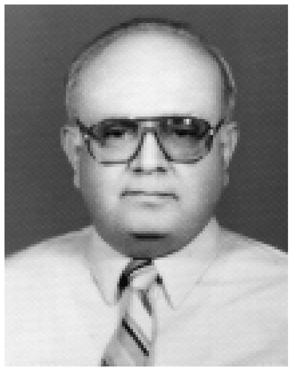
The uniqueness of TQMizational training is that the training program typically goes on continuously with growing awareness and preparedness of the organization to embrace TQM as a way of corporate life. Another key aspect of this is the learn-as-you-do and do-as-you-learn approach, and the trainer's role as a consultant such that TQM training continues as TQM is being implemented, in phases. To be truly comprehensive and effective, training programs have to cover all technical staff, and also offer appropriately modified version for other functional groups, such as, purchasing and contracting, personnel administration, computer services, finance/accounting, etc. This helps develop a common knowledge base and a shared set of values.

Conclusions

People are the greatest asset for any organization. However, it is probably too obvious to be recognized in practice. It is a most cherished concept among HR professionals, and the least fulfilled in reality. People satisfied with their own performance and mutual support, and their interaction with management, are more likely to lead to customer satisfaction by producing quality goods and providing quality services.

Quality management means good management, and can be a provider of motivation and job satisfaction in exchange of dedication and performance with satisfactory results. As a corporate function, HRM is a natural contender to lead and coordinate the companywide TQM project. The emerging new role for TQ/HRM, that is, HRM providing a home for TQM, calls for HR's participation in establishing corporate strategy, policies and procedures, and in TQM related activities like quality fitness reviews and improvement teams.

Such correlation between HRM and TQM has come to the fore in recent times, which upgrades HRM's role in the organization and enhances its value to management. Organizational transition to the new TQ/HRM entity is quite imminent. The HRM function will have to restructure itself by inculcating the TQM ideology and expertise. This may have to be linked with company's strategic business planning for total effectiveness. HRM is most suitably poised at this time to provide the leadership in the TQMization project, and to ensure customer satisfaction through employee satisfaction.



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On the Management of Risks in Construction Projects

Small and Medium Sized Projects with Low and Medium Complexity Levels and "Zero" Situations

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Keywords: project risk management processes and techniques, construction projects, small and medium sized projects, low and medium complexity projects

This paper discusses processes to follow and techniques to use while performing the risk management function in the small and medium sized projects with low and medium complexity levels. The first part deals with the relations between project characteristics and the project risk management process. Then a simplified eight phases risk management process is proposed in case of small and medium sized projects with low and medium complexity levels, establishing the possible risk analysis techniques to use in relation to the project size and complexity. Finally, an example of simple project risk management process for cases of small sized projects is suggested. This process is also recommendable for any kind of project sizes and complexity levels when it is the first time the company applies project risk management ("zero" situations). The paper includes various practical rules and recommendations in relation to all the aspects covered in it.

Classifying the project. Relations between project characteristics and the project risk management process.

The ways of distinguishing between small, medium and large projects are diverse, and the limits between sizes are vague. Table 1 is an example of classification of construction projects according to their size in man-hours, included in the internal documentation of a company for a purpose different from project risk management. Table 2 shows a simple and interesting classification of construction projects established by Brown&Root Inc. (1993). The reader can find other suggestions to classify construction projects by size, as the ones proposed by Bent (1990), which classification limits can be quite different to the proposed in Tables 1 and 2.

Industrial projects:	
· Small	<30.000 m-h
· Medium	30.000-150.000 m-h
· Large	>150.000 m-h
Building projects:	
· Small	<3.000 m-h
· Medium	3.000-15.000 m-h
· Large	>15.000 m-h

(*) Including conception, basic engineering, detailed engineering, procurement, planning and control, supervision, coordination and other project management activities.

Table 1. An example of classification of construction projects according to the project size in man-hours (*)

We consider that two different size aspects must be taken into account when establishing the processes and techniques to deal with risk in projects. The relative size of the project is the first one. The relative size of a project is the relation between the project budget and the capitalisation of the company that undertakes the project (Turner and Payne, 1997). For example, we can say that a project has a large relative size if the budget is of the order of the company capitalisation, a medium relative size if the budget is of the order of 1/10 of the company capitalisation, and a small relative size if the budget is of the order of 1/100 of the company capitalisation. This relative size establishes the importance of the project for the company, and so the need to use complete project risk management processes as the one proposed by Chapman and Ward (1997). Shortcuts can be accomplished over a complete project risk management process when the relative size is small or medium.

The second aspect is the absolute size of the project. The absolute size of a project is related to the project budget. For example, we can say that a project is small sized if the budget is under US$ 25 millions, medium sized if the budget is between US$ 25 and 100 millions, and large if the budget is over US$ 100 millions. There is a relation between the absolute size of a project and the techniques to use in the risk analysis process. When the size is large the budget allows to use even the more sophisticated quantitative analysis techniques from the broad variety existent. Decision trees, combined or not with other probabilistic techniques (as can be Bayesian theory or semi-Markov processes) (Chapman, 1979; Cooper and Chapman, 1987), probabilistic influence diagrams (Huseby and Skogen, 1992), system dynamics (Cooper, 1997; Forrester, 1961; Rodrigues, 1994;

Criteria/Size	Small	Medium	Large
10^3 engineering man-hours	<15	15-50	>50
Cost in 10^6 US$ (1993)	<25	25-100	>100
Time span in months	<9	9-18	>18

Table 2. Classification of construction projects according to different criteria (Brown&Root Inc., 1993)

Rodrigues and Bowers, 1996), process simulation (Ahuja et al, 1994; Carrol, 1987; Mesterton-Gibbons, 1995), risk mapping (Al-Bahar and Crandall, 1990), analytic hierarchy process (Alidi, 1996; Badiru and Pulat, 1995; Saaty, 1980), or combinations of these techniques can be used when the budget is medium-large and large. Even Controlled Interval and Memory theory (Chapman, 1990; Chapman and Ward; 1997; Cooper and Chapman, 1987) or fuzzy logic (Coffin and Taylor, 1996; del Caño, 1992; Gazdik, 1983; Kangary and Boyer, 1987; Kangary and Leland, 1989; McCahon, 1993; Nguyen, 1985; Schuyler, 1996; Tah, 1997; Wu and Hadipriono, 1994; Ward, 1985), without available commercial software, could be used in special cases of large projects. On the contrary, only qualitative assessment or even only checklists to identify and assess risks and responses can be used when the budget is extremely reduced.

On the other hand, the processes and techniques used to deal with risk in projects are also related to the project complexity. A project can have two different kinds of complexity. We will refer to "direct" complexity to the one related to differentiation and interdependence between the elements or subsystems of a project. This is the complexity in the sense expressed by Baccarini (1996) and that is called structural complexity by Williams (1997). We will call "indirect" the other kind of complexity, that is related to aspects different from differentiation and interdependence. That aspects are more in the line of "complication" and use to have the consequence of generating more interrelations between the subsystems of the project (Williams, 1997). Uncertainty is one of the main sources of indirect complexity. Finally, the need to use complete project risk management processes increases with project complexity (direct plus indirect complexity); shortcuts can be accomplished when complexity level is small or medium. And also the more complex is a project, the more need to use sophisticated quantitative analysis techniques exist.

Dealing with complexity and the definition of project risk management processes and techniques, let's note that an aspect related to project complexity is the kind of project in the sense referred to by Turner and Cochrane (1993). The degree of definition of project objectives and the degree of definition of the methods to achieve those objectives are the two criteria proposed by Turner and Cochrane to classify projects in order to define the launching process. As Williams (1997) indicates, those aspects are a source of complexity (indirect complexity) because, in case of poor definition of methods and/or objectives, more feedback loops will be developed to undertake the project. It's obvious that a poor definition of objectives and/or methods is a source of risk, meaning that the probability of rework will be high. Turner and Cochrane establish four types of projects, as a function of objectives definition (poor defined, well defined) and methods definition (poor defined, well defined). And then they suggest different ways of launching the project in relation to the type of project. That four types of projects are:

- Type 1 (earth): engineering projects. Normally in these projects the objectives and methods can be well defined.
- Type 2 (water): product development projects. Normally in these projects the objectives can be well defined, but not the methods.
- Type 3 (fire): systems development projects. Normally in these projects the methods can be well defined, but not the objectives.
- Type 4 (air): research and organizational change projects. Normally in these projects neither the objectives nor the methods can be well defined.

Besides that, a capital program may include several projects with different size and type (Turner and Payne, 1997). In that case the program risk manager must take into account the more problematic project within the program to establish the general approach for the global process, and the individual risk management for each project will be influenced by the project characteristics and also by the program needs.

In general terms the aspects related by Turner and Cochrane (1993) imply an added indirect complexity to the project. If the risk management is to apply to a normal construction project those aspects are not applicable, and we are in a typical engineering (earth) project. If the risk management is to apply to a capital program, those aspects must be taken into account.

So the definition of possible shortcuts to a complete risk management process is influenced by the complexity and the relative size of the project. And the kind of risk analysis techniques to use is influenced by the complexity and the absolute size of the project.

Taking that into account, the problem is to define possible simplified processes and possible analysis techniques to use in small and medium sized projects with low and medium complexity levels, that are the most frequent projects.

The project risk management process in case of small and medium sized projects with low and medium complexity levels

The phases of a risk management process in case of small and medium sized projects with low and medium complexity levels can be the following eight:

1. Project.
2. Process.
3. Identification.
4. Analysis.
5. Evaluation.
6. Planning and immediate actions.
7. Monitoring and control.
8. Post-process learning.

This eight phases process is a simplification of a complete project risk management process for large projects developed by the authors as part of a research project funded by the University of La Coruña (Spain). The complete process (de la Cruz, 1998) includes a total of twelve phases and will be a matter of forthcoming publications.

This complete process is based on an analysis of the previously published project risk management processes and on the professional experience of the authors (in positions of project engineer, control engineer, project manager and Operations Manager at construction project management companies, working on the conception, design and management of small, medium and large construction, environmental and urban-planning projects) combined with a set of interviews to professionals in the construction sector with experience in domestic and international construction projects.

References that have been taken into account are Al-Bahar and Crandall (1990), Archibald and Lichtenberg (1992), Chapman (1979, 1997), Chapman and Ward (1997), Clark et al (1990), Down et al (1994), Grey (1995), Klakegg (1997), MoD(PE)-DPP(PM) (1991), Project Management Institute (1996), Reitan and Hauge (1997), Simon et al (1997) and Wideman (1992).

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Figure 1 includes the basic flow diagram for the simplified project risk management process, only including the basic feed-back loops. The first phase (project) is directed to gather and summarize the existing information about the project, and then to identify and generate other risk related necessary info. For that purpose it's important to consider the six basic questions (the six W's: Who?, Why?, What?, Which way?, Wherewithal?, When?) referred to by Chapman and Ward (1997). It's also very important for the other process phases to define now the hierarchy for the several project objectives. Finally this phase must establish the project success measure factors, the objective related limits that will define the success or failure of the project and other non quantifiable project success aspects.

The second phase (process) is first-of-all directed to define:

- the stakeholders in the project risk management process, beginning with the process clients identification,
- the several motivations to develop the process,
- the process scope (methodology and techniques),
- the time and cost objectives for the process,
- and the hierarchy for the several process objectives.

After that, the second phase must plan the process in the same way that a project is planned. In case of small and medium projects, and specially in case of small and very small projects, the scope or even all the aspects in this phase can be covered by a standard corporate procedure to reduce the risk management work to do by the project team.

The third phase (identification) must:

- Identify all the risks and opportunities for the project. A practical rule on the number of risks to concentrate the risk management process in normal cases can be to establish the 5-15 main risks, in case of small projects, or the 10-20 main risks in case of medium projects. This doesn't implies to forget the other risks. It's a question of prioritize. A simple way to prioritize risks in this phase can be a qualitative estimation (for example, insignificant, low, medium, high, catastrophic) of the expected value (probability times impact) for each risk. Any way, let's note the bi-dimensionality of risk (Williams, 1996). Using only the expected value can lead to deceive oneself. Not only expected value is important, but also the probability and the impact. So if the project has a minimum of importance a better way of prioritize is to establish a qualitative estimation for probability and impact (for example, 5=insignificant, 4=low, 3=medium, 2=high, 1=catastrophic), and to prioritize by probability, by impact and by the product of probability and impact.
- Identify the several alternative sets of responses to the identified risks and opportunities.
- It's obvious that a specific response can be the source of a new risk. For example, to compress the schedule can cause a decreased product quality, can cause a cost overrun, and can influence over the human resources motivation if the introduced stress is excessive, among other consequences. So now it's necessary to identify the "secondary" risks following to each response. And after that, the responses to the secondary risks must be identified too. In special cases of medium complexity levels can be necessary another loop to deal with a third level of risks. In case of very small sized and low complexity level projects a simple risk-response identification can be enough.
- Finally, the alarm signals or trigger events must be identified, as signals driven to establish the moment to implement corrective actions.

This is the moment to use existing corporate risk databases, standard check-lists, risk and response lists from other projects and final review reports from past projects (generic or specifically related to risk management). In case of small and medium projects is more than recommendable to generate corporate databases and check-lists for the purpose of this phase, in order to reduce the work to do by the project management team.

On the other hand, it's highly recommendable to verify the results of this phase with the help of other sources outside the project management team, inside or even outside the company. This can be achieved through individual interviews (using or not the Delphi technique) and/or through panel discussions (that can be traditional structured or brainstorming meetings).

The fourth phase (analysis) is intended to establish one (or more) risk model(s) for the project. This is the moment to deeply analyse risks and responses to build the base for the next phase. The first step in this phase is to formulate the problem, establishing the purpose and the boundary conditions for this phase and, then, deciding the risks that will be taken into account in the model and the risks that will be excluded (insignificant risks) by the moment. The second step is to build the risk model(s) for the project. The model can be as simple as a table summarizing activities, risks, responses and the main interrelations. If considered necessary, this is the moment to establish a mathematical model taking into account the software that will be used to run the model. This software will be normally a commercial package or a small set of packages, in the cases we deal. Below is included more information related to this kind of software. Standard models can be used in cases of projects with many historical information and/or in cases of medium or small projects with low complexity. Finally, the last step in this phase is to contrast the established model checking it with the identification phase results and with the project planning.

The fifth (evaluation) phase must:

- Estimate the uncertainty related to the several model (models) parameters. This will lead to a definitive prioritization of risks.
- And, finally, introduce the parameter estimations in the model to evaluate the general risk situation by project objectives (scope, time, cost, quality) and even the general situation at the project level (profitability).

In case of low complexity levels these phases can be reduced by a corporate procedure including a check-list that the project team and the other risk management participants must follow and fill. An example of this will be explained below (Table 3).

In case of medium sized medium complexity level projects a complete analysis phase can be developed, using non sophisticated modeling techniques. For example, range estimation (triple estimation adjusted to a distribution function) can be developed for the project activities duration, and then a Monte Carlo simulation (Willis, 1986) can be developed on the project schedule. Several software add-on tools are available for that purpose, as can be Opera for Open Plan (Wellcome Software, USA), Monte Carlo for Primavera P3 (Primavera Systems, USA), @Risk (Palisade, USA) for Microsoft Project or Risk+ (Project Gear, USA) for Microsoft Project. Some of these packages also perform Monte Carlo simulation for the project budget purpose.

Anyway, simple all-purpose software packages like @Risk (Palisade, USA) or Definitive Scenario (Definitive Software, USA) can perform range cost estimating (or other project management functions risk analysis), Monte Carlo simulation and sensitivity analysis. @Risk (Grey, 1995) is an add-on to Excel or Lotus 1-2-3 with specific risk functions that automates Monte Carlo simulation and sensitivity analysis. Definitive Scenario (Huseby and Skogen, 1992) (Definitive Scenario is product based on DynRisk by TerraMar, Norway), is based on probabilistic influence diagrams. It's not an add-on to an electronic sheet, but any model build on Definitive Scenario can include links to existing Excel files to build a mixed model in order to reduce the work to do. It's not necessary much training to develop feasibility, cost estimating, or schedule influence diagram models for a project. Using Definitive Scenario each influence diagram node can include a deterministic or probabilistic parameter, or a computation (+, *, /, Max, Min, etc.) to calculate an output as a function of the several inputs (arrows). And each arrow can include a function, with available functions very similar to the financial, mathematical, trigonometric or logic functions available on the typical electronic sheet packages. After estimating parameters and building the model, the software develops a Monte Carlo simulation. And sensitivity analysis can also be developed to have several subsequent Monte Carlo simulation processes in order to compare the initial situation with the potential situations after several alternative sets of responses are implemented. PrecisionTree (Palisade, USA) is an add-on to Excel and Lotus 1-2-3 to create decision trees and influence diagrams. Combined with @Risk, it adds the Monte Carlo simulation and sensitivity analysis performance to develop the same kind of analysis as Definitive Scenario.

The sixth phase (planning and immediate actions) includes:

- Defining the risk allocation internally and externally to the organization that undertakes the project. This implies to define the risk allocation policies, distinguishing between the persons or companies that manages a risk and the persons or companies that will support the risk impact. It also includes the contractual type and clauses definition.
- Planning (re-planning) the project and planning (re-planning) the risk aspects of the project in the proactive (response planning) and in the reactive sense (contingency planning).
- Planning the subsequent risk monitoring.

The seventh phase (monitoring and control) includes:

- Risk monitoring. The team must monitor the project and its objectives, the evolution of risks, responses and alarm signals and the general risk function.
- Reviews. The team must review, periodically and when necessary, the risk and response identification, the analysis, the evaluation and the planning.
- Crisis management. When crisis arises (many times a consequence of a bad project risk management) the team must:
  - analyse the crisis,
  - implement planned corrective actions
  - and develop and implement urgent and non previously planned responses or workarounds (Project Management Institute, 1996; Wideman, 1992).
- As a result of the previous steps in this phase, periodical and exception risk reports will be issued, to be included in periodical and exception project reports.

An eighth and last phase is needed to learn from the current project at the end of it and to update the corporate risk databases and check-lists. It's recommendable to issue a specific final risk report to be included in the final project report.

An example of simple project risk management process for cases of small sized projects or "zero" situations

In case of small sized projects a very simple project risk management process can be undertaken. It's also recommendable for any kind of project sizes and complexity levels when it's the first time for the company (de la Cruz, del Caño, Domínguez, 1996) to apply project risk management ("zero" situation).

The project risk is the possibility of system non-compliance with some of the project objectives, and it's associated to the probability of the non-compliance event and to the potential loss (severity or impact: scope or quality underruns, time or cost overruns), many times translated into monetary terms.

In this way, the risk management will try:

- To identify the risks before they can cause any problem.
- To evaluate those risks paying

special attention to the more important ones, in terms of probability, severity and expected value.

- To analyse the more suitable strategies to reduce (if possible, to a zero level) the probability and/or the impact.

The process is a simplification of the previously explained eight-phase approach (Figure 1). Some of the shortcuts for this case have already been defined in the previous paragraph. Other aspects will be explained here. First of all, in case of "zero" situations it's highly recommendable to make use of the first time risk management is used to develop a simple, short, formal corporate procedure covering the process. A global view must be considered, relating the project risk management procedure to every other project aspects and functions: general management, planning, scope, quality, time, cost, information, communications, human resources, procurement and project environment (client characteristics, stake-holders, etc.). In this way, a meditation about the main problem causes and solutions must be made, classifying the several project risks and including all that risks in a database, and all the possible responses in another database. These databases must be comprehensive in relation to the current project, but not so much in relation to the company. An amount of, let's say, 50 risks and 200 responses can be identified in the database zero revision, including external (predictable and unpredictable), internal-non technical, technical and legal risks. Each risk factor can normally have a number between 5 and 15 associated responses. A specific action or strategy can be a response for more than one risk factor. And there can be several alternative sets of complementary responses. Both databases (founded on the existent internal and external experience) must be incorporated to the formal procedure, to conform a first documentation to make easier the identification, analysis, evaluation and planning phases for the project team. The software support for databases can be as simple as any DBase, Microsoft Access or even any normal electronic sheet or word processing.

The first process phase (project) must be developed at its complete scope in any case. In this case the second phase (process) can be included in the formal procedure, establishing the scope here explained as the standard scope for this kind of projects. Several typical stakeholders and motivations can be included in the procedure, to reduce the team work. The time and cost objectives can also be more or less defined in the procedure.

As mentioned above, the procedure will include the two databases to help the team in identifying risks and responses (third phase). Tables 3 and 4 include an example of that databases configuration. A secondary identification loop can be established as optional.

The first database will also serve as a check-list for the analysis and evaluation purpose (phases forth and fifth). Considering the case (small sized projects), the analysis phase is obviated including in the formal procedure the standard "model", defined by the identification-assessment database (Table 3) and common to all projects of this kind. The evaluation phase is a qualitative one, where the project leader, leaning on the project team, evaluates each risk factor as a low, medium or high risk level factor. The identification-assessment database serves to this purpose and is designed to make this phase easier for the project team. When it's possible, the database directly establishes the risk level (low, medium or high) as a function of some accountable factor, for example, one of the risk levels related to the project volume is assessed as a function of the total estimated necessary man-hours, being 3.000 and 15.000 man-hours the corresponding limits. So the evaluation is sometimes based in quantitative aspects (e. g. the estimated necessary man-hours to complete the project, the estimated completion time, the number of project personnel or the number of organizations involved), but finally the assessment of the risk level is qualitative, because the complete subjectivity to determine the limits, in man-hours, for a low, medium or high risk related to the project volume.

The planning work to do for the sixth phase (planning and immediate actions) can also be reduced using the second database (Table 4). The seventh phase (monitoring and control) must be developed at its complete scope using the results of previous phases and also the two databases to review the identification, evaluation and planning. The final post-process learning phase will consist, as a minimum, in updating the databases. And it's recommendable to document the results of previous phases.

The procedure and the databases implies a risk management concept applicable to the owner and the contractor. A minimum process must begin when the owner is conceiving the project or when the contractor is invited to bid, trying to avoid unfavorable project conceptions or unfavorable contracts.

The simplified process and the formal procedure are very simple and low time consuming for the project leader and for his/her team. There is an initial hard work while studying the project. Then a very reduced work while performing the second phase. And a certain work of meditation, then, while reading, completing (if necessary) and evaluating the risk factors contained in the database. This can be based in a project team "brain-storming". At the end of the evaluation phase, the project manager will write a report (in one or two pages) summarizing the results of phases one to five, and adding the filled check-list related to the first database.

Once the risk factors and levels are established, the planning for the risk response is performed by the project team at the same meeting and with the help of the second database. The formal procedure must make the project manager know that a specific response can improve the situation related to a risk factor, but in parallel can increase the risk level in other project areas. A better way of reflecting that reality in the procedure is to include in the second database the possible secondary effects for each response. Finally the response plan is built as a part of project plan (writing the project team a report in 2-5 pages), and both are implemented. The corresponding report is communicated to the General or Operations Manager.

To begin as soon as possible and to make a continuous process are two key aspects. The later the risk is identified, the bigger the impact may be and the bigger the difficulty to respond. In that sense, the identification, the evaluation and the planning phases will be revisited. So the procedure must establish a feed-back iteration always when an important event occurs, and also periodically all along the project life cycle. For example, a minimum of one iteration for projects shorter than 4 months can be established. In case of longer projects the review can take place, for example, every two months. When a new risk factor is identified, the project manager, according to the formal procedure, must increase the database with it, and with the corresponding assessment "formulas" and responses.

After a continuous minimum use of, let's say, 10-15 projects or 1-2 years, the process could be increased in its scope, including more sophisticated risk analysis tools. But this will not be advisable if the initial implementation was difficult, or its utilization costs were higher than expected or profitless than expected, or the increased risk management system will be much more expensive than this simple version. It's also important to achieve a "fun" perspective of risk management.

So, after that period of system testing and assimilation by the company culture (depending on the actual acceptance and effectiveness), it is possible to more or less (as a function of project complexity and of project absolute and relative size) increase the system scope in the ways already referred to in paragraph 3. As mentioned, the only conditions will be easy to use tools and low time consuming.

Benefits of using this kind of processes

There are many benefits that can be obtained from using this kind of processes in a correct way. Some of that benefits can be:

- All project aspects and objectives can be better understood from the early project phases and, so, a more realistic project planning can be achieved.
- The uncertainty assessment is more realistic and the project objectives definition can be improved.
- There will be an improved communication flow between the project team members and between the project team and the other stakeholders, in a context of data exchange that will stimulate the reflection and cooperation between the project participants.
- A more detailed information is available to plan the project and, in general, to make decisions.
- The reasons to make decisions are adequately documented, so there will be a learning process for future projects.
- The contingencies planning and the contingencies budget and reserves will be better documented and supported.
- Corporate experiences and knowledge are documented for future projects using data bases and procedure manuals. After a transitional period, that documentation will allow easier and quicker actions. Besides that, all the company personnel will share the experiences and the knowledge.
- In certain circumstances, the company can achieve cost reductions when contracting specific insurance policies.
- In general, cost reductions can be achieved. Nielsen and Galloway (1992) say that an adequate

PROJECT RISK IDENTIFICATION & ASSESSMENT
Page DB 1-1

Project: ____________
Assessment date: ____________
Code: ____________
Precedent assessment date: ____________
Client: ____________
Project manager:

1. Aspects related to project volume and complexity

Risk factor assessment	Risk level
(1-1) Total estimated man-hours:	
- less than 3.000	low
- between 3.000 and 15.000	medium
- more than 15.000	high
(1-2) Project estimated completion time:	
- 4 months or less	low
- between 4 and 8 months	medium
- more than 8 mounts	high
(1-3) Project team volume:	
- 2 persons or less	low
- between 3 and 7	medium
- more than 7	high
(1-4) Number of existing or to be built by other) systems that imply interfaces with the system to be built by us:	
- none	low
- between 1 and 3	medium
- more than 3	high
(1-5) Number of user organizations (departments, etc.) to coordinate:	
- only 1	low
- from 2 to 4	medium
- more than 4	high

Table 3. An example of project risk identification and assessment database

PROJECT RISK RESPONSE
Page DB 2-1

Project: ____________ Review date: ____________
Code: ____________ Precedent review date: ____________
Client: ____________ Project manager: ____________

Risk factor/Responses:

(1-1) Project volume in estimated man-hours
- To make a formal documented project plan (project manual; see procedure 110)
- Communication with any possible stake-holders and corresponding feed-back
- To obtain the stake-holders leaders commitment
- To obtain the users and client or sponsor acceptance to the change management procedure (included in project manual or contract; see procs. 125 and 110)
- Independent sub-projects braking-down
- Special attention to the project team needs or requirements
- To involve the project team leaders into the management activities
- Discussion with the project team and reviewing the total quality strategies for this project (see procedure 115)

(1-2) Project estimated completion time
- Strategies related to the precedent risk factor
- If innovation project, development and implantation by phases to check partial results
- Clear interfaces and project landmarks identification
- To document any decision making related to design
- To promote the variation on the project team work to avoid the routine
- If familiar project, to overlap design, procurement, construction, testing and training phases

(1-3) Project team volume
- Clear and formal responsibility matrix definition and formal resources allocation
- Individual and formal global and personal objectives communication to the project personnel, specially on the budget aspects
- Estimation of the time and cost necessary for the correct communication and coordination, and its inclusion in the global estimations
- To restrict the number of team members under direct supervision to 5 persons, or provide a project engineer
- To foster informal communication procedures
- To maintain periodical meetings with the key persons and with predefined agenda
- To divide the team on sub-teams responsibles for final products, with an assigned leader for each sub-team

Table 4. An example of project risk response database

project risk management can achieve a minimum of 5% of cost reduction. That aspect will be a competitive advantage to sell the product or to win contracts.
- Documenting the risk aspects will also allow the company to bid in less time and at a less cost.
- An adequate risk management will facilitate the definition of the most suitable contract type for every procurement to undertake in the project.
- An adequate risk management will allow to take advantage of the project opportunities, and that will facilitate to achieve or even to exceed the project objectives.
- The project management will be more proactive (less reactive), anticipating and controlling the possible future events.
- The confidence, calm environment that can be achieved when the project team know that the real implications of uncertainty and risk have been analysed and included in the project plan.
- The project manager will acquire a feeling of really being leading the project, instead of the frequent feeling of being led by the project.
- A reduction of the probability of sub-optimal project execution and, so, higher opportunities of success for the project.

The reader can find more achievable benefits of using this kind of processes in Association of Project Managers (1992), Chapman and Ward (1997), Clark et al (1990), Nielsen and Galloway (1992), Reitan and Hauge (1997), Simon et al (1997), Ward and Chapman (1997) or Wideman (1992), among others. And all that benefits can be achieved by all the project participants (owner, contractors, sub-contractors) in any type of contract (traditional, turn key, BOT).

Conclusions

In a very competitive environment, as the construction market is, it's necessary to develop a correct project management culture and to use adequate project management techniques, and that also includes the project risk management functions.

The definition of possible shortcuts to a complete risk management process is influenced by the complexity and the relative size of the project. And the kind of risk analysis techniques to use is influenced by the complexity and the absolute size of the project.

Even in the large construction projects the management solutions for the risk response should be simple. In case of small and medium sized projects with low and medium complexity levels, the process here suggested (summarized in Figure 1) avoids the use of sophisticated computer systems and mathematical methods, which cost, in addition, can be difficult to support in that kind of projects. It is a simplified eight-phases risk management process with the following phases:

1. Project, to study the current project and the possible aspects that are sources of uncertainty.
2. Process, to define the project risk management process stakeholders, motivations and characteristics.
3. Identification of primary and secondary risks and responses, and also of project opportunities.
4. Analysis, to establish a model (or models) for the risk evaluation purpose.
5. Evaluation, to quantify parameters and model(s) uncertainty. This phase can be reduced to a qualitative evaluation in cases of small sized projects.
6. Planning for risk (proactive and contingency planning) and immediate actions, including risk allocation, contractual type and clauses definition and the planning of the subsequent risk monitoring.
7. Monitoring and control. Including monitoring the project, its objectives, the risks, the responses, the alarm signals and the general risk function. It also includes the necessary feed-back loops to previous phases and the crisis management. As a result of previous steps in this phase, periodical and exception reports will be issued.
8. Post-process learning, and updating corporate risk databases and check-lists.

The paper also suggests possible risk analysis techniques to use in relation to the project size and complexity. Range estimation, decision trees and probabilistic influence diagrams combined with Monte Carlo simulation and sensitivity analysis are suggested to use for feasibility, scheduling, budgeting and quality purposes. And several alternatives of commercial software packages to be used are commented.

It's also suggested an extra-simplified process and a formal procedure in case of small sized projects and/or environments where this is the first time a formal procedure to manage project risks is used. This process is based on standard corporate check-list databases (Tables 3 and 4) to help the team to identify, assess and respond to risks.

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Management of Finances and Profitability in Project Companies

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Keywords: Project Company, Project Business, Project Accounting, Management Accounting, Profitability Measurement

The article provides a framework of three important approaches for managing the business in a project company in profitable manner. First, deriving company income statemgnts from project data is discussed. Second, timing principles of recording costs and income are considered, aiming at an implication that rather future than past income statements and future profitability are derived from project data. Deriving forecasts of future profitability instead of sticking to past or current status enables proactive management in the company. Third, principles of applying budgets and estimates as well as using the data associated with bids and not just that of order book projects are discussed. Such project related organized budget, estimate, and bid data allows deriving future income statements as forecasts of future profitability. As the principle of how the company and its projects are organized as a whole is the basic important aspect in this context, organizational and management accounting frameworks are first elaborated as the basic important structures and management practices enabling the suggested features.

Introduction

Basic management accounting principles are introduced for managing profitability of the overall business consisting of the project flow in a project company. Management accounting principles applied in project companies such as large engineering companies and major process plant turnkey supplier organizations forms the empirical background of the discussion.

The organizational and management accounting framework and calculation principles introduced allows deriving company income statement from project data. Principles of arranging the organizational structures allow appropriate calculation. The important principles include accounting practices associated with borrowed and lent resources, income recognition, project budgets, updating project estimates, deriving committed costs from purchase orders, and taking into account bid information that will contribute to future profits.

The aim is to provide a concrete tool for managing future profit accumulation not only at the level of single projects, but at project portfolio level as well. Applying budgets and continuous estimate updating enables reporting of estimated profit accumulation - at all levels from company income statement level to business units and further down to projects, sub-projects, and separate sub-project items. The aim is to enable proactive management practices that support precautional corrective actions.

The article first introduces important basic principles of establishing organizational structures and related management procedures in a project-oriented company. After elaborating this basic important organizational and management basis, deriving of company income statements from project data is discussed. Early timing principles of recording costs and income enable deriving future income statements as forecasts of future profitability. Principles of applying budgets, estimates as well as organizing the data associated with purchase orders and bids are discussed as means of recording costs in an early stage. Income statements of future periods ca be derived from such project related data.

Research Methodology and Introduction to Existing Research

The analysis conducted results to a conceptual framework for managing and organizing a project company. The research methodology for constructing such a conceptual framework is basically decision-oriented - or management science oriented (Neilimo, Näsi 1980, Kasanen et. al. 1993). The article includes theoretical reasoning of a framework suggested for managing project companies. The empirical organizational model and management practice development occurred in large process plant turnkey supplier organizations forms the empirical background of the framework presented. The reasoning is partly based on the author's experience and insight obtained when developing the field empirically when working for a major turnkey supplier of power plants, power transmission lines and other energy systems. The article could be thought of as a first basic theoretical construction of the framework, and in the future there will be empirical case and other studies that will build on this framework study.

There are not many studies that provide theory of project business. Projects and the management of single projects are important vehicles in the management of a project company. However, within the company management context such company management oriented areas as strategic and operative management and problems of organizing for project sales and marketing, easily overrule the problem of just concentrating on executing a row of single projects successfully.

The existing project management standards concentrate on providing definition and content for project management in the context of managing single projects (see PMBOK 1996, ISO 10006, 1997). In the project company side, a project company model is derived and project business is outlined by Artto et. al. (1998). The other few existing studies that can be thought of being closer to the project company field concentrate on the 'management by projects' principle, the specific areas of project sales and marketing and systems selling, and specific aspects in the project company business context as a whole.

'Management by projects' introduced in more detail by Turner (1993) and Gareis (1994, 1996) refers to an organization's way of conducting its work and tasks in a project form. In such an organization, projects cross the organizational department boundaries and may get their resources, say, from the hierarchical functional organization. Management by projects means applying project management to the management of organization's ongoing operations. Applying this approach means that planning and executing projects and applying project management are important parts of the overall management effort. Also Cleland (1994) discusses projects as tools in an organization that should be used to contribute to execution of organizational strategies, objectives, goals and mission. The project sales and marketing aspect is discussed in Ahmed (1993), Cova et. al. (1993), Gunter, Bonacorsi (1996) and Holstius (1989). Business aspects of a project company from a wider context are discussed in Kosonen (1991) and Robinson (1988).

The article discusses the economic and management accounting side of the new paradigm concerning management of a project company and project-oriented business. The important basic organizational aspects and management practices of a project company are discussed by Välimäki (1996). Söderholm (1997) introduced notions on management accounting and accounting systems approach in project-oriented companies. The discussion in this article is to a large extent based on Artto's (1998a) discussion of management accounting in a multi-project environment. The article elaborates further the project company model and project business theory by illustrating an organizational model and developing a management approach in the area discussed previously by Artto et. al. (1998), Välimäki (1996), Söderholm (1997) and Artto (1998a).

An Organizational and A Management Accounting Framework

Company and Project Structures in the Organizational Context of Business Processes

In the following, basic elements of the organizational framework are illustrated in order to provide a foundation for appropriate management practices and management accounting in a project company. Company structures and project structures are shown in Figure 1. The company organization is subdivided into business units (or resource units respectively, c.f. the later discussion about resource pools). Business unit subdivisions and further subdivision of the organization are often based on criteria about product or project type, customer, and geographical area. Project structures represent descriptions of the work to be done in the project; project structures are formed by subdivisions based on a mixture of components and products as deliverables of the project, and tasks as description of work and activities to be conducted. Projects are first subdivided into subprojects, and then further to lower level items.

The content of the project structures depicted in Figure 1 can be understood by analysing the business processes in a project company. Project processes generally can be subdivided into project management processes and product-oriented processes (PMBOK 1996). Product-oriented prosesses conducted in projects include engineering and manufacturing. From a structural - and management accounting - point of view, projects are depicted by hierarchical Work Breakdown Structures (WBS) that define project management, engineering, and manufacturing tasks.

In a project company, a project business management process is a process comprising management of the whole company and its projects (Artto 1998b). From a structural viewpoint project business management relates to company level management rather than management of single delivery projects. Project business management can be thought of being situated in a leading role above project management, engineering, and manufacturing, as it provides guidelines and instructions about general business practices in projects, and further, balances resources as well as profit and risk aspects across projects (meaning a company level project portfolio aspect in e.g. risk taking). Project business management includes administrative components such as:

- General administration
- Sales and marketing
- New product development

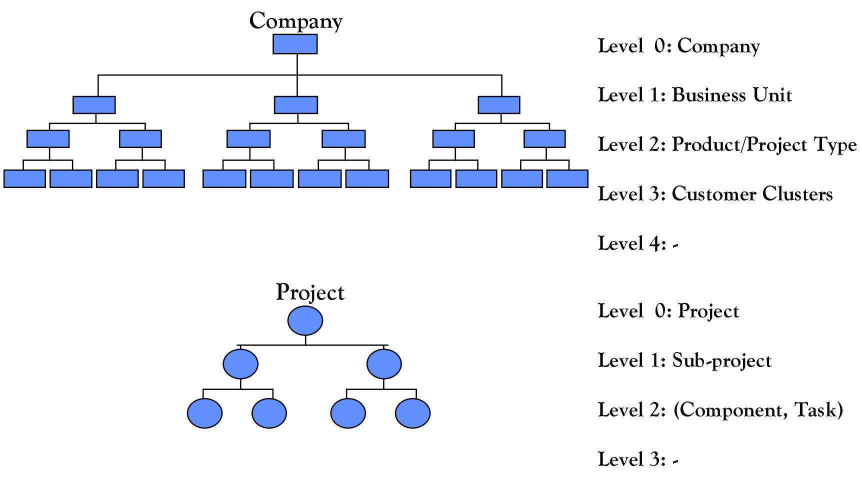

Figure 1. Company Structure and Project Structure

- Development, i.e., organizational and process development, research, training and education

Although at least some parts of administrative activities are permanent in nature, it is suggested that the costs and resources of such administrative efforts are recorded to a project structure, too. The term administrative project is in the following used to indicate to company's internal efforts such as general administration, sales and marketing, and development. Some of the administrative efforts are real unique project-wise efforts that may be managed as projects (see e.g. discussion of organizing project sales and marketing in Välimäki 1996). However, although some part of the administrative work is not of project nature, it is suggested that uniform management practices are applied by constructing analogous project structures for administrative projects as in case of e.g. external delivery projects. Actual costs, budgets and estimates of administrative efforts in the whole company are then suggested to be recorded to project like structures. However, the difference between administrative and delivery project accounting is in recording income: administrative projects are not invoiced from customers but only costs and not sales income is recorded to them.

The hierarchical structure of an administrative project could be the following (see Figure 1). Level zero will be titled according to the owner organization unit (see Figure 2 illustrating the organization units as owners of project structures), e.g. administrative project of the resource unit 'Electric Engineering Services'. First level of the administrative projects defines standard items such as general administration, sales and marketing, and development. Second level then, may be a standard subdivision of items, or may include certain project like efforts with a specific start and end date, e.g., a customer specific marketing effort, or a product specific development task.

Company and Project Structure Interaction - Projects in a Company

The project company organization with project and resource interaction is illustrated in Figure 2. The organization in the figure is subdivided into a resource pool side a project pool side. In the figure, there are two business units in the project pool side that own exter-

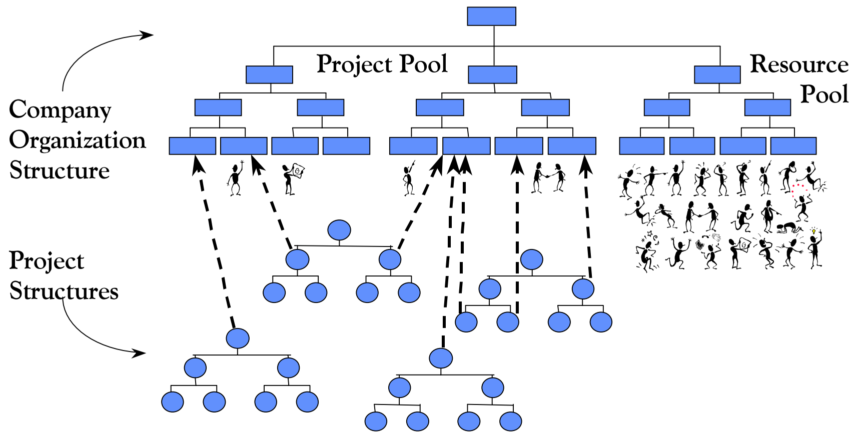

Figure 2. Projects and Resources in the Company - the Ownership Aspect

nal delivery projects, and there is one resource unit in the resource pool side. In general, the subdivision into project pools and resource pools is not so clear. Usually there are several project and resource clusters in different levels of the organization. For example, in modern organizations there are competence centers situated to different parts and different levels of the organization. The principle of a competence center corresponds to what is discussed here concerning the resource pool part of an organization. However, although there may be several project pools and resource pools at different levels of the company organization, for clarity reasons, our discussion is based on the illustration in Figure 2. The figure provides us a platform of clear distinction between the project pool and the resource pool at the very top of the organization.

As we discuss resources and resource usages, we make here an assumption - again for clarity reasons - that we refer to individuals and their man-hours. However, the principles discussed in the following can be generalized i.e., they are applicable also with other resources types. Figure 2 illustrates the feature that resources are owned by company organization units. The majority of resources are owned by the resource pool, but there are certain amount of employees that are owned by organization units in the project pool side as well (e.g. project managers, project sales and marketing staff). External delivery projects are owned by organization units in the project pool side. The ownership of projects is marked in the figure by arrows (dotted line). The arrows indicate the organization unit where the project (or lower level item in the project hierarchy) belongs to. The arrows also indicate simultaneously the organization unit where the project profit is accumulated to. Note that it is not necessary that the whole project is owned by one single organization unit. The ownerships can be defined at sub-project level, or at even lower levels as illustrated in the figure. If the ownership of a project is shared e.g. by two organization units - say the other being responsible for the civil works sub-project, and the other for electrification sub-project - the sales income invoiced from the customer should be shared and recorded internally at least down to the sub-project level. This way, sales income is accumulated in both sub-projects, and balances the cost incurred in the sub-projects, enabling that both sub-projects are profitable. The income from both sub-projects are then summed up to both owner organization units. However, in any case, the project remains as one entity, of which the project manager is responsible for. The arrangement to share the responsibility and profit as described above, will remain as a company internal scheme only; The external customer will see only one well coordinated delivery project, not two internal construction and electrification subprojects delivered by two internal suppliers.

It is suggested that in a project company costs of resource usages are always recorded to project structures only - not to any organizational unit directly. The principle of recording costs to project structures applies also in case of external costs. External ('material') costs are allocated to project structures by recording the costs to projects from purchase invoices (usually in the company's accounts payable system, to be then transferred to management accounting). However, from the management accounting perspective, the case with costs of internal resources is much more complicated than what is the case with external material costs. This is because of other (internal) organization units lending the resources to borrowing projects owned by other organization units. Lending and borrowing resources across organization units raises up the problem of pricing resource usages in order to compensate the resource loans to lenders. The management accounting problems and solutions with lending and borrowing resources are discussed in the following.

Enabling Efficient Use of Resources - Resources Lent and Borrowed

Organization units belonging to the resource pool side of the organization maintain special skills of their resources. The 'business idea' of those resource units is to provide internal services by lending resources to projects. It is required that resource units remain competitive in their field of offering special services internally. A sign of competitiveness could be e.g. that there is enough demand for their services. The management accounting solution of the internal supply and demand relationship would be to arrange compensations to the lender party, and on the other hand, allocation of the costs to the borrower party accordingly.

As far as the compensation arrangement is concerned, the principle might be e.g. that the lending resource organization unit gets, say $100 per man-hour as internal compensation (internal income). Accordingly, the project as the borrowing party must let the employee record a man-hour cost of $100 to its project structure. The follow-up of internal income and cost transactions may be based on weekly, bi-monthly, or monthly resource time reports of man-hours allocated to projects.

Naturally the internal transaction cost must be agreed upon. The internal compensation arrangement should be understood as a management vehicle increasing the willingness of the resource organization unit to develop and hire its resources, and aim at efficient use of resources. Also, the internal man-hour cost should be reasonable from the borrower's point of view. This way, the arrangement promotes efficient use of resources.

This discussion about internally pricing man-hours means that not only raw costs equal to the employee's direct wage or salary per man-hour is recorded to the project, but in addition to the raw costs, also burdened costs per man-hour are used to adjust the price of a man-hour to an appropriate level. Leveling man-hour costs by using appropriate level of burdened costs could also be thought of applying cost levels that covers also overhead costs allocated to man-hours. The use of 'pricing' man-hour costs with burdens is applicable and useful especially to situations where the lender organization unit is different from the borrower's (project's owner) organization unit. In situations where an employee works for a project owned by his own organization unit, allocating just raw costs to the project is appropriate.

One principle might be to define the burdened cost per man-hour (or compensation per man-hour) to represent a cost level that will at an aggregate level compensate internally all direct costs for the resource unit at a certain demand. This principle would probably motivate the resource unit to target at full compensation for its direct costs, by aiming at desired man-hour lending magnitudes. Further, if the aggregated compensation matches with aggregated direct costs of resource units, the burdened costs allocated to projects represent a realistic level of what the man-hours cost for the company. Using such burdened costs then at the project level reveals how each project contributes to the operating income of the whole company.

The problem of internally pricing of burdens is very complicated in practice, being related to the problem of allocating overhead costs to external (or internal) projects and to organization units as project owners. Application of burdened cost per man-hour brings the overhead costs to the project level as burdened costs are recorded to project structures. Whereas aggregating just raw costs to upper levels in the organization is rather straightforward, aggregation of burdened costs becomes rather complicated. Major problem with aggregation of burdened costs to upper organizational levels is related to the fact that burdened costs usually cover in a complicated manner overhead costs. Thus, burdened costs could be thought of to cover at least some (raw) costs recorded to administrative projects of our framework. Consequently, aggregation must be conducted by avoiding that costs are not taken into account twice when summing up costs. This is done by eliminating carefully in the calculation those costs already taken into account, as same costs recorded to administrative projects might already be covered by burdened costs. Further, another and more straightforward problem area is to always eliminate pairwise burdens and corresponding internal compensations (internal incomes) as opposite to costs in the aggregation procedure.

Deriving Company Income Statement from Project Data

Deriving Income Statements for Current and Future Periods from Project Data

Figure 2 is illustrated in a way as if there were no administrative projects at all. However, we may say that some of the projects illustrated in the figure might be administrative. As far as the figure is concerned, at least one controversy exist: The organization units of the resource pool side own administrative projects that are left out of the illustration of the figure. As all organization units must conduct administrative work at least to some extent, each organization unit must own at least one administrative project where administrative costs are recorded. As the rule was presented above that the use of resources and respective cost will be recorded only to project structures - and not organization units directly, the resources must have the possibility to record their man-hours also to administrative projects owned by the resource pool side units. This occurs e.g. when there is need to record costs and man-hours used for training and education organized by the resource unit.

The established organizational framework above allows a standard procedure to plan and monitor work and operations in a company by applying analogous project structures for whatever effort performed by the organization: All activities are seen as a part of some project structure, and costs are always recorded to a project structure (owned by an organization unit).

It was suggested above that projects are the basic structural building blocks for recording both costs and sales income. External delivery projects are profit-making vehicles. Costs and sales income are recorded to projects, and project specific cost and income reports are used for management of profitability. Company income statements (and also balance sheet information) and business unit or other organization unit specific income statements can then be derived by aggregating project income and cost information to organization units.

Applying raw cost applied in delivery projects and delivery project reports means that gross income is monitored at the project level. Raw cost of man-hours correspond to the wages and salaries paid to the employee. The gross income of the company level income statement is got by aggregating the gross income from projects. The interrelation between company income statement and cost data recorded to hierarchical project structures is depicted in Figure 3. The income statement of the company is illustrated at the left side of the figure, and at the right there is an illustration of a hierarchical report with sales income, raw cost and gross income paragraphs, the format of which allows reporting of project structures (and any other organization unit item above the project, or subproject item below the project level). Figure 3 illustrates that from sales income data and variable cost data of a company income statement it is possible to drill down along the hierarchy to organization units and single delivery projects, and from single projects further down to lower levels. This occurs due to the fact that sales income is aggregated from delivery projects, and variable cost in an income statement is aggregated from raw costs recorded to delivery projects.

Further down in the income statement, costs incurred in administrative projects represent fixed costs in the company income statement. Thus, fixed costs in the income statement are aggregated from raw costs recorded to administrative projects. Deducting fixed costs from gross income gives the company level operating income as a result. The hierarchical approach again allows analysis of fixed costs by drilling down from the company level back to organization units and administrative projects along the hierarchies (see Figure 3).

The structural and hierarchical approach described above allows a steady reporting possibility with the same report format at different levels and enables management of a company and its projects where the management at different levels is based on same principles. The advantage of the above described arrangement is that the reporting formats are standardized and the profit target set to a project contributes directly to the profit of upper levels and the whole company. And vice versa, the drilling down to lower levels from the company income statement level allows focusing on how targets set to projects are achieved and what is the contribution of a project to the overall result of a company.

Using burdened costs instead of raw costs at the project level then allows calculating a project specific profit based on different cost assumptions. Burdened cost refers in case of man-hour cost to use of man-hour cost that is higher than the raw cost. For example, full cost accounting could be applied if appropriate cost level for the burdened cost is chosen accordingly. The use of burdens is related to the problem of pricing lent and borrowed resources. If costs are burdened, consolidations become complicated as discussed in the previous section: When aggregating the income and cost up to organization levels, burdens must be purified in relation to administrative overhead costs, and internal transaction costs and their pairwise compensations (opposite to cost) must be eliminated in the aggregation procedure.

burdens caused by transactions across organization items below must be purified.

The structure and related management accounting principles suggested above enable judgements of project and business unit profitability, and how different projects and business units contribute to overall profitability of the company. Further, if project income and cost estimates are updated in a frequent manner, and income recognition calculation is applied as discussed in the following, it is possible to automatically derive income statement estimate concerning any future time period. Proactive management practices are thus supported by enabling corrective measures that can be taken in advance.

Income Recognition Principles for Matching Income and Cost for Profitability Calculation

Income recognition is of importance in order to enable in a systematic way and automatically calculate the profit earned at any period of time. The basic idea why income recognition calculation is needed is the fact that invoicing for the work performed is not synchronized with when the income is earned. The incoming and outgoing money flow is recorded to projects with no synchronization with an implication that the income statement for any period cannot be derived from projects by just aggregating the invoiced income and paid costs. Basically, the income is earned when the work is performed - whether it is invoiced immediately or not. For example, in fixed price delivery projects, the terms of payment for the customer - and revenues invoiced by the project - do not necessarily correspond to the actual work performed and income earned. Thus, to obtain the profit, the income that match the cost and work performed must be calculated in a periodwise manner regardless of the invoicing status.

For simplicity, we divide project company's external delivery projects into two categories:

- Time and material type projects. Income is based on applying agreed man-hour price lists on work performed (time); The

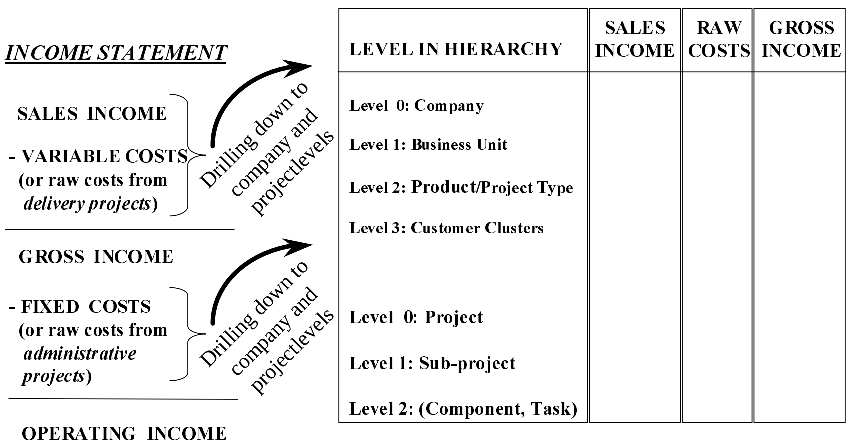

Figure 3. Deriving Company Income Statement from Project Data

customer is invoiced in certain periodical increments as agreed with the customer, say on a monthly basis or so; Further, purchase costs from sub-suppliers (material costs), and in addition, certain percent of material costs as material handling fee is invoiced.
- Fixed price type of projects. Income is based on fixed price, and invoicing is performed according to the terms of payment agreed with the customer.

When we are in a situation to calculate the accumulated income from the beginning of the project until say e.g. timenow period, its is clear that in both time and material and fixed price projects the cost incurred is obtained directly from the company cost accounting system where costs have been recorded. However, an important factor to consider here is the potential delay in recording costs in company systems. If man-hours are recorded to the cost accounting system from time reports frequently, say e.g. on a weekly basis, the man-hour costs are probably rather up-to-date. If - and often when - suppliers' costs are recorded from suppliers' invoices to accounts payable and then transferred to cost accounting, there usually are delays between the time of performing the work and the time of recording costs. Delays might be significant from the moment when the supplier has performed and handed over the work, to the point of time when the supplier's invoice arrives as a purchase invoice and is then recorded to a company accounting system.

However, despite the discussion above, we make here an assumption that the man-hour and cost data in the accounting system is made on accrual basis, i.e., costs are accumulated as work progresses. Thus, it is obvious that we have costs available in the system that are in accordance with the (work) realization principle.

Now, in case of time and material type project, the income recognition means that income for the timenow period is calculated by applying the man-hour price list and material percentage price list for deriving the income earned so far. The price lists are those that are agreed with the customer; The same price lists are used for customer invoicing. In fixed price type projects the income recognition is conducted in the following way:

- Income is calculated by applying percent complete.
- Percent complete is calculated by dividing costs accrued by the latest updated cost estimate of the total project.
- The earned income is obtained by then multiplying the latest income estimate of the total project by percent complete.

If time-phased estimates are applied, earned income can be calculated for any given point of time in the future. This occurs if the principles explained above are used by replacing the actual man-hours and costs until timenow by latest cost estimate based man-hours and costs at that point of time in the future. The inherent logic is that the timenow point of time is shifted to a future point of time, and as actual costs are not available in the future, latest estimates of that point of time must be used instead. This way, also future profitability of projects, and when aggregated, future income statements for the whole company and its organization units can be calculated in advance by using the project estimate data available.

About Timing Principles: Recording Future Costs Rather than Actual Costs

It was described above how company income statement could be derived from project data. As far as the actual income and cost are concerned, it is important to calculate income statements of actual data on a monthly basis or so in order to be able to compare the actual accomplishment with the plan. However, it is suggested here that forecasts of future income statements are calculated well in advance in order to enable corrective measures. When calculating future profit from project data, we face the question of timing principle of when to record costs and income to projects. The obvious solution to the timing problem is to record costs and income as early as possible.

For early recording of costs and income, three concrete aspects of cost and income of different early time points are introduced in the following. The first aspect is to record budgets and estimates to project structures that reflect forthcoming actual costs. We can establish the first estimate in the beginning of the project and update it any time when we obtain information that allows us to provide a more accurate estimate. Budgets and estimates can be recorded to projects even years in advance which enables calculating of company profit from the project portfolio in a very early stage. Second, recording committed costs to projects associated with purchase orders also enables rather accurate follow-up of costs well in advance.

The early estimate updates can be made more accurate by using committed costs. A committed cost occurs when a purchase order is signed or a purchase order is sent to a supplier. Committed cost refers to costs that we are bound to use as we have ordered the job, signed a purchase contract, or otherwise agreed upon the delivery. We have practically used the committed money already although the related actual costs will not incur until much later.

The different timing principles of costs recorded to projects is illustrated by a graphical cost status report in Figure 4. The figure shows that actual income and costs up to the time now period enables calculation only of the profit earned in the project so far if income is matched with the cost by some income recognition principle. However, the latest updated time-phased income and cost estimate of the project can be used to calculate the contribution of the project to the company profit for any future period until the end of the project. The committed cost (the steepest curve showing the committed costs up-to-date) in turn reflects future costs rather accurately as far as the purchase orders and contracts are concerned, and it can be used to define future costs in a more accurate manner. For example, committed costs can be derived from the company's materials management system where purchase orders are registered to project structures with information about their monetary values. Project specific time-phased costs for future periods can then be estimated from the terms of payment data recorded to purchase orders.

The permanent type internal administrative efforts of no considerable actual project nature should be treated in the accounting system as hypothetical projects with a limited duration, the duration of which match to the yearly corporate planning cycles. This way, budgets and estimate updates could be

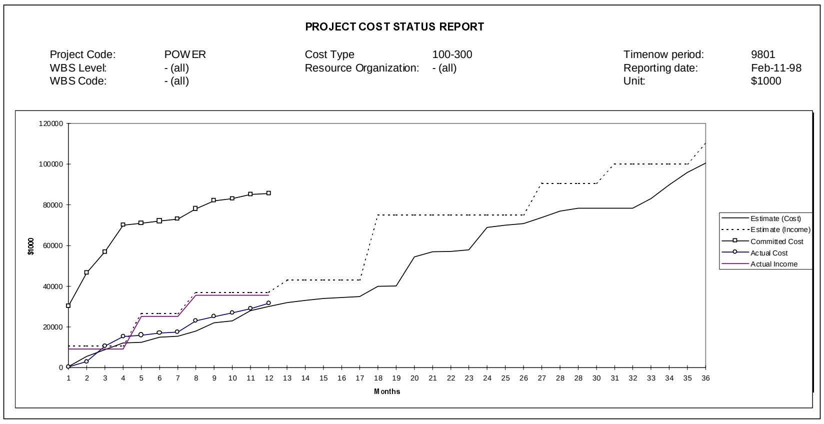

Figure 4. Project Cost Status Report

applied also to administrative work in a natural way that is analogous to all (other) projects. When subdivided into twelve periodical increments if needed, the yearly budgets for fixed costs would in this way be treated as time-phased monthly project budgets.

The third - and most far-reaching - future oriented aspect of calculating income statements from project data is that of deriving expected income and cost from bids. As we have so far discussed projects as work items included in company's order books, bids represent project prospects in a pre-project phase that have not reached the status of a project yet. The mechanism of bids turning into projects in a project company is illustrated in Figure 5. The figure shows that in a certain point of time there is certain magnitude of bids and ongoing projects. After certain period has elapsed, some projects have been closed and handed over to customers. Others are still ongoing, and in addition, some of the bids have turned into new projects and will now after project start be given a status of ongoing projects. Each bid does not lead to a contract but the bids each have certain probability of becoming an executable project. The 'hit ratio' indicates the average proportion of bids turning into projects. When bids are used to forecast the forthcoming profit of a company, it is important to develop an algorithm that takes into account the bid portfolio as a whole by considering the probabilities of individual bids as hypothetical projects of turning into contracts and executable projects if agreed with the customer.

Conclusions

There are not many studies that provide theory for project business and the management of a project company. The article elaborates further the few studies of management of a project company and project-oriented business by illustrating an organizational model and developing a management approach supported by appropriate management accounting principles. The solution introduced can be thought of as the basic framework for an overall organizational model to support efficient project flow in a project company.

The analysis conducted represents theoretical decision-oriented - or management science oriented - reasoning of a framework suggested for managing project companies. The empirical organizational model and management practice development occurred in large process plant turnkey supplier organizations forms the empirical background of the framework presented. The article could be thought of as a first basic theoretical construction of the framework, and in the future there will be empirical case and other studies that will build on this framework study.

The article provides a framework of important approaches for managing the business in a project company in profitable manner. A management accounting framework was introduced for project companies for managing future profit accumulation. Deriving of company income statements from project data is discussed. As the principle of how the company and its projects are organized as a whole is the basic important aspect in this context, an organizational framework is elaborated as the basic important structure that enables the suggested features. The organizational and management accounting framework, and calculation principles introduced, allows deriving company income statement from project data. The interaction between project structures and the organizational aspect is important. An ownership relation was suggested where external delivery projects are owned by organization units in the company. Establishment of administrative projects - or project structures - was suggested for e.g. general administration, sales and marketing, and development efforts. Costs and revenues are recorded to projects, and project specific cost and income reports are used for company management. Company income statements can then be derived by aggregating income and cost information from projects to organization units.

The management accounting applied must enable allocation of resources to the borrowing projects or sub-projects across business units. From a management accounting perspective, the company-wide use of resources occurs when business units get compensation for resources lent to projects that are owned by other business units. Accounting principles are introduced that promote efficient use of resources in the project company.

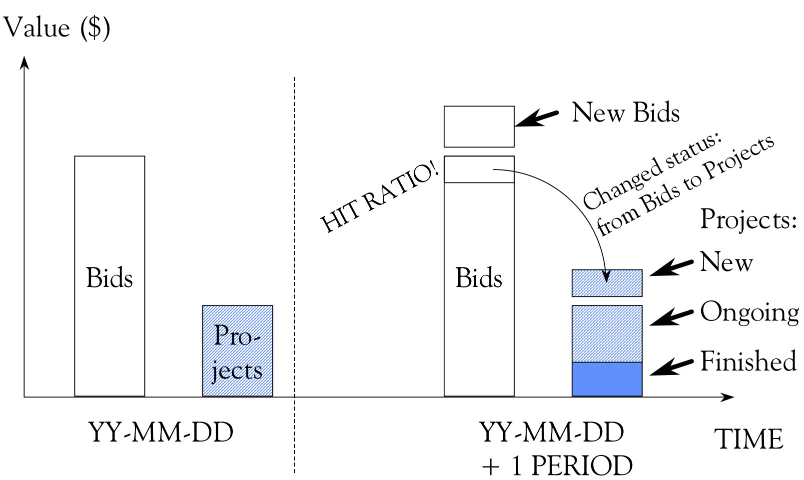

Figure 5. Mechanism of Bids Turning into Projects within a Period of Time

Deriving of company income statements from project data is discussed. The structural and hierarchical approach described allows a steady reporting possibility with the same report format at different levels and enables management of a company and its projects where the management at different levels is based on same principles. The established organizational framework allows a standard procedure to plan and monitor work and operations in a company by applying analogous project structures for whatever effort performed by the organization: All activities are seen as a part of some project structure, and costs are always recorded to a project structure. The advantage of the arrangement is that the reporting formats are standardized and the profit target set to a project contributes directly to the profit of upper levels and the whole company. And vice versa, the drilling down to lower levels from the company income statement level allows focusing on how targets set to projects are achieved and what is the contribution of a project to the overall result of a company.

Income recognition is of importance in order to enable matching income and cost for automatical calculation of the profit earned at any period of time. The basic idea why income recognition calculation is needed is the fact that invoicing for the work performed is not synchronized with when the income is earned. The income recognition calculation principles introduced are used for calculating income that match the work performed regardless of the invoicing status.

The article considered timing principles of recording costs and income, aiming at an implication that future income statements and future profitability should be derived from project data. Deriving forecasts of future profitability instead of sticking to reporting of just past or current status enables proactive management in the company. When calculating future profit from project data, we face the question of timing principle of when to record costs and income to projects. The obvious solution to the timing problem is to record costs and income as early as possible. Three concrete aspects of recording cost and income in different early points of time to project structures were introduced. The aspects were to record budgets, estimates or committed costs to project structures in advance that all reflect forthcoming actual costs. Budgets and estimates can be recorded to projects even years in advance which enables calculating of company profit in terms of the income statement from the project portfolio very early. The even more far-reaching future oriented aspect of calculating income statements from project data is that of calculating expected income and cost from bids. When bids as potential project prospects are used to forecast the forthcoming profit of a company, it is important to develop an algorithm that takes into account the bid portfolio as a whole by considering the probabilities of bids as hypothetical projects of turning into a contract and an executable project if agreed with the customer.

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CATEGORY: RESEARCH

Projects for Shareholder Value:

The Influence of Project Performance Parameters at Different Financial Ratios

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Projects are undertaken to add value to the sponsoring organisation. In the private sector, this ultimately means increasing the value of shares to the holders of equity in the company. Traditionally it has been said that projects are successful if they are completed on time, to budget and to quality. Certainly, all else being equal, the earlier a project is completed, the more cheaply and the greater the functionality, the greater will be its contribution to shareholder value. However, it is often not known what the relative impacts of time, cost and functionality will be. This paper uses shareholder value analysis to assess the impact of projects on the sponsoring organisation, and the relative impacts of time, cost and functionality. First it is necessary to enhance the traditional model of shareholder value analysis to make it more appropriate for the analysis of projects. It is shown that the impact of projects on their parent organisation can be predicted from seven financial ratios or value drivers, and that the nature of the impact is different for different industries with different ratios. The different impacts are analysed for ten of the UK's top 100 companies

Introduction

Research has shown that many people judge project success by whether or not the project contributes value to the sponsoring organisation, (Wateridge 1995, 1996, 1998). Further, if the project team co-ordinate their efforts to deliver value to the sponsor, it increases the chance of achieving a successful outcome. This may require individual project team members to sub-optimise the parameter that most interests them, (time, cost or functionality), in order to achieve an overall optimum for the project.

A modern technique for investment appraisal of projects analyses the project's contribution to the value of equity of a company, called shareholder value, (Mills 1994, Mills and Turner 1995). Shareholder Value Analysis calculates the value of a company as the net present value of future dividends, paid out of free cash flow after profit has been used to pay tax and reinvest in the business. It estimates future free cash flow from eight value drivers, (listed on the next page). The contribution of any new project is the net present value of the project.

The eight value drivers alone cannot be used to determine the net present value of a project. However, the value drivers can be calculated from seven traditional financial ratios, which can in turn be used to predict the net present value of projects. In this paper, I introduce the financial ratios, and show how they can be used to predict the shareholder value of a company and to determine the net present value of a generic project undertaken by an organisation. I use the model for net present value of a generic project to analyse the impact of changes in time, cost and functionality on the net present value, and hence the shareholder value of the organisation. I use ten of the UK's top 100 companies as examples to show how the impact varies between companies with different ratios. I then do a more detailed analysis on two of the companies to provide a basis for extrapolating the data for the other companies. The two organisations, Zeneca and ICI, were the same company until their demerger five years ago.

Shareholder Value Analysis

Shareholder Value Analysis calculates the value of shares in a company as the net present value of future dividends. Future dividends are paid out of free cash flow, which is profit, less tax, less money reinvested in the business, (Mills 4, Mills and Turner 5):

Dividends = Free cash flow
= Profit - tax - capital invested in the business

In traditional shareholder value analysis, future free cash flow is calculated from eight value drivers. There are three operational drivers used to estimate future cash generated by the business:

- sales growth rate
- operating profit margin (= 1 - operating costs/sales)
- cash tax rate

and five investment drivers used to calculate the amount of cash invested in the business, and at what cost, and over what planning period:

- replacement fixed capital investment, (assumed equal to depreciation)
- incremental fixed capital investment, (required to generate sales growth)
- incremental working capital investment, (also required to generate sales growth)
- cost of capital
- planning period

There is no replacement working capital investment: that is treated as revenue and paid out of operating costs.

The contribution of a project to shareholder value is the net present value, (plus a very small allowance for new debt required to invest in the project). In a previous paper, I analysed the impact of a fictional project on the shareholder value of a fictional company, looking at the impact of variations of time, cost and functionality on the value of the project, (Turner 6). In that paper, I identified that changes to functionality, measured through changes in sales, had a greater impact than either time or cost. I also identified that the influence would be dependent on the different nature of organisations, and that it was not possible to measure the influence of projects directly through the traditional eight value drivers. In order to properly analyse projects, it is necessary to split costs into direct costs, indirect costs and depreciation. Thus, it is possible to calculate the value drivers and the impact of projects from the following financial ratios:

1. direct cost to turnover	=	direct costs/turnover
2. indirect cost to turnover	=	indirect cost/turnover
3. depreciation to turnover	=	depreciation/turnover
4. rate of depreciation	=	depreciation/fixed capital employed
5. fixed capital employed to turnover	=	fixed capital employed/turnover
6. working capital employed to turnover	=	working capital employed/turnover
7. debt equity ratio	or	debt to capital employed

(Ratio 3 can in fact be calculated from 4 and 5).

The value drivers can be calculated from ratios 1 to 6. Ratio 7 is used to calculate the impact of new debt, (which is small). Shareholder Value Analysis takes the turnover in a base year, and an assumed rate of growth, to calculate shareholder value. Table 1 shows the calculation for a UK company from the pharmaceutical industry, Zeneca, using numbers obtained from the 1997 annual report. This calculation is done assuming constant debt equity ratio. It was also done assuming constant debt. The latter gives an answer about 3% smaller. Table 2 contains the ratios for ten of the UK's top 100 companies, using figures obtained from their annual reports for 1996 or 1997. This Table also includes the calculated shareholder value for each of these companies using a six year planning period. The final column shows the amount the companies are currently trading above or below the calculated figure.

The direct costs include costs of sales, materials and labour where included. They also include attributable duties for liquor sales and oil and gas products, and research and development costs.. It is usual to treat research and development as a sunk, and therefore indirect cost. However, this distorts the investment appraisal process, favouring products with high research and low production costs over products with low research and high production costs. Some firms make R&D a direct cost by charging an internal royalty. However, it can be argued that as part of the investment appraisal process that the research cost should be treated as a direct cost if the comparison is between making the product as opposed to licensing its production elsewhere.

The Generic Project

We can calculate Net Present Value, NPV, for a generic project from each company using the ratios. Table 3 contains the calculation for Zeneca. Starting with an initial fixed capital investment of 100 units, all other figures are determined using the ratios. Table 4 contains the NPV for the generic project for each company in Table 2 for a project with initial investment of 100 units. Using the generic project, it is possible to calculate the effect of changes in time, cost and functionality on the outturn of the project. The following assumptions are made.

Functionality

Loss of functionality either reduces sales volume, or sales price or both. Both result in a loss in turnover. If there is a loss in sales volume, then presumable it will be possible to achieve some savings in direct costs, and hence direct costs might be treated as variable. If there is a loss in sales price, then there will be no reduction in costs, and so they will need to be treated as fixed. The two extremes of treating direct costs as fixed and variable were considered. In any given case it is expected that the actual outcome will be somewhere in between.

Cost

I assumed overspend of fixed capital only. Overspend can be paid by equity or new debt. I investigated equity only, debt only and both. The difference in shareholder value was around 1% of the amount of new debt, which can be ignored. All figures assume the overspend is paid for by equity. Paying for the overspend out of debt reduces its impact on shareholder value, but by about 1% of the overspend.

Time

I made one of three possible assumptions when considering a delay to a project:

1. The start of the project is delayed, but the cost is spent in the original period, with no overspend.
2. The start of the project is delayed, and the expenditure is spread over the extended time period, but there is no overspend, that is the same amount of money is spent over a longer period.
3. The start of the project is delayed, the expenditure is spread over the longer period and there are some time dependent costs. I assumed that 25% of the costs were time dependent. The resulting overspend could be paid for out of a mixture of debt and equity. Again that impact is very slight, and so is ignored.

Assumption 3 causes the greatest reduction in net present value and assumption 2 the least. I give below examples of the impact of 2 and 3. However, in considering all ten companies, I only considered assumption 3.

Impact of Project Performance

Table 4 shows the impact of underperformance of functionality, cost and time on the generic projects from the ten companies. The first column, as I said above, is the net present value of the generic project, given a fixed capital investment of 100 units, with all other figures calculated using the financial ratios in Table 2. In all cases, except Sainsburys, I have assumed that the project has a six year life. In high cost, high capital companies, a longer project life may be more appropriate. For Sainsburys I had to assume a ten year project life to obtain positive net present value. The second and third columns contain the percentage reduction in net present value resulting from a 10% re-

Year	Data	0	1	2	3	4	5	6
Sales Growth Rate	12.0%		12%	12%	12%	12%	12%	12%
Sales		100.00	112.00	125.44	140.49	157.35	176.23	197.38
Direct Costs	50.5%	(50.50)	(56.56)	(63.35)	(70.95)	(79.46)	(89.00)	(99.68)
Indirect Costs	24.5%	(24.50)	(27.44)	(30.73)	(34.42)	(38.55)	(43.18)	(48.36)
Interest		(1.50)	(1.68)	(1.88)	(2.11)	(2.36)	(2.64)	(2.96)
Depreciation	10.0%	(4.15)	(4.65)	(5.21)	(5.83)	(6.53)	(7.31)	(8.19)
		=====	=====	=====	=====	=====	=====	=====
Operating Profit		19.35	21.67	24.27	27.19	30.45	34.10	38.19
Cash Tax Rate	35.0%	6.77	7.59	8.50	9.51	10.66	11.94	13.37
		=====	=====	=====	=====	=====	=====	=====
Profit After Tax		12.58	14.09	15.78	17.67	19.79	22.17	24.83
Add back Depr'n		4.15	4.65	5.21	5.83	6.53	7.31	8.19
		=====	=====	=====	=====	=====	=====	=====
Operating Cash Fl		16.73	18.73	20.98	23.50	26.32	29.48	33.02
Less RFCI		(4.15)	(4.65)	(5.21)	(5.83)	(6.53)	(7.31)	(8.19)
Less IFCI		(2.29)	(2.57)	(2.87)	(3.22)	(3.60)	(4.04)	(4.52)
Less IWCI		(0.50)	(0.56)	(0.62)	(0.70)	(0.78)	(0.88)	(0.98)
		=====	=====	=====	=====	=====	=====	=====
Free Cash Flow		9.79	10.96	12.28	13.75	15.40	17.25	19.32
Cost of Capital	6.0%	6.0%	6.0%	6.0%	6.0%	6.0%	6.0%	6.0%
Discount Factor		1.00	0.94	0.89	0.84	0.79	0.75	0.70
PV Free Cash Flow			10.34	10.93	11.55	12.20	12.89	13.62
Cummulative PV			10.34	21.27	32.82	45.02	57.92	71.54
Residual Free Cash								**24.83**
Residual Value								**413.77**
								=====
PV of Residual Val								**309.19**
Cummulative PV								**71.54**
								=====
Value of Company								**380.73**

CAPITALISATION

Year		0	1	2	3	4	5	6
Fixed Capital	41.5%	41.50	46.48	52.06	58.30	65.30	73.14	81.91
Incremental FCE		4.98	5.58	6.25	7.00	7.84	8.78	9.83
IFCE from Equity	46.0%	2.29	2.57	2.87	3.22	3.60	4.04	4.52
Working Capital	9.0%	9.00	10.08	11.29	12.64	14.16	15.86	17.76
Incremental WCE		1.08	1.21	1.35	1.52	1.70	1.90	2.14
IWCE from Equity	46.0%	0.50	0.56	0.62	0.70	0.78	0.88	0.98
Total Capital		50.50	56.56	63.35	70.95	79.46	89.00	99.68
Debt	54.0%	27.27	30.54	34.21	38.31	42.91	48.06	53.83
Equity	46.0%	23.23	26.02	29.14	32.64	36.55	40.94	45.85
Interest	5.5%	1.50	1.68	1.88	2.11	2.36	2.64	2.96

Table 1. Shareholder Value Analysis for Zeneca

Sector	Name	Direct Costs %T	Indirect Costs %T	Depr'n %FCE	FCE/ Sales %T	WCE/ Sales %T	Debt/ CE %	SVA6Y %T	SVA/ Capit'n %
Pharm	Glaxo	33.0%	27.0%	10.5%	45.5%	5.5%	49.0%	680%	11.9%
Brewery	Guiness	40.0%	28.5%	5.0%	93.5%	51.0%	35.0%	310%	24.7%
Media	Reed Elsevier	38.5%	34.5%	3.0%	85.5%	18.0%	77.5%	394%	-17.6%
Pharm	Zeneca	50.5%	24.5%	10.0%	41.5%	9.0%	54.0%	380%	21.7%
Stores	Marks & Sp	76.5%	8.5%	4.5%	46.0%	25.0%	18.0%	190%	11.4%
Chemical	BOC Group	59.5%	20.0%	8.5%	90.0%	12.5%	37.0%	139%	-13.9%
Electrical	GEC	66.0%	22.5%	22.5%	16.0%	8.0%	-83.0%	148%	21.7%
Engin'ing	B Aerospace	84.0%	6.5%	8.0%	32.5%	7.5%	40.0%	104%	20.5%
Stores	Sainsbury's	91.5%	2.0%	0.0%	44.0%	7.5%	46.0%	74%	-34.6%
Chemical	ICI	72.0%	19.0%	6.0%	54.0%	15.5%	71.0%	40%	61.9%

Table 2. Ratios and Shareholder Value for ten UK FTSE100 companies, (data obtained from company reports)

duction in sales, the second column assuming all sales costs are fixed and the third column all variable. The fourth column shows the reduction in net present value resulting from a 10% overspend and the fifth from a one month delay on a year long project. You will see:

1. Loss of sales, (functionality), always has a greater impact than time or cost. As would be expected, the impact is more severe if the sales costs are fixed. The higher the cost to sales ratio and the higher the capital to turnover ratio the more severe the impact.
2. In low capital companies, (low capital to turnover ratio), time has a greater impact on net present value than cost. I have not shown it here, but as the delay is increased, the loss of sales has an increasing effect, so that eventually time had a more severe impact than loss of sales alone.
3. In high cost, high capital companies, a 10% overspend has an impact on net present value almost as severe as loss of sales, and greater than the impact of a delay.

All these results suggest that it is more important to obtain the correct functionality for a project than to finish rigidly on cost and time.

Comparison of Zeneca and ICI

Zeneca and ICI are two companies which split about five years ago from the then one company ICI. Table 5 contains a more extensive list of variations of project performance to compare the impact on the value of each company. It can be seen the impacts are quite diverse. This raises the question of how was it possible to make rational comparisons of projects from different parts of the business when they were the same company. The assumption must be that projects from the part of the business that is now Zeneca will have always won out in competition for scarce resources. The part of the business that is now ICI was being milked to invest in Zeneca, meaning it would have been gradually run down if the two businesses had not been split. In the mid 1980s I was employed by ICI to do investment appraisal of projects from the petrochemical industry. I found that my projects, with high operating costs but low indirect costs could not compete against projects from less profitable parts of the business with high indirect costs but low operating costs.

Conclusions

The following conclusions can be drawn from the research:

1. It is important for project managers to understand the impact of loss of functionality on the performance of their projects, and to balance the need to obtain the appropriate functionality against a desire to finish rigorously on cost and time.
2. Project managers should be judged in their annual performance appraisal not just on how many of their project were finished on cost and time, but also on the ability of their projects to generate sales. Given the results of this paper, greater weighting should be given to sales potential than cost or time performance.
3. Understanding the impact of financial ratios on the performance of their project will help project managers weigh up conflicting demands for performance on cost, time and functionality on their projects. Perhaps project managers could be judged against their performance compared to the generic project for their organisation.
4. When undertaking investment appraisal, and comparing competing projects in a portfolio, research costs, although sunk, should be treated as direct costs, because:
   - in order to stay in the business, the company needs to conduct ongoing research
   - without conducting future research the company will lose shareholder value
   - the research cost should be treated as a lost royalty payment

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Project Management Maturity

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The issue of what makes some project managers and some organizations better at what they do in delivering projects than others has been a question that has been studied for many years. These studies have looked at critical success factors, key result areas and project manager skills and personalities. All have contributed in their own way. Recently, however, the question of maturity of project management has been raised. Driven largely by the work of the Software Engineering Institute (SEI) and its Capability Maturity Model (CMM), a number of more generally applicable models for project management have been developed. This paper addresses the issue of project management maturity and how it may be modeled. Starting with the published models, it develops a framework for a more powerful maturity model that challenges our current body of knowledge.

Introduction

Project Management has traditionally dealt with the work that takes an idea from funding to delivery. There are, however several other parts to this process that impinge on its success, starting with the original idea, its business context and how it was funded. Maturity of project management helps us understand several things. First it tackles the competence of the practitioner and tries to measure it on a generalized scale. Second it helps us understand the working environment of the practitioner, if it also assesses the business for which the project is being done. It also creates an opportunity to study and understand the growth of excellent project managers and could help us understand the mechanism that underlies this growth.

The debate on how to certify project managers continues, with different views on this from different national professional associations. The Project Management Institute (PMI) in North America has a knowledge-based model for its PMP (Project Management Professional) designation. Experience and project management competencies are the basis of other models favored in some European countries. The link between maturity models and certification within the profession of project management is a natural one. In this paper this and other links, with growth of the body of knowledge, moving beyond the traditional bounds of project management and the changing work environment are considered and presented.

The paper also presents a framework for development of a more universally applicable model for assessing and developing project management maturity. This framework is presented as a starting point for discussion rather than a final or even interim product or proposal. The paper concludes with some suggestions for areas of study or debate, which would help us understand the phenomenon of project management maturity. The principal author developed the initial SMART model. Much of the background work on current models was undertaken by the co-author as part of his preparation for studies into project management maturity in the software induustry.

Maturity Concepts

The models for project management that have appeared in the last short while have started the process of building this concept. The published models are briefly described below. Starting with the one that got this idea going: the SEI CMM model (Paulk et al., 1997).

SEI Capability Maturity Model

This model includes five levels. The Initial level is based on no stable environment existing in the organization for development of software. Often commitments are made and not met. It is difficult to achieve a methodical process that results in any consistency in project delivery. The objective is simply to produce software.

At the Repeatable level, the goals have shifted to delivering projects in a controlled fashion. This usually takes the form of schedules that drive the project. At this level, the organization will also control cost and functionality and will have developed policies and procedures around the process it needs to achieve these objectives.

The third level is the Defined level. At this level there is a coherent and consistent approach to project delivery with organization-wide training to ensure that the participants in the process have the skills needed to fill their project roles. The organizations standard practices are now modified on each project to suit the specific needs and demands of the situation. At this level the focus is not on managing the project, but managing the product.

At the fourth, or Managed level, the focus shifts to managing the process to ensure that customer needs are properly met and balanced with cost and other standard measures. Quantitative quality measures are set. There is an organization-wide quality and productivity measurement process. The objective is to achieve improved consistency and predictability of outcomes.

At the fifth level we have achieved the Optimized process. What sets this level apart is that the organization is now continuing to improve on what it has done to grow from level one to four. And it is doing so in a structured way.

Although this model has been widely accepted and adopted, it has been the target of some criticism. The three primary criticisms have been that it increases corporate bureaucracy and rigidity, it causes organizations to focus on CMM issues at the expense of others that are important to its business and finally, organizations will tend to avoid risky projects in order to get better CMM ratings. All of these have been disproven by studies to investigate these phenomena (Herbsleb et al., 1997). Brooks (1987) sought a "silver bullet" for software development. CMM is not that bullet. Nor is any of the other models for project management maturity.

The next models reflect a strong basis in PMI's Project Management Body of Knowledge (PMBOK). As such they may all be open to criticism in that they are limited to more traditional approaches to project management. This means they look specifically at the project execution phase only.

Project Management Maturity Model (PMMM)

Fincher and Levin (1997) proposed their PMMM on the basis of goals that an organization may use to to assess their maturity level. By focussing on the weak areas identified in a comparison to the suggested goals, it is possible to identify where improvements may be made to improve project management performance. All nine of the PMBOK areas of knowledge are included at each level in this model. It is a fairly close adaptation of the SEI CMM, so it too has five levels and their definitions reflect the same types of goals as the CMM. An analysis of these levels by Skulmoski (1997) suggests that there are inconsistencies between the different levels in the model. There is no evidence that it has been empirically tested. Mastery of the PMBOK effectively constitutes level 4, so it does not challenge the status quo in any significant way.

CMM/Project Management Maturity Model

This PMBOK-based model was developed by Goldsmith (1997). This model is specific to software projects. Goldsmith's focus was on accelerating development time. The process includes steps such as learning about project management and then becoming certified by PMI as a PMP. This model simply brings together SEI's CMM and PMBOK. It adds nothing new beyond this.

Project Management Process Maturity Model (PM^2)

This is the last of the PMBOK-based models. It was developed by Ibbs and Kwak (1997) and is reported in a PMI publication. This is the most comprehensive of the PMBOK-based models. It is based on a study that was intended to identify the organizational and financial benefits of Project Management. The authors looked at 38 organizations and assessed their maturity, using a simple and prescriptive model. This model was developed to help project managers assess maturity and return on investment that might accrue from this process. The model is loosely based on SEI's CMM. It starts with an ad hoc approach to project management at level one and grows to continuous improvement at level five. At level 2 some informal procedures and plans are in place. At level 3 organizations have partially developed procedures and practices, and trend data is collected and shared between teams. Systematic and structured project management occurs at this level. At level 4 integration across the entire organization occurs. At this level, too, project management is documented and well understood.

The authors of this model point out that previous studies and models trying to identify the benefits to project management have been unsubstantiated and anecdotal.

The next two models (one published, the other under development) are not based directly on PMBOK.

The Project Management Maturity Model (PM^3)

This model was developed and trade marked by Remy (1997). This model, like the others is loosely based on the one by SEI. It has five levels. The creator of this model does not advocate trying to get all of the organization to the top level. Instead, he suggests that the organization achieve a balance that best suits its business objectives. This model differs significantly in that it is based on the domain of Modern Project Management as defined by Kerzner (1996). It is similar to Ibbs and Kwak's model in that an organization can have several different levels of maturity, and still be effective.

One of the prime differences in this model is that it recognizes that "Effective project management is the evolving interaction of process, systems and culture. Addressing one aspect without considering the others produces little more than expensive frustration". This model is, however, not backed by any empirical research. It is anecdotal and from a consulting company that makes a living in this business.

SMART Project Management

This early concept of a maturity model is also loosely based on the SEI model. It is the result of three years of empirical study in the application of derived best performance studies, described below. It challenges many of the standard practices in project management by pushing the envelope of accepted expertise and processes.

The SMART model is based on the following elements:

- Projects are Strategically Managed and integrated with the corporate objectives.
- Teams and objectives are properly Aligned and this alignment is tested and validated.
- The project is performed in a Regenerative culture that encourages and supports high performance teams

- The project id defined, planned and managed in the context of a continuously changing (Transitional) environment with corresponding shifts in demands on the project and its assigned resources.

These models, when applied to projects in organizations, consistently yielded significantly better project performance in terms of customer satisfaction, cost and time required. However, it had proven to be unsustainable when implemented in an environment that was at level 1, 2 or even 3 on most of the maturity models previously defined. In order to understand what the cause of this might be, further study was undertaken, based generally on the principles of identifying best practices.

Best Performance Issues

We were not interested in the quality of practices in industry, but rather in the results obtained. We therefore looked at projects that were perceived to be successful and then we looked at the project manager and tried to understand the skills, knowledge and other attributes that these highly successful project managers had. As the source of information was diverse, the results of this study are questionable. As sources, published cases, documentaries and docu-dramas (such as the story of the Avro Arrow by the Canadian Broadcasting Corporation) were considered. Also looked at were cases that were not in the public domain, but were known to the author through personal contacts and through consulting work. As a consequence, these latter sources cannot be published, further weakening the case for the model for maturity that is about to be presented in this paper. Finally, a number of studies and monographs were considered in formulating the model. These studies, papers and monographs are extensive and cover a multitude of industries and a broad spectrum of companies, cultures and socio-economic situations.

A significant amount of information synthesis has led to the development of a model for project management maturity that is based on setting level four at "world class" performance. The other readily definable levels are level one - the entry level and level five - the level at which structured and logical continuous improvement on performance at level four occurs. However, to put some meat on the bones of this skeletal definition of a maturity model, we need to consider the elements that constitute performance at entry level and at "world class" level, and we need to define these terms more clearly. That done, the next step in developing a rational maturity model is to determine the building blocks required to go from level 1 to level 4. The final step is to find the right sequence for assembly of these blocks to allow individuals and organizations to develop their project management skills in a sustainable way.

Elements of Maturity

As a starting point, we defined levels one and four in the proposed model as follows.

Level One:

At this level we see the typical first-time project manager with little or no formal training but a mandate to deliver a project. From an organizational point of view, this level would be defined as one where there is no formal career path for project managers, the title "project manager" may be assigned without any recognition in terms of promotion, training, pay increase or added authority to do the work.

Level Two:

This level is the one at which three elements need to be in place. The first is a formal training program with an appropriate certification, diploma or other qualification associated with successful completion. This is needed to allow the individual project manager to obtain two important requirements: basic knowledge in accepted project management practices and credibility in the organization and with the team. The credibility of the project manager will also depend on a number of other - and often more important - elements. Some of these elements include technical competence in the content of the project, experience and reputation for success in some form. The second element needed is acceptance at the organizational level of formal project management. Specifically, this means that the organization expects projects to be managed, rather than just happen. Symptoms of this include formal recognition of the title "Project Manager" perhaps with differing levels from Assistant to Senior or Executive. The underlying organizational commitment is important, not lip service to a process and to job titles. The third element at this level is that the organization permits its project managers to do what they need to in order to manage their projects properly.

For the organization, this level requires a formal and effective training programme in project management to be in place. It typically needs project management standards to be in place and a career part for project managers is in place within the organization.

Level Three:

The third level of project management maturity is the one at which the definition of project management in the organization has been broadened to include all of the steps in the project life cycle. This goes from when the idea is first thought of through to final closeout of the project or its product at the end of its useful life. This is a much larger mandate. It does NOT mean that the same person is managing every step of the process. At this level, we expect project managers to consider the technical elements (classical project management) as well as the business context in which the project takes place (modern project management). Finally we would expect the project manager to consider social and societal issues (SMART project management).

The organization needs to reflect these additional factors as well. This means that a number of additional issues need to be addressed. First, the project selection process should consider how well aligned each project is with corporate strategy. It also needs to consider where the project fits in a risked portfolio of projects that the company must chose from in order to achieve its objectives. Currently, most organizations that do this risked selection will include in the evaluation a risk factor for technical and commercial success of the project. They will not consider the risk in project delivery. This latter risk can have a profound impact on the outcome of the project, and helps to explain the significant difference between the expected return on investment when the project is approved and the actual return on completion that is commonly reported.

At level three, the project is developed as part of the corporate strategy. It is also routinely and predictably delivered at or below a stretch budget and schedule, with little or no rework and with a satisfied customer.

Level Four:

This is the level at which high performance is achieved. In looking for the differentiation between good and world class project managers, one characteristic stood out in particular. That was the ability to make and maintain all the connectivity between disparate elements of the project and its successful management. For example, What impact will approval of this project have on others in the organization and vice versa. What does selection of one contracting strategy over another have on schedule, team effectiveness, the effort required to maintain effective communications, cost, administrative processes and so on. No decision is made in isolation. The project manager finds solutions to the disease, not the symptom.

At the organizational level, steams cooperate between projects. Priorities are set to suit corporate goals, rather than those of the project with the strongest manager or sponsor. It is not just acceptable practice, but good practice to cancel your own project if that is the right thing to do. Currently it is a career limiting move to do so in many organizations.

Essentially, at this level, the project manager, with the conscious support of the organization, is working beyond corporate guidelines, procedures and processes, adapting or changing them to suit the needs of the situation. The result of this final set of skills and competencies is that projects at this level are scheduled and budgeted aggressively to perform at up to 30% faster and more cost effectively than projects at level two. Projects at this level consistently come in on time and within expected cost, scope , safety and quality expectations.

Level Five:

This level, like that in the SEI CMM is one at which controlled and organized process improvement is achieved.

It is not enough to define these elements. Several other things need to be done. First we need to develop ways to perform at level four. By the definition in the model above, this has been done with SMART project management, but has not been done yet in a sustainable way. Three pilot projects in organizations are currently under way to test the concept to this maturity model. Results will take several years to develop. Faster approaches need to be found.

Next, we need to detail what knowledge, experience, competencies and other skills or attributes are needed at each level for both the individual and the organization. The different levels can co-exist within an organization. Career paths for project managers, company standards and other infrastructure elements need to be defined for each organization so that the framework for growth in this increasingly important area of management is in place.

A Framework for Development of a Universal Model for PM Maturity

The model outlined in this paper is presented as a framework for discussion. The authors welcome input, advice and suggestions from researchers and practitioners on how this framework might be developed. Ideally, with international cooperation, we will be able to develop a truly useful model for project management maturity that will help us all understand the real drivers for project management effectiveness, together with the myriad of peripheral factors that contribute to such success.

The intent behind this framework is to develop a platform for future study of project management. If of use, this platform will help us understand the elements that are required to develop truly competitive project delivery. Such elements will include technical, business and social issues. Some of these may be as follows.

- Technical Issues:
  - More effective resource-based scheduling techniques
  - Better tools for scope and change management
  - Ways of measuring team alignment
  - Simplified tools for earned value, risk analysis and more, to make them more accessible and user-friendly
  - Tools to plan for and manage communication
- Business Issues:
  - Multi project management to include inter-project communication and priority setting
  - Planning that helps align projects with, and support, corporate strategy
  - Risk plans for projects that are consistent with the risk-taking and investment policy of the sponsor organization
- Social and Societal Issues:
  - Ensuring legal and regulatory compliance
  - Understanding the impact of the project long term on the community and on the team
  - Developing good working environments for the WHOLE project team and stakeholders
  - Ensuring a sustainable social infrastructure to support the project during implementation and in the operating phase
  - Understanding and mitigating social, environmental and economic damage to third parties.

There is still much to be learned about effective project management. The wider we cast the net, the sooner we will find the most critical factors that will positively influence the outcomes of future projects.

Conclusions

This paper reports the general structure of an evolving model for understanding and improving project management. A model based on the concept of maturity in capabilities offers a new opportunity to revisit what we know of project management. Perhaps just as important, if set correctly it will challenge how we think of the profession and the skills needed for success.

No maturity model will ever be correct or complete. This is because project management will continue to evolve and will affect the model as a result. The Organization for Project Advancement and Leadership (OPAL) will host and support this particular maturity model and will cooperate with anyone who wishes to participate in collaborative or independent work in developing it as a basis for future study, certification, training development and other action that will support fast growth in the profession. OPAL is housed at the University of Calgary and is supported by a growing number of member corporations from around the world, including Computing Devices Canada, Imperial Oil, KPMG, Nortel, PanCanadian Petroleum and Shell.

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A Set of Modeling Methods for Process-Oriented Project Modeling

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Key words: Project management, Process-oriented modeling, Modeling methods

Project management suffers from numerous problems due to static and dynamic complexities inherent in projects. In this paper, the authors infer the necessity of project model building by analyzing project intrinsic elements and their relationship over time. A process-oriented project model is built on purpose to describe and handle various project complexities. Because of the disadvantages with existing project management methods and techniques, a set of methods is conceived by combining them together with IDEF0, Petri Nets, and fuzzy logic. This method set is constructed especially for fulfilling the requirement of project process modeling.

Introduction

Project management - "the application of knowledge, skills, tools, and techniques to project activities in order to meet or exceed stakeholder needs and expectations" (PMI Standards Committee, 1996) - suffers from numerous problems due to static and dynamic complexity of projects. The static complexity of a project results from its intrinsic elements, i.e. project scope, time, cost, and resource and their mutual-restricted relationships. The scale of a project serves as a multiplier that determines how complicated these scope-time-cost-resources relationships can be. Static complexity can be described as:

Static complexity of a project = scale x (scope ∩ time ∩ cost ∩ resources) where "∩" is the symbol 'intersection', mapping mutual-restricted relationships among project scope, time, cost, and resources.

The dynamic complexity of a project is the result of project changes during the project life cycle. These changes include alterations of project scope, time, cost, and resources. They are invoked by a number of potential environmental factors (Lientz et al., 1995) that can be classified into following two types:

- social factors: regulation, parent company and subsidiary relationship, labor union and organization relationship, political elements
- nature-related factors: technology, development of technology, competition, market globalization, escalation of customer's expectation

Compared to nature-related factors, social factors are relative stable. They are easy to detect but difficult to be forecasted. Nature-related factors are more objective than social factors, but they change more frequently. Environmental factors influence each other in every phase of a project. For example, the alteration of political elements can seriously affect the utilization of current technology and the development of technology, as well as competition patterns and the global market for a project. Project execution could become extremely complicated when several or all of these factors are involved simultaneously. Each of them could induce disturbance or improvement and the output of a project is affected by their joint effect. As cardinal elements of project management, they must be considered both in early project planning phases and project execution and control phases.

In order to manage the static and dynamic complexities of a project, a process-oriented model for project management modeling and a set of methods are suggested in the following sections.

A Process-oriented Model for Project Management

A project model is an abstraction of project reality in terms of some formalism by filtering out irrelevant details and displaying only information that is essential. It embodies the static complexity of a project in terms of project scope, cost, time, and resources. Because it is used to exhibit only those features and characteristics which are necessary, this model helps us to grasp critical elements and their relationships in the project. As an aggregation of project information, it can be adjusted in course of project execution. A project model serves not only as a platform upon which the common understanding can be obtained but also as a baseline for project coordinating, prediction, decision-making, and improvement. A successful project model can be re-used as a template in many similar situations.

Decomposition

A process is an independent functional unit that can transform some type of input into same or other type of output

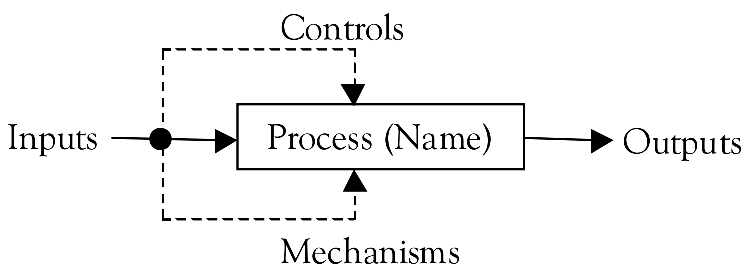

Figure 1. Functional view of a process

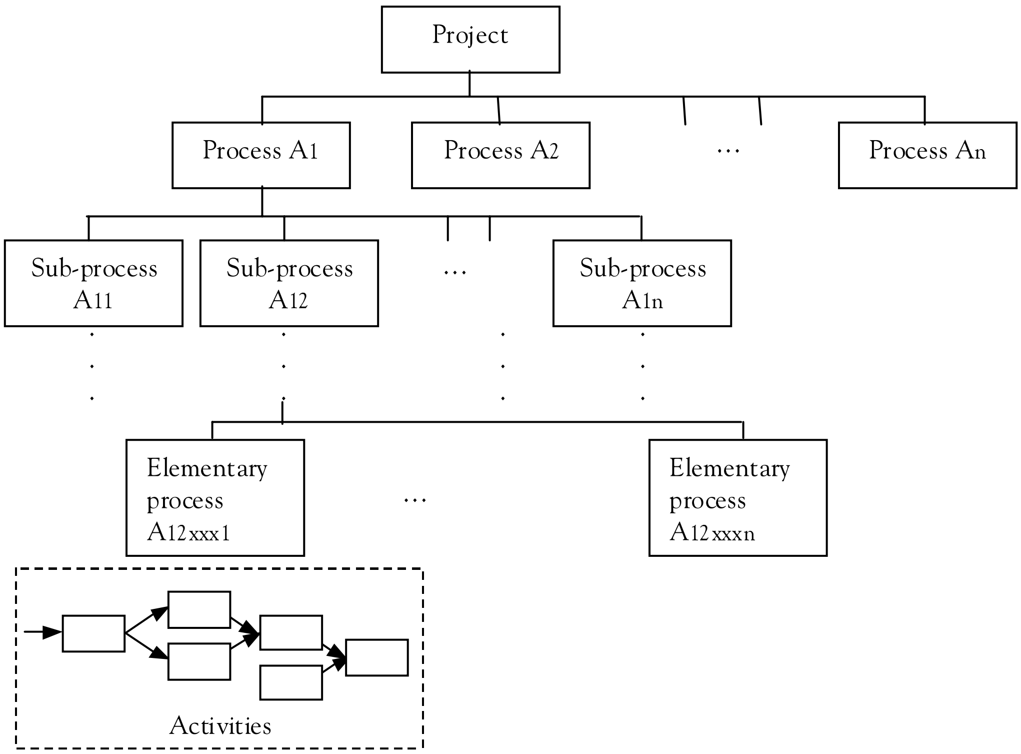

Figure 2. Process decomposition of a project

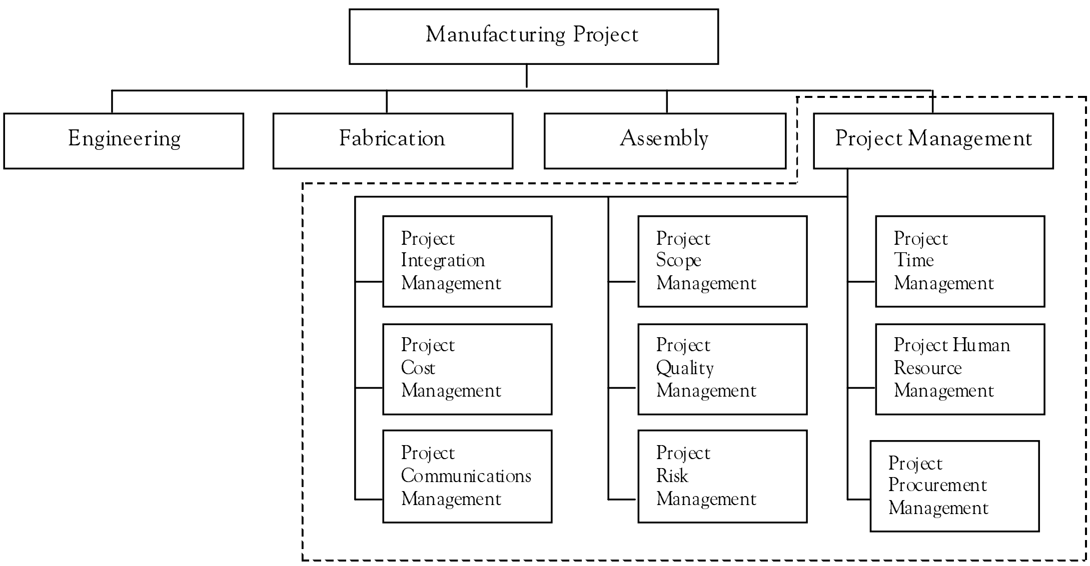

Figure 3. A process decomposition of a manufacturing project
(Project management processes shown inside the dotted lines are adapted from PMI Standards Committee)

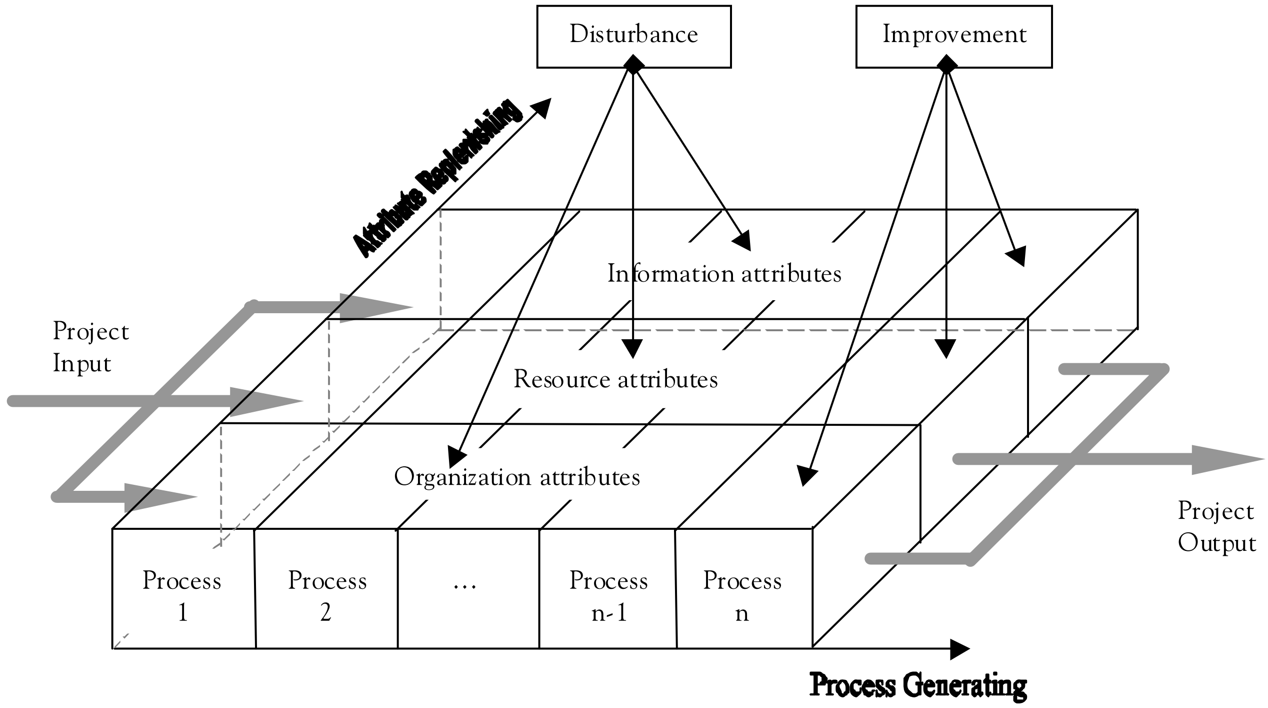

Figure 4. A Process-oriented Project Model

with the assistance of specified mechanism and control information. It can be applied to accomplish a complete work package of the project. The functional view of a process is depicted in Figure 1. Process controls and mechanisms are part of the inputs, but they also provide information for control (e.g. a standard) as well as physical resources (e.g. a computer) for a process. Usually, they will not be transformed during the execution of the process.

A project contains a number of processes. These processes may be further decomposed until the elementary process level is obtained. As shown in Figure 2, an elementary process is constituted by a series of activities. Each of them carries out a part of the process function. The functional properties of a process make it to be a natural basic unit for project modeling.

Figure 3 shows an example of the decomposition of a manufacturing project. The project is divided into four processes: engineering, fabrication, assembly, and project management. According to the Project Management Institute (PMI Standards Committee, 1996), a project management process can be further divided into nine sub-processes as shown in the figure. Each of these sub-processes consists of several elementary processes. For example, the project integration management process is divided into three elementary processes: project plan development, project plan execution, and overall change control. Each elementary process includes at least one activity.

A Process-oriented Project Model

A process-oriented project model focuses on describing the essence of a project by its interrelated processes. Processes are classified according to their types of attributes. Attributes of a process are properties that represent its uniqueness. In project management, process attributes may be classified into three types:

- organization attributes: describe organizational properties for a process, e.g. type of process ownership, number of owner,
- resource attributes: describe resource-related information for a process, e.g. type, name, and quantity of resources,
- information attributes: describe process-related data, e.g. process history data, type of process precedence or successor, process duration.

Figure 4 shows a two-dimensional project model. The horizontal axis represents the generation of processes in a project. This procedure itself describes the process-oriented decomposition of a project that was discussed in previous section. The generation of a process can be evaluated by following criteria:

- necessity: a non-value-adding process is unnecessary;
- explicitness: a process should be defined to avoid cross-functional conflict;
- sufficiency: a set of processes should be designed in the way that represents essence of the whole project;
- interrelated: all processes in same project are coherently related.

The vertical axis represents the attribute replenishing procedure. The classification of process attributes was described in the previous section.

According to their negative or positive effect in project execution, project environmental factors can be classified into disturbance and improvement factors. An improvement factor causes innovation or other positive changes in a project while a disturbance factor hinders or delays progress of the project.

In order to perform the on-line control and coordination of the project change, an environmental factor will be analyzed and decomposed into three aspects (organization, resource, and information) once it is triggered. For example, the improvement from technology factor could affect organizational structure (e.g. by requiring a new organizational structure), cause a redistribution of project resources (e.g. the project processes which utilize new technology may need less resources and the 'saved' resource can be reassigned to others), and require more information because of the new technology. After all environmental factors are decomposed, a total effect on each aspect of the project can be determined. For example, for any environmental factors Ei, it can be decomposed into three aspects:

$E(O_i, R_i, I_i)$, where

E_i: environmental factor;

O_i: organization aspect for E_i;

R_i: resource aspect for E_i;

I_i: information aspect for E_i.

Total effect on organization aspect = $\sum O_i$.

Total effect on resource aspect = $\sum R_i$.

Total effect on information aspect = $\sum I_i$.

By distributing these total effects on relative project processes, the influence of environment factors on each process unit is clearly defined. Considering the inter-relationships among processes, several suggestions on coordinating these impacts under current situation of the project are proposed. An optimal solution will be obtained by testing these proposals under simulation.

A Set of Modeling Methods for Process-oriented Project Modeling

In order to build a process-oriented project model successfully, modeling methods and techniques are needed. Among a number of existing project modeling methods and techniques, Gantt chart, critical path method (CPM), program evaluation and review technique (PERT), work breakdown structures (WBS), and project network techniques (PNTs) have been successfully applied in many projects. The typical disadvantages with the above mentioned modeling methods are:

1. *Non-comprehensive description of processes and their relationships*
   In course of process-oriented project modeling, Gantt chart and WBS can be applied to describe static inherence of a project by decomposing project scope into processes. But neither of them provides a clear functional view of the process.
2. *Lack of integration of project* scope, resource, and information
   None of current project modeling methods/techniques has a formal description of integrated view of project scope, resources, and information.
3. *Limitation of simulation ability*
   One of the most important goals of project modeling is to assist project decision-making. This requires that project model possesses the potential of simulation which can be applied to trace the project plan from project proposal in different phases. Among all those project modeling methods and techniques mentioned above, the PNTs were developed in order to solve the simulation and modification problems during the mid-1950s and early 1960s (Locker, 1996). The simulation carried out by PNTs model is used to determine whether the duration of a process can be adjusted so that the project schedule can be met. Because the duration of a process usually depends on the amount of resources available for the process and this resource view is ambiguously expressed in a PNTs model, this method can hardly be used to simulate a project in a comprehensive view. Besides, the PNTs model represents the proposed project as a diagram that built up from a series of arrows and nodes, its ability for large-scale project simulation and modification is limited.
4. *Deficiency when dealing with non-precise data*
   In course of project model building, many non-foreseeable events exist and non-precise data must be used in modeling. None of the existing project modeling techniques can provide such a mechanism to deal with this problem.

These shortcomings can be remedied by utilizing IDEF0, Petri Nets, and fuzzy logic. Figure 5 shows a modeling method set that consists of WBS, IDEF0, CPM, PERT, PNTs, Petri Nets, and fuzzy logic with Gantt chart in its center.

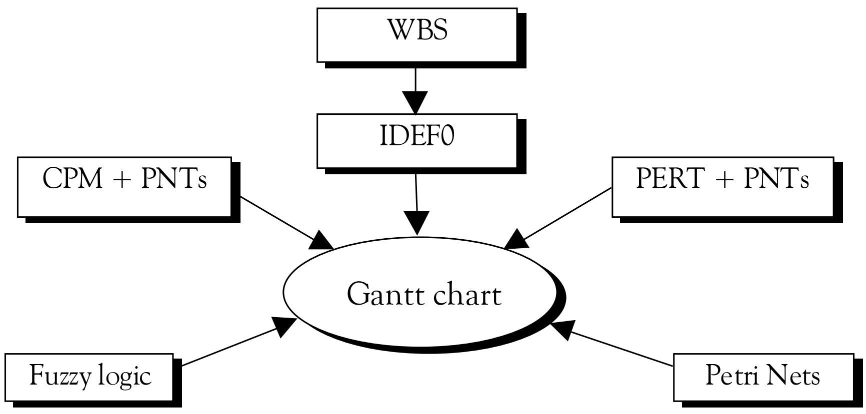

Figure 5. A set of modeling methods

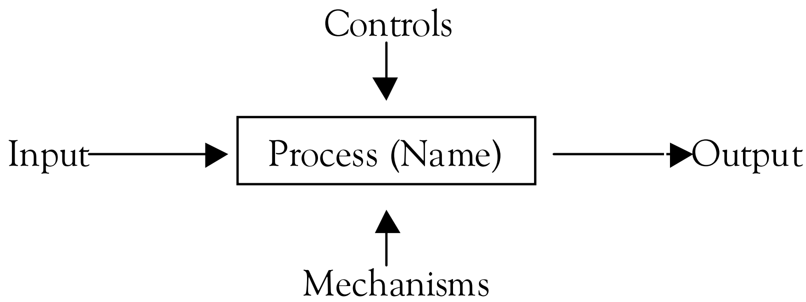

Figure 6. IDEF0 graphical notion of a process unit

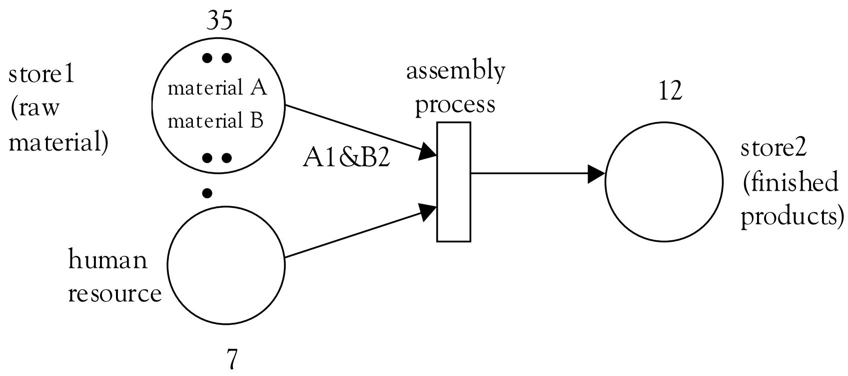

Figure 7. Colored Petri Net

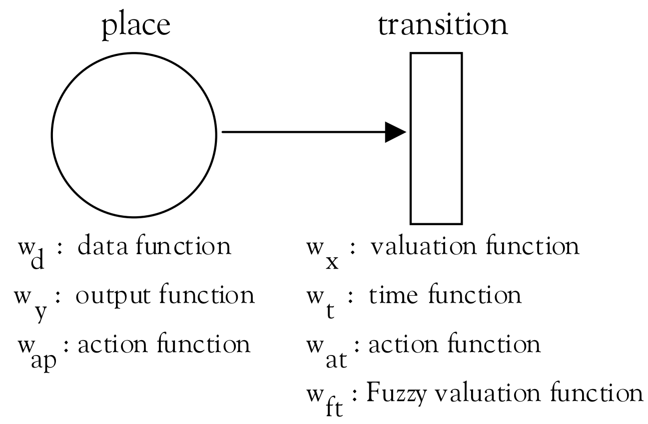

Figure 8. Additional functions

This modeling method set starts by describing project static complexity. WBS is used to decompose project scope into processes and these processes are further decomposed until elementary process units are achieved. Because we apply a process as the basic unit for modeling, it is necessary to define its relative information in its functional view. In order to do so, IDEF0 is applied. This functional description of a process is depicted in Figure 6. Process name describes the function utilized to transfer inputs into expected outputs. Inputs elaborate basic requirement of process execution. They are classified in three categories: resource, organizational, and informational. Control and mechanism could also be described in these three forms, but mostly the control takes the form of information and the mechanism represents information or physical resources (Vernadat, 1996).

The process duration is calculated by applying PERT or CPM. While CPM deals with deterministic activity duration, PERT uses three elapsed times (optimistic time, most likely time, and pessimistic time) for further calculation. Both methods need the participation of persons who are familiar with technical aspect of processes. By combining PERT and CPM together with PNTs, the logical structure of processes in the project is built.

In order to integrate a finite description of project views in this process model, Colored Petri Nets are used. Further, for handling of non-precise data, Fuzzy Logic can be applied. In the following sections, Colored Petri Nets and Fuzzy Logic will be elaborated.

Colored Petri Nets

Petri Net (PN), proposed first in Carl Adam Petri's dissertation in 1962 for the analysis of concurrent computer systems, are a graphical oriented language for design, specification, simulation and verification of systems. It is particularly well suited for the description of processes in which communication, synchronization and resource sharing are important.

However, the graphical representation of PN models is complicated even for medium-sized projects since such graphs tend to become excessively large. A Colored Petri Net (CPN) is a variant which enables a more concise representation with the same modeling power. The development of CPN has been driven by the desire to develop a modeling language - at the same time theoretically well founded and versatile enough to be used in practice for complex processes.

A Petri Net - also named Place/Transition Net - is a net structure that consists of two disjoint sets: places (represented by circles) and transitions (represented by bars) which are connected by directed arcs (edges). Places can include tokens that move from one place to another when transitions can be fired. Place/Transition nets can be extended to Colored Petri Nets by folding of the net elements. The places and transitions of the PN occur in the CPN as colors in places or transitions (Figure 7).

Colored Petri Nets have the following definition (Jensen, 1992; Fengler, 1993):

A CPN is a 7-tuple (P, T, F, C, V, K, m_0) with

P: set of places
T: set of transitions
F: flow relation F = (PxT) ∪ (TxP)
C: color function
V: multiplicity
K: capacity
m_0: initial marking (token)

The CPN in Figure 7 represents in general an assembly process (see Figure 3) that has various kinds of raw material as input and the finished products as output. This process can be further decomposed. The different colors in the places which correspond to inputs of the process can symbolize conditions, data, raw material or human/physical resources. For instance, two colors inside a place represent two various kinds of raw materials. The colors in the places that correspond to outputs can be post-conditions, processed data, products, parts of product or released resources. The number of token indicates the number of objects available in the store (place). The capacity shows the maximal allowed number of objects. The colored transitions symbolize events, data processing, manufacturing operations or project activities. The arcs establish the connection - of material or informal kind - between the places and the transitions according to the label of the arcs. The multiplicity represents the number of items of data or materials that are either necessary or generated.

For the description of environmental influences, the CPN will be extended with four additional functions (Figure 8). The valuation function wx can be used as an additional condition that means the influence on the process. The variables or expressions at the transitions re-present for example binary sensor si-gnals. The output function wy shows the current state of the process, machine or plant. The varia-bles at the places represent for example control signals. The time function wt leads to a more real description of the process. At the transitions, either time duration or a time delay can be specified. The action function wa realizes an assignment of the process to places or transitions by ele-mentary description means, for example commands in Statement List (SL). All of these are valid per color (Wendt, 1994).

There is one more additional function (Figure 8). The data function wd can assign data structures to the colors in the places. It represents per place and color a cache for additional information (data). The value of all functions has an influence whether a transition can be fired, apart from the data function.

CPNs provide a real-time related modeling approach that can be used to analyze the dynamic behavior of the system. Combining with IDEF0, the flows of dynamic processes are effortlessly extracted. CPN can be introduced into project management area because of their timing-related property. The dynamic states of the ongoing project can be easily identified and the effects of system perturbation, for example project scope changing, time varying or resource modification, can be analyzed. CPN can be used for project planning, problem forecast, conflict solving, performance analysis and system simulation.

Fuzzy Logic - Fuzzy-valued Petri Nets

In real life processes there are non-foreseeable events. Non-foreseeable events cannot be described adequately with their statistical properties. If data, and hence knowledge, are not precise, fuzzy-logic modeling should be employed by transforming the human expertise into IF-THEN rules and membership functions in order to solve such problems (Phillis, 1998). The use of fuzzy logic has been spreading in traditionally non-fuzzy methods and application areas. This also concerns the theory of Petri Nets providing simulation and analysis techniques for many domains.

With the combination of the theories of Petri Nets and Fuzzy Logic concepts for so-called Fuzzy Petri Nets (FPN) could be developed. Numerous authors have been contributed to this field, for example Chun (1993), Konar (1996) or Lipp (1995).

In this paper the Fuzzy-valued Colored Petri Nets (FCPN) will be introduced (Wendt, 1996). These nets are a further development of the Colored Petri by extending the colored transitions with a fuzzy-valuation function wft (Figure 8) and by connecting fuzzy variables to tokens (markings).

The fuzzy-valuation function generates a set of valuation marks for the transition that influences whether the single transition color is fired or not. The firing-ability depends on the following conditions:

- number of tokens at input-places, per color
- number of tokens at output-places, per color
- value of a threshold from which the transition can fire (switch), per color and
- values of fuzzy variables of single tokens.

All this information can be combined in different ways in order to make a decision in which color the transition is fired. As opposed to Dubois (1989), the transition is fired as in Place/Transitions Nets (non-fuzzy).

A Fuzzy-valued Petri Net is simulated as follows: The pre- and post-conditions are tested with each clock. If fuzzy algorithms are defined, a fuzzy interpreter is started and the fuzzy rules are worked. The result of that is reflected in possible change of the fuzzy variables of the tokens or in the conflict resolution or in the influence of the firing-ability.

In the following it is explained how Fuzzy Logic is used. After interviews with experts or operators who having experience on the process (for example a production process), one can find out by which rules decisions are taken and in which priorities the rules are involved. Following rules could be possible:

Rule I: If a job is very urgent, then it has to be processed as soon as possible.

Rule II: The more urgent the job, the higher the qualification of the operator has to be. The operator with the best qualification takes the most urgent jobs.

The next step is to define the most important criteria for the rules, for example it can be the urgency of a job or qualification of the operators. After that, a linguistic variable is generated for every criterion, for example "Urgency" or "Qualification". Then the output linguistic variable for making a decision is defined. Usually this variable is fuzzificated in a fuzzy-valuation function. Every variable has some terms (from one to seven); normally there are five or three (for example the terms "low", "normal" and "high"). The state of a linguistic variable is represented by the grade of the fulfillment of its terms. So for example, the room temperature of 22°C is classified with a probability of 0% as "low", 60% as "normal" and 40% as "high". If there is one term that is more important than another then the membership function has to be changed. From experience it is recommended to use triangular terms.

After defining the linguistic variables the second step should be the definition of the rule blocks. The linguistic variables (actually their terms) have to be connected by fuzzy operators. The MIN-MAX-operator is very often used (Zimmermann, 1991). In order to keep the rules clearly arranged it is better to connect not more than two input variables by one rule block. Thus, further linguistic intermediate variables are necessary.

The intermediate variables are connected again in order to get a decision note. This note states for example when a job is urgent enough, so that it has to be processed immediately. Such notes are computed for all variable-pairs, so that the settlement of conflict situations in the net becomes clear.

After defining and verifying the fuzzy algorithm in a special tool it can be attached to the fuzzy-valuated Colored Petri Net. The fuzzy-valuation functions are placed at those transitions that are related to the fuzzy rules. The fuzzy-valuation function will run every time if the transition is ready to be fired. Depending on the amount of tokens at the pre-places and on the values of data structures of tokens a set of notes is computed and the pair with the best note is chosen, and the transition is fired.

The input of linguistic variables with membership functions and their combinations can be made with a separate tool, for example FuzzyTECH (FTECH, 1996), where the fuzzy algorithm can be tested and verified, or in a Petri Net tool, called PENECA (PNC, 1997), having the same functionality.

In real life cases, there are often large numbers of rules that partly contradict each other. The fuzzy approach seems to be better applied for such contradictions than deterministic or stochastic concepts. The simulation with fuzzy valuation determines more precisely the order of processing and the connection of jobs to the machines and operators than it is possible with fixed rules and numbers.

The FCPN are, among other things, used to create models for forecasts and decision-making. Therefore especially the processes that are not algorithmic definable as well as the non-adequately definable influences, for example human behavior, are considered.

Conclusion and Future Work

The paper discusses the problems with existing modelling methods and techniques in project management; existing modeling methods and techniques in project management can hardly cover all aspects required by process-oriented project modeling in all project stages. It is suggested that disadvantages with current methods can be eliminated by using IDEF0, Colored Petri Nets (CPN) and Fuzzy Logic combined with present project management techniques. IDEF0 is a powerful method in terms of functional modeling capabilities. It provides advanced features to model the control flow of processes (information, resource, and organization aspects) and can be easily transformed into equivalent Petri Nets. Colored Petri Nets are mostly used for detailed analysis of the produced models. Fuzzy Logic can be applied for handling of non-precise data. Combining CPN and Fuzzy Logic, the main objective of the model is to simulate the process in order to be able to forecast future performance of the system as exact as possible.

Future work includes further verification of the process-oriented project model and the modeling method set by carrying out case studies in a wide range of practical domains. The design of an integrated measurement system is necessary for quantifying and evaluating efficiency and effectiveness of process performance in each project management phase.

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Analyzing the Context and Process of Inter-Firm Projects

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The interaction-context between client and contractor in large projects is often characterized by technological uncertainty, and by not being embedded in a long-term buyer-seller relationship. These characteristics call for special attention both from a managerial and a theoretical point of view. In this article we discuss the overall question of how project transactions are regulated in such dyadic relationships. The research is based on a multiple case study of projects within three Scandinavian project-based. The overall aim of the article is to outline a framework of important situational factors and to analyze important aspects of the interaction process in project situations characterized by low continuity and high technological uncertainty. From the analysis of projects characterized by low continuity and high technological uncertainty we identify two managerial strategies that seemed to be used to avoid these situations. We label these two strategies technology-controlling and relationship-building. However, in certain situations these managerial strategies might not only be unfeasible but also economically irrational. Moreover, we analyze and discuss problems associated with projects characterized by low continuity and high technological uncertainty.

Inter-Firm Relations in Large Projects

The question of how transactions among firms are regulated has attracted researchers for a long period of time. The well-known transaction cost theory points to the importance of transaction costs to understand the appropriate coordination structures (Williamson, 1975). This view has been criticized from several perspectives for taking a short-term view of transactions, and ignoring social issues between economic actors (Johanson and Mattsson, 1987). In contrast, the network approach of industrial marketing puts greater emphasis on social aspects and relationships in marketing and selling activities (Håkansson, 1982). The literature on interactions on industrial markets focuses on two key aspects; interdependency and trust, which are both considered to be consequences of long-term interaction (Liljegren, 1988). One might assume that such continuity is very dependent on the expectations of future interactions, which form a basic trust between the interacting parties (see also Axelrod, 1984; Lewicki and Bunker, 1996; Zucker, 1986). Our argument is that none of the theoretical frameworks provided so far, has shed light on the unique problematic of inter-firm relationships when the transaction is a complex and technologically uncertain project.

Projects have certain characteristics that call for special interest, such as being time-limited, complex, unique etc. (Bresnen, 1990; Packendorff, 1995). One might expect that these characteristics affect the interaction context between buyer and seller that is the focus of this article. Our starting point in the analysis rests on certain assumptions about project-based industries. Obviously, any statement, with regards to what a project is and what characterizes a project-based industry, will rely on ideal typical thinking. In our analysis we will especially consider the following:

- Firms in the interaction process have limited experience of working together,
- Firms have limited prospects of working together again, and
- Projects are often complex or uncertain.

To begin with, let us consider two of the dominant perspectives in the analysis of interactions between firms, namely the interaction approach (or network approach), and transaction cost economics, and relate the above mentioned characteristics to these schools of thought. In our view the network approach places too strong an emphasis on the existence of long-term relationships between buyer and seller to fully explain situations of project-based industry. Transaction cost economics, on the other hand, would assume that projects should be performed within a hierarchical order due to the low transaction frequency and the high uncertainty (Winch, 1995). However, hierarchical arrangements are not observed as there are two parties involved in the interaction process, the contractor and the client. Within the literature on project-based business, the low frequency of purchase has led writers to introduce the notion of managing 'discontinuities' (Hadjikhani, 1994). In line with this, some writers have even argued that there is a need for a separate theory for the project-based organization and its marketing activities (Bansard et al, 1993; Cova and Holstius, 1993). These writers, though, have generally focused on the time prior to contract writing, thus downplaying the interaction during project execution. Our research has not focused the buying or selling behavior of the two organizations. Instead we have tried to capture the interaction context and process during the completion of the project. A time period often as long as three or four years where there is a great need for extensive communication and sharing of information and knowledge between the parties involved. Our perspective mainly considers the project from the view-point of the contractor.

The research stems from single case studies of three projects within the companies, one project in each firm. From these case studies, which were inductive in nature, we were able to construct different explanations of each project. In the analysis section we use the concepts of technological uncertainty and continuity of the customer-supplier relationship to explore characteristics of project dyads. Moreover, from the analytical concepts we identify different situations and discuss the problem of managing projects in these different contexts. Our analysis will especially consider projects that are technologically uncertain and where the interaction is not embedded in a long-term relationship between the firms. Realizing that these are not characteristics of all types of projects we still believe that quite a few projects have aspects that are related to these characteristics. Thus, we argue that lessons can be learned from the ideal type situation of technological uncertainty and discontinuity. Our main point with these characteristics is to emphasize certain problems of project-based industries and the managerial problems connected with these problems. It is not our intention to provide a total analysis of these complex issues but rather to contribute in a discussion of important situational factors and in what ways these factors can be handled.

Research Approach and Methodology

Our research is guided by an abductive approach using empirical regularities as the basis for generating empirically grounded theory (Alvesson and Sköldberg, 1997; Söderlund, 1998). The article reports on findings from studies of three Scandinavian firms (see appendix 1). In these firms we have studied mainly two different levels of analysis; project management and top management. In Alpha, which operates in the boiler business, we have studied two projects, one in each of the firm's two divisions. One of the projects was embedded in a long-term relationship, the other was not, both projects were associated with degrees of technological uncertainty. In Beta, which mainly operates in the power transmission area, we studied two projects similar two to the ones in Alpha, that is both projects were associated with uncertainties in the used technology. In the Beta case, one of the projects was embedded in a long-term relationship, while the other was more clearly a relationship of a time-limited nature. In the third study we collected data from four projects. The firm under study-Gamma-operates in the industry of telecommunications. Two of the projects that we studied were associated with rather high degrees of technological uncertainty. All the projects were embedded in long-term and continuous relationship between client and supplying firm. During the research process we have conducted over seventy interviews with members of project management and top management (the projects and firms are classified and briefly described in the appendix).

Aim and Outline

The overall aim of the article is to analyze and explore the context and process of customer-buyer relationship in project-based industries by providing a coherent framework and analytical concepts. The article is structured in the following way. First, we provide a framework that identifies important contextual factors of project business. Then we discuss different types of relationship contexts and propose different types of exchange relations that emerge from the analytical framework. We identify and discuss two overall strategies that firms seem to adopt to handle the context in which projects are carried out. After that we proceed our analysis by focusing on the process of interaction between client and contractor. This analysis is mainly one that seeks to increase our understanding how firms operating in project-based industries through managerial activities can manage the relationship with their clients during project completion.

A Framework for the Analysis of Interaction Contexts

In this section we suggest a framework focusing on two important dimensions of project contexts, namely technological uncertainty and relationship discontinuity. These overall characteristics are directly derived from the characteristics discussed previously. The framework will serve as our starting point in a discussion about the dyadic relations in projects. Many projects are associated with technological uncertainty, as they deal, for example, with not completely well known technologies. We define technological uncertainty as a situation where the means and ends of the project are difficult to define in advance (cf. Ahmed 1993; Hellgren and Stjernberg 1995). Furthermore, as we stated earlier, project-based business is often characterized by discontinuity, i.e. a low frequency of purchase (Hadjikhani 1994). We define high continuity as a situation where the project is more or less embedded in a long-term relation between buyer and seller, i.e. a situation where the firms have limited experience of working together and limited prospects of working together again in the future. We can therefore present the following grid, identifying four types of contexts in which projects are carried out.

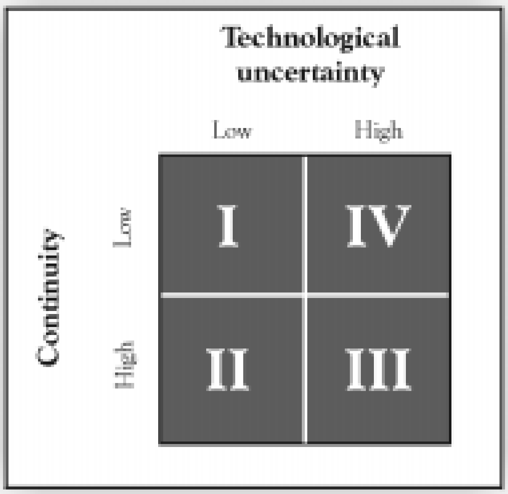

Figure 1. A typology of project dyadic contexts

We will shortly discuss each of these four situations and contexts in the following analysis, starting with situation I.

I: Low uncertainty, low continuity

In a situation where technology is known and the means and ends are relatively easy to specify before a project begins, it is theoretically possible to write a detailed formal contract and make the project manager responsible for fulfilling the terms specified (cf. Macaulay, 1963). The buyer-seller relation will be at 'arms-length' distance and the supplier can carry out the project based on the specification in the contract. The atmosphere is characterized by competition and the actors feel that it is a win-lose situation, very much related to how e.g. Porter (1980) describes the function of the market. We will relate this type of exchange relation as a 'contract-based exchange relation'. The way to manage the project is in theory well described in the traditional project management literature (e.g. Burke, 1993; Lock, 1996; Meredith and Mantel, 1995) and in the discussion of repetitive projects (Lundin and Söderholm, 1995), where focus is upon rather standardized project management tools, planning techniques and methods.

II: Low uncertainty, high continuity

When buyer and seller both have a long-term ambition with the relationship, different forms of ties between the firms are likely to emerge (cf. Eccles, 1981). The interaction process, as described in e.g. Håkansson (1982), consists of different kinds of episodes and exchanges which create a pattern that becomes routinized over time. As interaction processes are repeated, the parties learn what to expect from each other. Thus one might speak of common learning in these situations. Moreover, as this learning and these expectations become more or less institutionalized they tend not to be questioned by the parties involved (cf. Powell, 1990). This process reduces complexity and costs, and makes the cooperation smoother (Håkansson and Snehota, 1995; Sahlin-Andersson, 1992). As in the situation discussed in the previous section, contracts and formal plans work well to specify the project in detail a priori (see also Madhok, 1995). A project in this situation is also of a repetitive nature (Lundin & Söderholm, 1995); however, in a situation of very high continuity it might not even be necessary to have a detailed formal contract if the degree of routinization is high, signaling 'business as usual.' In a situation characterized by low uncertainty and high continuity the interactions are assumed to form routines, clear roles for the parties, which lead to forms of routinized behavior (cf. Noorderhaven, 1995). Such a situation will lead to, what we label, a 'routine-based exchange relation.'

III: High uncertainty, high continuity

Under technological uncertainty the applicability of contracts and formal plans becomes limited. In such a situation the means and ends of the project cannot easily be specified in advance. The technological uncertainty calls for constant re-definitions of the project and of the interaction between the parties. Routinized behavior as discussed above will not be sufficient due to the technological uncertainty. Instead a learning process is called for. We might assume that the deeply rooted long-term mutuality between the parties will prevent opportunistic behavior on the part of the actors involved in the specific project in much the same way as infinite games are treated in traditional game theory. As continuity is prevalent, actors have a certain degree of trust based on past exchange and from an economic perspective on expectations of future interaction specific to the relationship. This basic level of trust forms the basis from where the learning process can evolve. We have chosen to label this a 'process-based exchange relation' (see also Perrow, 1986; Zucker, 1986).

IV: High uncertainty, low continuity

A situation with high uncertainty and low continuity generates projects of a unique type (cf. Lundin and Söderholm, 1995). In such projects, standardized and traditional project management tools have probably limited applicability. We argue that in a situation where technological uncertainty is prevalent it is necessary to facilitate an open flow of information between the organizations in order to solve the unforeseen problems that occur when technology is uncertain. This calls for 'organic' organizing principles that seem to require a high level of trust (Burns and Stalker, 1961) and a project management style that allows for a significant degree of learning both in terms of technological characteristics and of learning about the other party (cf. Bennis and Slater, 1968). The paradox however, is that organic principles of organizing rely heavily on mutual trust that stems from previous interaction or expectations of future ones, which are no characteristics of project-based business.

Trust is obviously an elusive concept (Gambetta, 1988; Hosmer, 1995). A certain degree of trust is necessary even in writing the simplest contract (Macaulay, 1963). In our analysis we have used a simplified version of the notion of trust focusing on future ex-

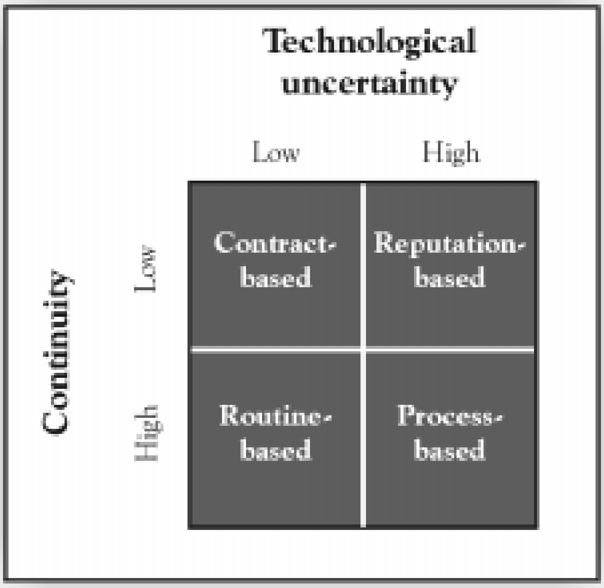

Figure 2. A typology of exchange relations in project dyads

pectations, i.e. in line with the following reasoning: 'if something goes wrong, I act in your best interest, because you will pay me back later.' This is not any different from pure economic rationality in terms of the value of the specific relationship. However, this presupposes a continuing relationship between the two parties (cf. Alvesson and Lindkvist, 1993; Perrow, 1986). Generally speaking, in temporary settings (Bryman et. al, 1987) trust cannot be based on either paying back old debts or on speculations about future revenues in terms of the 'specific relationship'. Instead of relating to the dyad, trust will be based on the parties' roles and reputation in a larger context (cf. Weigelt and Camerer, 1988). Trust is viewed here as a product of the actors that relies on each actor's relation to the network. In such a situation the reputation of each actor will curb opportunistic behavior. However, a prerequisite for this is probably that the network is relatively 'tight coupled' and thus able to 'balance' actors' performance in the long run (Meyerson et al, 1996). Moreover, actors in the interaction process must from an economic standpoint have long-term ambitions for their membership in the overall network. We assume that 'defending' one's role and reputation in an overall industrial network is a hindrance to and a prevention of opportunistic behavior in much the same way as repeated games among known players are treated in traditional game theory. Hence, our basic notion of the interaction and exchange in this situation relies upon a 'reputation-based exchange relation.' The following typology summarizes the discussion in previous sections.

Strategies for Managing the Interaction Context: Technology-Controlling and Relationship-Building

From the above-outlined framework we identify two strategies that firms can apply in order to avoid what we labeled as situation IV. These strategies, however, are not totally coherent with our empirical observations. The first we will relate to as strategy of 'technology-controlling', the other as a strategy of 'relationship-building'. Quite frequently we have observed the technology-controlling strategy as firms try to avoid introducing unknown or uncertain in a project where the firm does not have a long-term relationship with the client. Thus, firms put a lot of effort in analyzing the technology to be used and different ways to decrease the risk associated with the project by going for well-known technological choices. Unknown technologies seemed to be used more frequently in situations where the project was embedded in a long term relationship

By applying the strategy of relationship-building managers can seek to establish a longer-term relationship with the client in order to avoid the problems of often discussed as 'finite games' (cf. Kreps, 1990). Hadjikhani (1994) argues that in a situation of discontinuity, managers can take marketing actions to maintain or strengthen the relationship for subsequent projects. However, our observations did not point to this strategy as being generally applied. In certain industries the time span between projects delivered to the same client is extremely long, often as long as ten years, there is difficult to see the reasons for a long term relationship. In such situations the customer often seeks a position to maintain and operate the plant on its own, thus interdependencies of technological character between the parties will be weak in the long run.

The reason why, technology-controlling, might be a bad strategy has to do with risk-sharing and opportunities to enter new markets early compared to competitors. Here firms might gain first-mover advantages and exploit windows of opportunities if they dare take the risk of project failures, which at least theoretically should be expected to be higher in situations of high technological uncertainty. Moreover, the strategy of relationship-building might also be unfeasible for certain reasons, for example that the client wants a free-standing position or that it is not within the core activities of the supplying firm.

In sum, the above-discussed managerial strategies are stylized ways to 'avoid' what we label 'situation IV projects'. As we have argued these strategies might in certain industries and certain projects be unfeasible and economically irrational. Hence, we need a deeper understanding of not how to avoid situation IV, but how to 'cope' with it. As we have stated previously, projects carried out in situations characterized by low relationship continuity and high technological uncertainty should lead to several managerial challenges.

Analytical Concepts for Managing the Interaction Process: Time-Pacing and Matching Hierarchies

The above analysis focused on the context in which a project is carried out. In our cases we observed patterns that characterized project completion associated with discontinuity and technological uncertainty. We believe that firms who operate in project-based industries often face problems that are related to these characteristics to a greater or lesser extent, and thus face somewhat similar problems that we observed. In our studies of how the supplying firm tried to manage the interaction process, we observed two important issues; the first labeled time-pacing, the other labeled matching hierarchies. We will briefly outline the meaning and significance of these issues to understand and manage the interaction process.

In the projects under studied classified as 'situation III projects' we identified different types of routines and mutual trust that played important roles for the interaction process (in appendix 1 labeled A1, B1, G3, G4). However, in projects clustered as 'situation IV projects' we observed a need for more conscious managerial efforts to handle the customer relationship (A2, B2). We especially observed problems of pacing the two firms' activities and problems of a joint-decision making unit, hence our concepts of time-pacing and matching hierarchies.

To emphasize the difference between the two main clusters of our study, situation III and situation IV (see appendix 2), we start with analyzing the role of continuity and what effects relational embeddedness as expressed by Granovetter (1992) have on the interaction process. When a project is embedded in a long-term relationship certain routines get established and mutual adjustments and trust will be prevalent. These forms of coordination seem to handle the problems of pacing and joint-decision making. As a contrast, projects associated with low continuity and high technological uncertainty cannot rely on either of these mechanisms of coordination. Instead the projects rely on reputation-based issues as outlined above, which might curb opportunistic behavior but not function as a sufficient way to establish a well-functioning interaction process. Thus, we need to take a closer look at certain aspects related to how the firms interact during the process of project completion.

Theoretically the above-mentioned issues of inter-firm coordination is a classical question. Our discussion of matching hierarchies bears similarities with Stinchcombe's (1985) analysis of the so-called 'violation' of the 'decoupling principle' in project-based industries. In this way; due to complexities and uncertainties connected with project transactions, it is very difficult to determine who is responsible for what and to decide upon joint action when several parties are involved with conflicting goal orientation. It is in a sense a classical discussion about boundaries between firms and in that way draws on transaction cost theory and discusses hierarchical versus market-based ways of coordinating activities.

Our concept of time-pacing has an orientation towards understanding how activities between firms are coordinated from a time perspective. In our studies we frequently observed that the client and contractor that worked on interdependent parts within the projects had a hard time figuring out when activities best should take place. As an example, the client seemed to have a different agenda and a different time schedule and thus a different list of priorities than the contractor. Moreover, the two interacting firms also seemed to rely on different macro-cycles, which they related and structured their present action against. In such a situation, the client had an important deadline to meet while the contractor had a different deadline to meet which led the interacting parties to speed up their activities and increase their level of effort at different points in time. In such a situation the client required answers on questions that the contractor had not yet started to frame and analyze. In the studied projects in cluster IV (A2, B2) we observed that the clients seemed to be 'ahead' of the contractor. The clients had started earlier and were in this sense closer to the final deadline from their point of view compared to the contractor. One of the project managers expressed it like "the client did not have an understanding of our situation and our way of working" (Project Manager, Alpha). In another project the situation was described as "the customer wanted answers on things that we hadn't even start thinking about. Everyone that knows about this process, knows that these things can't be set until later stages of project" (Project Engineer, Beta).

Obviously, it does not always have to be the case that the client is ahead of the contractor, the opposite might just be as common. Our main point with this discussion is to show the importance that both parties need to pace their activities due to interdependencies between their respective activities. Moreover, the discussion also shows that each party has different perspective on the project and what needs to be done in certain stages, and that this might not be fully compatible with the best way of working for each single actor. Hence, in technological uncertain and complex projects it is probably difficult and problematic to make a clear cut 'decoupling' between each party in the interaction process. Thus, from such a perspective the actors cannot take a standpoint where the project is viewed only from either a customer perspective or a supplier perspective and the respective processes.

As the activities between the interacting parties are interdependent, one would expect that there be several occasions when the parties need to make joint-decision making, which was the case in the projects under study. In our studies we have found that there is a need for what could be seen as a 'last resort' in decision making. The logic behind this is that when differences in opinion between for example the two firms' project managers appear, they have the possibility to move the decision up one step in the hierarchical ladders, making it a top management issue. Top management, often only a group of four persons, seemed to have easier and more power to handle the problems on a trust-based manner. Following to that the project management of each company could follow the direction set by the top management. Our cases also showed that it seemed to be important not to enter legal discussions that focused on dividing responsibility between the parties, but instead, build a shared understanding on top management level. Moreover, it also seemed to be important that the levels within each firm's hierarchical levels were not interfered. This made it easier to take a new look at the problem and the decision and also to avoid problems of prestige that had gotten into the situation on a lower hierarchical level

Concluding Remarks

In this article we have presented a framework of contextual factors for analyzing project dyads. In each of these situations, a basic exchange relation was identified. In simple situations contracts are theoretically a sufficient way to regulate the relationship between the two parties. A situation characterized by high continuity and low technological uncertainty, opens up for opportunities to establish routines for the interaction process. In such a situation it seems fitting to assume that the regulation of the exchange will be 'routine-based.' Higher levels of technological uncertainty call for more 'organic' approaches towards the interaction process. We assume that neither contracts nor routines will be well suited; instead the actors' long-term ambitions within the dyad will constitute the main regulating basis. In these situations we therefore suggest a 'process-based exchange relation' to be well-functioning. The situation depicted in our fourth quadrant, characterized by low continuity and high technological uncertainty, calls for other forms of regulating bases than trust towards the specific relationship. Instead, the overall industrial network and the actors' roles and reputations in that population will produce a certain degree of trust. Here actors may fear e.g. that a bad reputation will affect their future relationship with other actors in the network. We labeled this a 'reputation-based exchange relation.'

As we continued our analysis we laid more focus on the interaction process. By this we especially mean the way the supplying firm seeks to manage the relationship during project completion. Our findings point to the importance of time-pacing and matching hierarchies. Time-pacing relates to the problem that the parties seemed to be in different phases of the project, asking different questions, and working in different rhythms. Hence time-pacing draws attention to the lack of routines and existing structures that often characterizes the interaction between firms that have limited experience of working together. The concept of matching hierarchies is related to the lack of a long-term perspective as the parties have limited prospects of working together and the problem of establishing a joint-decision unit. Hence, it draws attention to the importance of a last resort in handling unexpected (not-contracted-for) contingencies. In such situations top management plays key role to handle issues on a more trust-oriented and personal basis.

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Author's note

Due to reasons of confidentiality we do not use the real names of the case companies.

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Appendix 1

Classification of projects under study

Alpha

- Type of industry: Chemical recovery and power generation boilers
- Number of projects studied: 2
- Project 1: Low continuity, high technological uncertainty (A1)
- Project 2: High continuity, high technological uncertainty (A2)
- Main sources of information: interviews with project mangers, CEO, division managers, chairman of the board, marketing manager and project engineers, and project documentation.
- Number of interviews: 10

Beta

- Type of industry: Power transmission systems
- Number of projects studied: 2
- Project 1: High continuity, high technological uncertainty (B1)
- Project 2: Low continuity, high technological uncertainty (B2)
- Main sources of information: interviews with project managers, CEO, division manager, marketing manager and project engineers, and project documentation..
- Number of interviews: 10

Gamma

- Type of industry: Telecommunication systems
- Number of projects studied: 4
- Project 1: High continuity, low technological uncertainty (G1)
- Project 2: High continuity, low technological uncertainty (G2)
- Project 3: High continuity, high technological uncertainty (G3)
- Project 4: High continuity, high technological uncertainty (G4)
- Main sources of information: interviews with project managers, division manager, members of division management, marketing manager and project engineers, and project documentation.
- Number of interviews: 12

Appendix 2

Illustrations and comments about the projects

Situation III projects (high continuity, high technological uncertainty)

- "In some cases with this customer we do not even use contracts. We know them and they know us." (Chairman of the board, Alpha)
- "We have a good relationship with this firm and we all know it's a 'what goes around comes around' situation." (Project Manager, Beta)
- "With this customer we have a very good cooperation. We test our new technologies in their plants, and it is a good pay-off for both parties. They learn about the technology and we can test how well it works" (Project Manager, Beta)
- "We have a constant dialogue with the customer about what to do with their systems, and we know that our success is dependent on their success." (Project Manager, Gamma)
- "In this project we were trying a new technology and we were a bit unsure whether it was going to work as planned. We had a lot of discussions during the project and I believe that we both understand how important it is to have a good relationship." (Project Manager, Gamma)

Situation IV projects (low continuity, high technological uncertainty)

- "We felt like they wanted to break us." (Chairman of the board, Alpha)
- "This project definitely caused us several problems. I believe the customer was very short-sighted and wanted to make a profit on this project on our behalf." (Project Manager, Alpha)
- "They hired consultants that took a very tough attitude against us." (Project Manager, Beta)
- "We have an explicit strategy for establishing top-management relationships in these types of projects." (CEO, Beta)
- "We had a lot of legal discussions. My opinion is that it is dangerous to enter such discussions because lawyers try to separate responsibilities, while we want joint action." (Project Manager, Beta)
- "To be honest with you, I believe that the customer would have gotten a better plant if they had not entered all these legal and bureaucratic discussions. I am sure that they have another opinion and that they believe that they way they chose to run the project was the best solution." (Project Manager, Beta)

Implementation of Strategies in Projects

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Keywords: Strategies, Projects, Strategy start-up

The competitiveness on the market requires ever faster completion of projects. The result of this trend is the reduction of both, the project strategy creation time and the project implementation time. The improvement is seen in a more effective connection between strategic management of projects and project management, which is referred to as strategy start-up. During strategy start-up it is still possible to create strategic goals while the transformation of strategic goals into project goals is already taking place. The advantages are: shorter project implementation time, better linkage between strategic directions and project implementation, and greater adaptability of the strategic goals to the influences of the environment.

Introduction

The link between strategic and project management can be considered two-fold. First, the business strategy itself is a complex project with all its characteristics, and secondly, the business strategy is implemented through projects (Schelle, 1997), which is the subject discussed in the article.

Business strategy must include the elements which will guarantee better competitiveness of products and services on the market. However, an appropriate strategy does not guarantee the desired results without a rapid project implementation of strategies, which is also the crucial point of the link between the strategies and the projects. Projects should be implemented so as to reach the competitiveness defined by the strategy. In this effort it is necessary to find the balance between the duration of implementation, cost optimality and adequate quality. The trends observed over the last years indicate that the above three attributes no longer assure an optimal implementation of projects, and that it is necessary to include the ability to cope with changes (Hauc, 1996).

The Deficiencies of the Existing Practice

In present time the projects running in companies are not sufficiently connected with the business goals and the business strategy, or putting it in other words, that the connections between the selection of projects and the business strategy are almost incidental (Schelle, 1997). It is evident that such connections must be introduced in order to assure an efficient implementation of strategies.

The question arises what are the reasons for this "short-circuit" between the strategic and project management. The first reason is certainly found in the internal organization structure of companies where the strategy creation units are separated from the project preparation units. As a result, the business strategy often remains a "secret" of the top management (Schelle, 1997). The second reason is the difficulty of linking the selection of projects with the chosen strategy, which is most obvious in project-intensive companies and in companies that are particularly sensitive to economic and market trends. As a consequence, the strategy is not adjusted soon and well enough, and it may occur that projects have to be implemented even where unforeseen by the strategy.

Project Strategies

Project strategies are designed prior to and during the strategy start-up. They should be subordinated to business strategies, which, however, is not always the case. In Table 1 goals of global business strategy, field business strategy, business units strategies and project strategies are shown.

Project strategies follow the goals of projects. They have to be defined, worked out and implemented separately for each project. The growing competitiveness and the resulting need for rapid project implementation have made it necessary to pay greater attention to project start-up and adaptation to new conditions. The strategy creation asso-

Strategy		Goals
Business Strategies	Global Business Strategy	· return on equity · stability of operation and workplaces · company growth
	Field Business Strategies	· improvement of product quality · improvement of operating quality · reduction of costs
	Strategies of Business Units	· concrete goals, such as rationalization of resources, increased scope of research, etc.
Project Strategies		· focused goals for achieving competitive advantages subordinated to business strategies

Table 1. Goals of business and project strategies

ciated with project start-up and conditions are discussed in the following.

Strategy Creation

When creating project strategies it is necessary to forecast possible changes in conditions, e.g. market changes, technical and technological changes, political changes or environmental changes. The possible changes of conditions and their influences must also be taken into account in the realization of projects. Since forecasting is known to be uncertain, we can resolve this problem by using the principles of mastering simultaneous change defined by Hauc (1996).

Project strategies are subordinated to business strategies which are created on several levels according to their importance. Thus we speak of global business strategies, field business strategies and strategies of business units which are again divided into, e.g. marketing and sales strategies, research and development strategies, staffing strategies and financing strategies. Regardless of the complexity or the importance of strategies it is our aim to transform strategic goals into project goals, and later on into an overall preparation process for project realization (Hauc, 1996). The process of transforming strategic goals into project goals and the subsequent preparation for project realization is called strategy start-up. With the transformation of strategic goals into project goals the strategic management is simultaneously transformed into project management, which is presented in Figure 1.

Strategy Start-Up

As mentioned above, the strategies are implemented together with projects, or in other words, project goals follow the

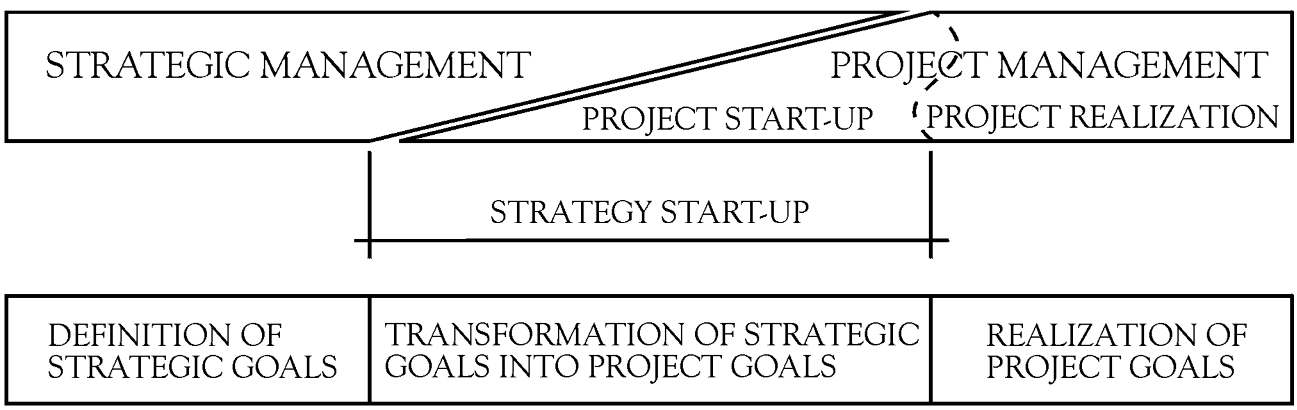

Figure 1. Strategy start-up and its share in project management

strategic goals. Thus, for example, marketing and sales strategies are implemented with projects of growth where the interaction of strategic and project management and their flexibility or adaptability to changes are of crucial importance.

In companies, strategies are implemented on three levels. Global business strategies, which are implemented through joint strategic projects, represent the highest level. Within these the strategic development fields are defined; they create and implement business field strategies and projects. In project-oriented companies strategic business units are formed inside strategic fields. Strategic business units create and implement their own substrategies and projects.

A rapid transition from strategies to projects is of great importance at all strategy implementation levels, so a prompt inclusion of project managers into strategy start-up is necessary. This way the continuity of the strategy creation and strategy implementation process is assured.

Coping with Changes

Changes have become a very frequent and a very important factor why strategies are developed in increasing frequencies. Changes take place every day not only in the business domain but also in the broader economic, social and political environment. Consequently, special attention should be paid to changes already in the creation of strategies. Since it is well known that the creation of strategies requires a lot of detailed and time-consuming analyses, it is impossible to change the entire strategy creation for each occurring change of conditions. Changes should be assumed or foreseen in the creation of strategies, but they should be definitely considered during the transition from the strategic management to the project management, i.e. in the strategy start-up. This procedure results in a substantial reduction of project duration. Strategy start-up can be seen as a process of transforming strategies into a project simultaneously with the preparation of project start-up; it should be noted that the strategic decisions, in cases when it is impossible to reach a high degree of strategy definition, are transferred into the project start-up and implementation up to a certain point and accompanied by a permanent simultaneous inclusion of measures regarding the influence of changes (Hauc, 1996).

Thus, at strategy start-up, the strategies are prepared only up to the level where the transformation of strategic goals into project goals is possible. This approach also requires the inclusion of project management already in the strategy creation phase, which improves the ability to cope with changes in the environment, to eliminate them or even to make them profitable. This does not mean that the activity of strategic management has been reduced; it only means that strategic management is implemented via projects until the end of strategy start-up and the beginning of further implementation schemes.

Conclusion

Strategy start-up is a new approach which substantially improves the competitiveness of project implementation. The linking of strategic changes management and project management in strategy start-up is of importance because the project manager has the opportunity to cooperate already in the phase of strategy creation, and also, the tasks of strategic management are transferred into the project preparation and start-up phase. In this way the problems of deficient cooperation between strategy creation units and project preparation units in companies can be overcome. In addition, a better connection between strategies and projects is obtained, and the transfer of undefined strategic decisions into the preparation of project start-up is made possible. Another advantage offered by the linkage of strategic and project management through strategy start-up shows in shorter project realization times, and accordingly, competitiveness is improved.

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Planning and Control of Projects Through Application of Time and Cost Significant Activities

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Key words: Project, Control, Costs, Time, Significant Activities

The paper discusses the criteria and methodology of selecting, and the possibilities involved in using cost and time significant activities in projects. Results of research performed on samples of construction project plans and bill of quantities values are shown in the form of mathematical relationships. Along with the description of possible applications, a model is proposed which includes about 50% of total number of activities which are significant. These activities have a direct control on 90% of costs and time sensitive paths in the project, as well as indirect control on the main resources and milestones in the project. The idea is that management can use this kind of knowledge in order to concentrate efforts to significant activities rather than spending time on insignificant ones.

Introduction

Planning and control of a project is one of the most important responsibilities of a project manager (Kerzner 1992). In construction projects it is especially complex and demanding work, during which the viability of choices of technological and organizational solutions is evaluated. Confronted with significant complexity in project management, researchers and plan users all encourage simplicity and quality as two major characteristics of the planning process. The basic source of complexity is located in the large data amount. It is caused by complex processes and products and the use of a large number of different resources on which a large number of unpredictable factors has an influence. At the same time more demanding criteria for project success additionally increase the complexity of the process, and solutions are sought after in ever increasing numbers of input and output data. This is seen in plans as an ever growing number of activities and their relationships, which additionally burdens project managers with more controlling and communicating. Research (Kerzner 1992) shows that a shortage of time significantly influences the occurrence of late decisions and problems in communicating. Our experience indicates that in most cases there exists a negative spiraling trend of extra time use by project managers (Figure 1).

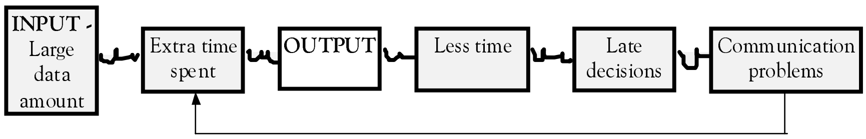

Figure 1. Large data base - time robber in the project management environment

At the same time, rationality of the entire process becomes questionable seeing as how usually a large number of input data of lower quality is processed by an exact mathematical high quality approach. Therefore, the use of certain simplifications has always been the topic of numerous research undertakings. In the research of simplification steps (Radujkovic 1997) we concentrate on:

1. Reducing decision and communication time, while retaining the quality of results .
2. Assuming that the possibility of data processing today has surpassed the quality of input data and an information balance between input and processing is suggested.
3. Simplifying should be applied in beginning phases, that is, as soon as possible.
4. There exist, in the project, various priorities of significance of individual data, processes, and activities...

Theory of significant activities

In the carrying out of a project, every component activity is important. Experience, however, shows that the contributions from individual activities to the total project cost and duration is not equal. With this in mind, this research was undertaken with the assumption that it is possible to quantify the various contributions of individual activities to a project's final results. In this paper significant activities are those that contribute with an above average share to the final results. Further, we

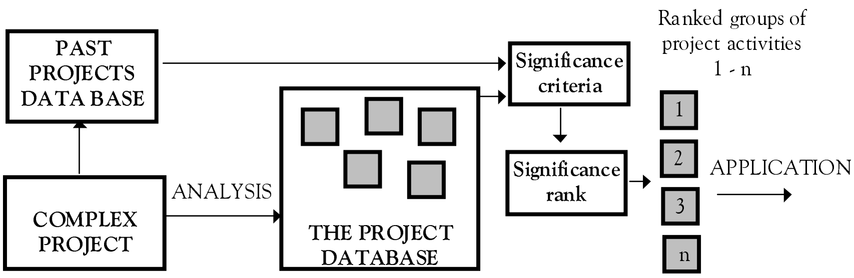

Figure 2. The process flow chart for establishing structure of significance in a project

supposed that significance can be ranked. These assumptions are based on the 80/20 principle developed by the Italian economist V. Pareto (1897) who claimed that in various economies 20% of the population earns 80% of the income (Saket 1986, pg. 6). According to Pareto in every large number of randomly chosen variables a significant subset can be found and some kind of structure of significance can be established. One possible scenario for establishing structure of significance in project is shown below (Figure 2).

Research into this concept on 32 construction projects showed that the combined contribution to cost of 50% of the items never surpassed 5.5% of the total cost of each project (Thompson 1981, p. 75). Additional research into cost distributions of construction project bills of quantities at the University of Dundee (Horner and Asif 1988.) confirmed the existence of a subset of 20% of items which contribute to about 80% of the costs. Horner defined an item as "significant" if it had an above average influence on the result on project level, i.e. if it had an above average value in the aggregate value of all items. Thus, the general criteria of importance was based on the average calculated from the data set. By being able to identify a chosen data subset in the large data set it is possible to define a ranking structure of priorities which can make an important contribution to the quality of decision making.

And while most previous researchers studied values of a construction bill of quantities and cost distributions, we focused on plans or programs of works which include the agreed upon project schedule, to begin with. Two significant principles influenced our orientation:

1. In that way it is possible to combine time dimensions to costs, and establish cost-time relationships.
2. The number of activities in the plans is usually smaller than the number of cost items in the bill of quantities for a construction project. So, we considered that the 80/20 rule is harder to apply for time oriented activities compared to cost oriented items. It follows that the combination of time and cost is also harder compared to cost alone. Nevertheless, we researched all possibilities.

Overview of research samples data base

Empirical research on this idea was made on several samples of randomly chosen construction projects whose characteristics are shown in Table 1.

The range of values of the investigated projects was between 0,5-32 million DEM. The number of activities in the project plans (programs of work) was between the minimum of 42 and maximum of 586, and the number of items in bills of quantities was always several times larger. All projects had the aim of constructing new structures, and the average representation of various types was: 35% buildings, 41% roads and bridges, 24% various hydrotechnical structures.

Ord. Num.	Type of data source	Number of projects	Year
1	Plans	35	1992
2	Plans	10	1993
3	Bills of quantities	50	1995
4	Plans + bills of quantities	40	1996
5	Plans + bills of quantities	34	1997

Table 1. Overview of characteristics of researched samples

Selection of cost significant activities based on average activity costs

During the research an analysis was made on cost contributions (c_j) of an array of selected subsets (S_i) of the total set of activities in the plan (S) in relation to the total plan costs. The selection of the subsets was made by changing the boundary values of minimum costs of activities (X) which were the criteria for some activity (A_j) to become a member of the subset. Due to the exclusion of the influence of inflation in continuos research during several years, it is appropriate to show data in percentages of total values of plans:

$$n_{CS}(S_i) = \frac{n(A_j \in S_i)}{n(A_j \in S)} \times 100 \quad [\%] \quad \ldots\ldots\ldots \quad (S_i \subset S)$$

Percentage of total plan costs in cost significant activities c_{CS}, is equal:

$$c_{CS}(S_i) = \frac{\sum c(A_j \in S_i)}{\sum c(A_j \in S)} \times 100 \quad [\%] \quad \ldots\ldots\ldots (S_i \subset S)$$

The criteria that an activity is a member of the significant subset

$(A_j \in S_i)$ is $c(A_j) \geq X \% \Sigma c(A_j \in S)$

The value, X, was within the closed interval, $X \in [0{,}1\% - 10\%]$
The graphical presentation of results is given in Figure 3. The analysis of the results confirmed average activity costs ($c \bullet (S)$) as an appropriate selection criteria for cost significant activities (A_{cs}).

$$c \bullet (S) = \frac{\sum c(A_j \in S)}{n(A_j \in S)} \quad \text{or} \quad c \bullet (S)[\%] = \frac{100}{n(A_j \in S)}$$

By applying the mentioned criteria the subset of cost significant activities (S_{CS}) can be separated, by the following condition:

$$S_{CS} = \{A_j \in S: \ c(A_j) \geq c \bullet (S)\} \text{ or}$$

$$S_{CS} = \{A_j \in S: \ c(A_j)[\%] \geq \frac{100}{n(A_j \in S)}\}$$

A statistical analysis of the all collected data was done by a bestfit calculation with 18 theoretical distributions (Palisade 1994.). The distributions were ranked by the Chi-Square and Kolmogorov-Smirnov tests. Based on achieved bestfit results we decided to use Weibull (α,β) distribution as the most appropriate for cost presentation in our construction project activities. Average values of α distribution parameter for all projects are between 0.87 and 0.95, and for β between 12.3 and 13.9. For a specific group of projects with similar characteristic a more certain values for parameters can be defined.

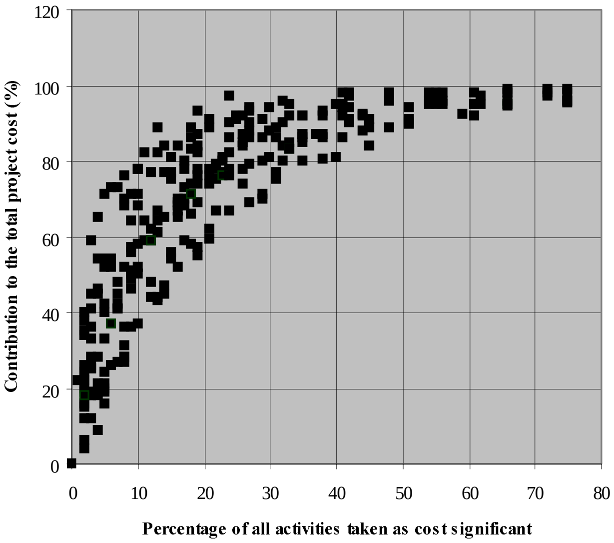

Figure 3. Results of investigation of relationship between different percentages of cost significant activities (n_{CS}) and their ascending cumulative contribution to the total project costs (c_{CS})

The average costs criteria is a good indicator of significance, since it is understandable and can be easily calculated. Results in Figure 3, show that the proper criteria with which a small subset of significant activities can be selected is found. These activities are activities of large cost contribution, and fit well with the Pareto rule of 80/20. In Table 2, results of the analysis of one database from Table 1, are shown. They confirm that on average 21-28% of activities give 77-82% of total project costs. The conclusion is that Pareto 80/20 rule stands for cost analyze in a construction project plan (program of work), even in the case of rather small number of activities.

Selection of cost significant activities based on average growth of costs with time

Growth of activity costs in a unit of time is investigated as a second criteria for selecting cost significant activities. Activities with changeable duration and large cost growth are especially significant in the case of project time compression. For the case of linear approximation of cost (c) and time (t) relationships during crashing process the average cost growth for single activity is equal to : $\Delta c = c_{max} - c_{min} / t_{max} - t_{min}$. The criteria for selecting cost significant activities can in this case be the average cost growth in a unit of time $\Delta(c_{CS}\bullet)$ of all activities in the plan:

$$\Delta c_{cs}\bullet(S) = \frac{\Sigma\Delta c(A_j \in S)}{n(A_j \in S)}$$

The subset of cost significant activities S_{CS} is determined according to the following condition:

$$S_{cs} = \left\{ A_j \in S:\quad c(A_j \geq \Delta c\bullet(S) \right\}$$

We used this criteria as an added cost criteria only in the cases of probability time approach (Radujkovic 1995).

ROAD AND BRIDGE STRUCTURES														
Project	1	2	3	4	5	6	7	8	9	10	11	12	13	Avg.
$n_{CS}(S_i)$ [%]	23	31	11	24	22	17	22	27	21	14	19	27	10	21
$c_{CS}(Si)$ [%]	81	89	82	86	92	73	79	79	89	77	74	86	78	82
HYDROTECHNICAL STRUCTURES														
Project	14	15	16	17	18	19	20	21	22	23	24			
$n_{CS}(S_i)$ [%]	23	18	29	26	21	31	24	13	13	26	25			22
$c_{CS}(Si)$ [%]	77	74	86	78	74	76	78	82	89	85	92			81
BUILDING STRUCTURES														
Project	25	26	27	28	29	30	31	32	33	34	35			
$n_{CS}(S_i)$ [%]	29	34	23	24	23	31	20	31	29	32	38			28
$c_{CS}(Si)$ [%]	70	85	76	76	80	75	87	77	71	80	71			77

Table 2. Percentage of cost significant activities (n_{CS}) and participation in total plan costs (c_{CS}) according to the criteria of average costs $(c_{CS}\bullet)$ - 1. sample.

Selection of time significant activities

In the paper for time significant activities, two possible criteria for selection are studied:

1. Average duration criteria.
2. Critical index criteria.

These criteria were tested by analyzing data from the sample in Table 1.

Selection of time significant activities based on average duration criteria

Using the principle of the theory of significance the average duration criteria generated the subset of time significant activities. The subset contained an average of 33% of project activities, which contained an average of 71% of the total sum of duration of all activities in the plan. The geometrical relationship of time is similar to the costs, except with a weaker growth curve (Fig 4).

The interdependency in the activity network has been considered as additional criteria (Radujkovic 1997.). However, results of testing the contribution of critical activities according to CPM analysis (A_j^K) in the subset of time significant activities ($S_i = S_{TS}$) chosen in this fashion show that on average they are somewhat greater than the percentage of significant activities in the set of all activities in the plan (Fig. 5).

$$\frac{n(A_j^K \in S_{TS})}{n(A_j^K \in S)} \times 100 \;\geq\; \frac{n(A_j \in S_{TS})}{n(A_j \in S)} \times 100 \;= n^*(S_{TS})[\%]$$

For the tested samples the contribution was on average: $n\,(A_j^K \in S_{TS}) \approx 40\,\%\; n\,(A_j^K \in S)$. Due to too little contribution of critical activities in a subset selected in this fashion, this criteria is not used any further.

Selection of time significant activities based on criteria of criticality index

The index of criticality of an activity is defined as the probability that it will be on the critical path (Van Slyke 1963, p. 840), and, hence, become critical in the plan (program of work).

$$i_k\,(A_j) = p\;(A_j = A_j^K)$$

The selection of time significant activities (A_{TS}) according to the criteria of criticality differs significantly from the previous criteria of duration of the activities:

1. Instead of analyzing an array of independent activities the plan as

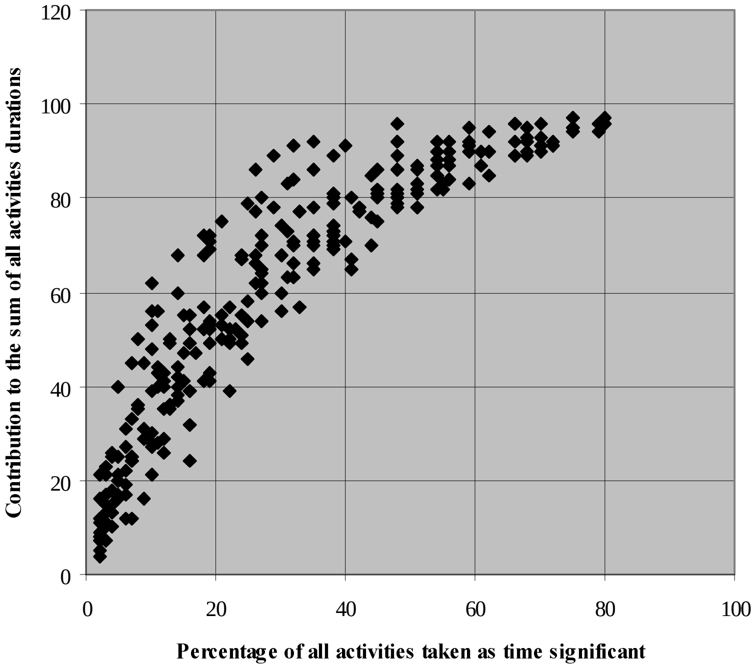

Figure 4. Results of investigation of the relationship between different percentages of time significant activities (n_{TS}) and their ascending cumulative contribution to the sum of all activity duration $\Sigma t(A) = t_{TS}$

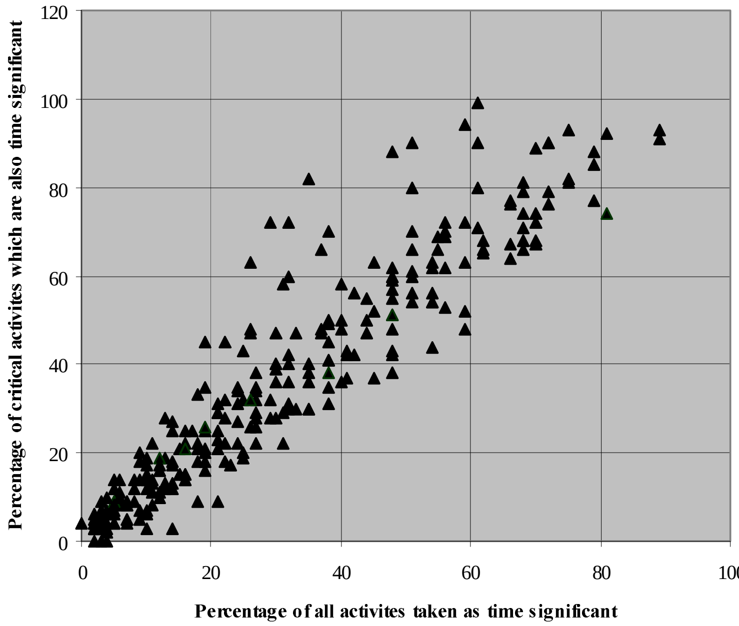

Figure 5. Contribution of critical activities according to CPM analysis % $n(A_j^K)$ in subsets of time significant activities $n(A) \in S_{TS}$ chosen on average duration criteria.

<table>
<tr><th>CRITICALITY INDEX (%)</th><th colspan="2">EVALUATION OF CRITICALITY</th><th colspan="3">POSSIBLE SUBSETS S_{TS} (1,2,3)</th></tr>
<tr><td>- 100</td><td>Absolutely critical activities</td><td>Critical</td><td rowspan="5">3</td><td rowspan="3">2</td><td>1</td></tr>
<tr><td>80 - 99</td><td>Highly critical activities</td><td>Critical</td><td></td></tr>
<tr><td>50 - 79</td><td>Normally critical activities</td><td>Critical</td><td></td></tr>
<tr><td>25 - 49</td><td>Highly subcritical activities</td><td>Subcritical</td><td></td><td></td></tr>
<tr><td>1 - 24</td><td>Low subcritical activities</td><td>Subcritical</td><td></td><td></td></tr>
<tr><td>0</td><td>Non critical activities</td><td>Noncritical</td><td></td><td></td><td></td></tr>
</table>

Table 3. Proposal for the index scale of criticality with three possible choices of subsets of time significant activities.

a whole is analyzed along with the activities within it.

2. Instead of fixed values, the duration of each activity is determined by variable intervals with corresponding probabilities.

Determination of the index of criticality is performed by project network simulation (Van Slyke 1963, p. 841 ; Fishman 1985, p. 579). It shows in how many iterations the subject activity was critical during the simulation. For reliable data it is suggested to use about 1000 iterations in the simulation (Crandall 1977. , p. 393). Application of simulation results in the selection subset of time significant activities (STS) in the plan requires the evaluation of the set scale for possible criticality. Our proposal is shown in Table 3.

Subset of time significant activities (S_{TS}) can be set according to the proposed scale (1, 2 or 3), depending on the users need for reliability in the results. In our research we used subset 2 which gave our research a resulting average contribution indication of 25-35%, which differs from literature (Brandenberger and Konrad 1980., p. 54) where the criticality is estimated to be up to 25% of all activities. By using a criteria of criticality index it is possible to identify all time sensitive paths in project network. Depending of chosen boundary value of the index (Table 3) for time significant activities selection the procedure will separate all critical and subcritical activities. A practical use requires input data of high quality, therefore a historical project data base is very much welcome.

Time and cost significant activities - Analysis of time criticality of cost significant activities

Subsets of time (S_{TS}) and cost (S_{CS}) significant activities have useful characteristics. To use them successfully it is important to determine the relationship between these two subsets:

$$S_{T+CS} = S_{TS} \cup S_{CS} \text{ and}$$
$$S_{T\&CS} = S_{TS} \cap S_{CS}$$

Results of practical research into both subsets indicates that the time subset is generally greater than the cost subset. That is:

$$n(A_j \in S_{TS}) \geq n(A_j \in S_{CS})$$

Activities which are located in both subsets are significant according to two criteria and form the subset of time-cost significant activities (S_{T+CS}). Determining the subset $S_{T\&CS}$ is carried out by finding critical activities (and subcritical, depending on the chosen boundary value for definition of time significant activities) in the set of cost significant activities.

$S_{TS} = \{ A_j^K \}$

$S_{CS} = \{A_j^{K1}, A_j^F \}$,.... $(A_j^{K1} \subseteq A_j^K)$

from which we have $S_{T\&CS} = \{A_j^{K1}\}$

Results of practical research into the contribution of critical activities in cost significant activities for the described sample plans indicate that the average percentage of critical activities is around 30% of the total number in the plan (Table 4), which is approximately equal to the proportion of cost significant activities and all activities in the plan. Hence, it can be expressed by the following relation:

$$\frac{n(A_j^K \in S_{CS})}{n(A_j^K \in S)}[\%] \geq \frac{n(A_j \in S_{CS})}{n(A_j \in S)}[\%]$$

In Table 4. the percentage of total number of critical activities in the subset of cost significant activities is shown. This subset is calculated by the method of average values (Radujkovic 1995). In Figure 6. data is shown graphically. The tendency of a linear relationship between percentages of project activities taken as cost significant and at the same time separated critical activities is evident.

Some characteristics of time and cost significant activities

By applying the proposed methodology it is possible to get smaller subsets from the set of all activities in the project. Some examples are:

1. Subset of time significant activities (S_{TS})
2. Subset of cost significant activities (S_{CS}).
3. Subset of both time and cost significant activities ($S_{T\&CS}$).

These activities have a large significance in the control of costs and duration of the project, which means that they indirectly control the main resources and the key milestones in the plan. If the initial plan would be reduced to a subset of such selected significant activities with an average expected characteristic model, control would be more than 80% of costs and control of critical and subcritical paths in the plan.

Average number of total significant activities (S_{T+CS}) will be smaller than the simple sum for the size of section of these two subset activities. According to research the section has a value around 27 - 37 % S_{TS} which are at the same time in S_{CS}. The number of common activities for individual types of structures can be arrived at from the results of sample regression, for example for road structures it is equal to about 25% for 13 plans from sample number 1 in Table 1.

$n(A_j \in S_{T+CS}) =$
$1{,}077\ n\ (A_j \in S_{CS}) +$
$2{,}086 = 1{,}077 * 21 +$
$2{,}086 = 24{,}7\ \%$

The final number of activities in the reduced time-cost model varied within certain boundaries, primarily depending on the variance of the number of critical activities and their contribution in cost significant activities. The number is determined by the following expression (Radujkovic 1995):

$$n(A_j \in S_{T+CS} = n(A_j \in S_{CS}) + n(A_j^K) \times (1 - \frac{n(A_j^K \in S_{CS})}{100})$$

With the combining of time significant activities and cost significant activities, an increased controlled contribution of costs in the plan occurs. The amount of the increase is variable due to the manner of selection of added time significant activities. Along with the assumption of an average for the additional 21% (45%-24%) of activities (Figure 8.) on the remaining 20% of costs that are equal to around 4% of total costs, the total controlled mass of costs in the project is increased to around 84%. When greater accuracy of model is required, it is necessary to change the selection criteria of cost significant activities from the average cost $(c_{CS}\bullet)$ to a lower value, which increases the contribution of controlled costs of the project. The performed polynomial regressions of data from the observed sample can give direction for relations of the number of significant activities and their contribution in total costs. In that way, for example, for road construction we have n_{CS}/c_{CS} relation:

$c_{CS}(A_j) = 22{,}1588 + 4{,}742\ n_{CS}(A_j) -$
$0{,}1028\ n^2_{CS}(A_j) + 0{,}0007\ n^3_{CS}(A_j)$ [%] ..... $A_j \in S_{CS}$

Application of time and cost significant activity model for managing projects

According to data on activity significance a priority structure in a project can be established in the way:

1. Both time and cost significant activities (two criteria significant).
2. Either time or cost significant activities (one criteria significant).
3. Other activities.

The proposed process can be applied in planning and control of all types of construction projects. It is especially efficient in two cases:

1. In multiple repetition of similar projects, where there exist databases from previous projects.
2. In applications of complex processes such as optimization, where a large number of activities causes a significant complexity in work or makes application of certain algorithms impossible.

Our use of the proposed theory is at the moment especially related to:

1. Early project phases for estimation which is usually made without detailed engineering data. Estimates are derived by analysis of significant activities observed in previous projects with similar characteristics as the one being planned. The final sum is done by adding a percentage for non significant activities.

Plan structure	Unit	Structure type: Road	Hydrotech.	Building	Average
Number of cost significant activities (n_{CS})	%	21	22	28	24
Cost contribution (c_{CS})	%	82	81	77	80
Critical activity contribution $n(A_j^k \in S_{CS}) / n(A_j^k \in S)$	%	27	28	37	30

Table 4. Average percentage of cost significant activities (n_{CS}) with the indication of contribution in total project costs (c_{CS}) and the content of critical activities which are also cost significant.

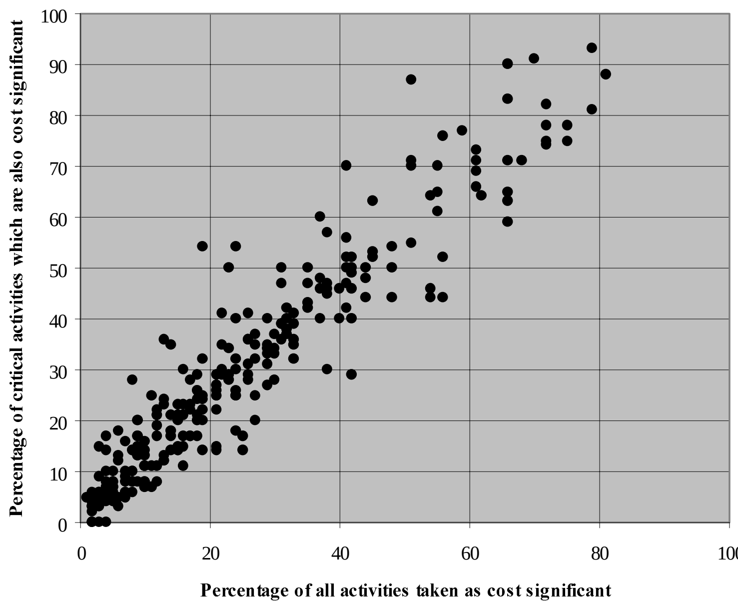

Figure 6. Percentage of the total number of critical activities of the project (% $n(A_K)$) in the subset of cost significant activities $n(A) \in S_{CS}$ in the research samples.

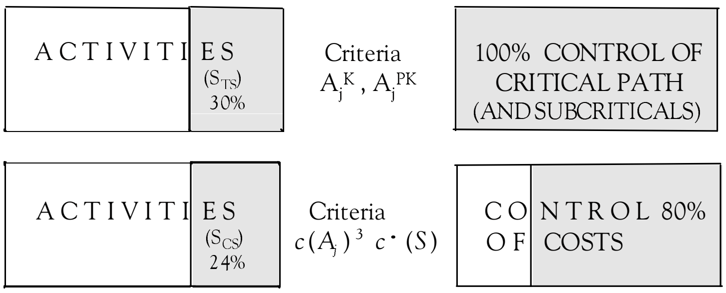

Figure 7. Average number of significant activities by two criteria and their influence on the project in the researched sample.

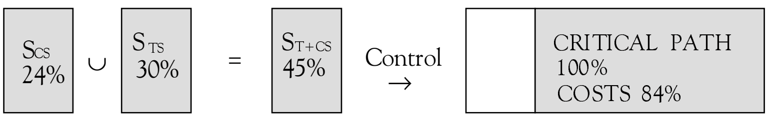

Figure 8. Contribution of cost and time significant activities to time and cost in the project.

2. Design phase for minimizing the number of alternatives which should be analyzed and reviewed by cost and time criteria. The analysis is performed only for significant activities.
3. Bidding phase for selecting a small group of activities which should be analyzed for quick changes of total project price.
4. Project execution phase in order to concentrate managers efforts to significant activities rather than to a large number on insignificant ones. This kind of data clearly shows project managers priorities in the completion and control of works, which in turn improves and simplifies resource assignment.

Conclusion

Research performed on several randomly selected samples of construction project plans and values of a bill of quantity values confirms the assumptions of various cost and time significance of individual activities (or items). Results show that there exists a certain subset of time or cost significant activities (45-50% of total number in the plan) which control the critical and subcritical paths and 85-95% of total costs in the project. The same activities indirectly control the main resources and key milestones in the project. Significant activities can be identified with quick and simple calculations. With similar projects significant activities are for the most part repeated, so they can also be predicted ahead of time. Data concerning significant activities suggests the importance of key activities for time and cost management of projects. Although the study was done on construction projects the stated theory can be also applied on other areas of business.

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