LOGO (LAPPEENRANTA UNIVERSITY OF TECHNOLOGY)

Juha Vehviläinen

Procurement in Project Implementation

Thesis for the degree of Doctor of Science (Technology) to be presented with due permission for public examination and criticism in Lecture Hall 1381 at Lappeenranta University of Technology, Lappeenranta, Finland on the 18th of December, 2006, at noon.

Acta Universitatis
Lappeenrantaensis
254

Supervisor Professor Tuomo Kässi
Department of Industrial Engineering and Management
Lappeenranta University of Technology
Finland

Reviewers Professor Emeritus Pentti Kerola
University of Oulu
Finland

Professor Pekka Kess
Department of Industrial Engineering and Management
University of Oulu
Finland

Opponent Professor Pekka Kess
Department of Industrial Engineering and Management
University of Oulu
Finland

ISBN 952-214-313-8
ISBN 952-214-313-8 (PDF)
ISSN 1456-4491

Lappeenranta University of Technology
Digipaino 2006

ABSTRACT

Juha Vehviläinen
Procurement in Project Implementation
Lappeenranta 2006
217 p.
Acta Universitatis Lappeenrantaensis 254
Diss. Lappeenranta University of Technology
ISBN 952-214-313-8, ISBN 952-214-313-8 (PDF), ISSN 1456-4491

This research focuses on procurement in project implementation. The topic is studied from the viewpoint of an engineering and consultancy company, Pöyry Oyj. The used research method, the constructive research approach, resulted in the enhanced procurement practice, the descriptions of the procurement software, and the programmed software. The topic and research method indicate that the research has dual scientific nature; it belongs partly to business science (procurement and project management) and partly to Information Systems (development of procurement application).

The primary task of the research was to develop the procurement function in project environments. The study began with the rewriting of the project manuals. The necessary background information of the procurement function was acquired in the revising of the *Project Management Manual* and *Procurement Manual*. The rewriting of the project manuals was a very efficient way to learn the company practices and get to know the people.

The study continued by designing and programming a procurement application. A new procurement framework was developed to support the software development. The framework integrates the project knowledge of Pöyry Oyj with the concurrent engineering approach. The framework changed the linear procurement model of Pöyry Oyj to a circular model. The original idea of the software development was to harness best practices in procurement, including the follow-up of procurement, via a procurement application. The application would force the project professionals to follow the best practices and thus use proper project procedures. At the time, there were no suitable commercial applications for procurement in industrial projects and procurement tasks were carried out with manual systems supported by miscellaneous office programs.

The software works following the new, circular procurement framework. The software covers the procurement process from the inquiry specification and ends at contract signing. If the procurement schedules and working hours are available, also schedule comparisons and workload-based progress estimates are calculated. Assuming that the basic system data is recorded, the software is able to automatically estimate the procurement status. The estimation method can be generalised to cover processes, whose progress can be estimated by the used working hours.

The rewritten project manuals, the *Project Management Manual* and the *Procurement Manual*, have been in use for ca. 15 years. These manuals have helped and supported project management in numerous projects and sustained the competitive advantage of Pöyry Oyj. The procurement software has been used in several projects and it demonstrably decreases direct labour costs in the procurement function in large industrial plant projects. The software is also assumed to bring considerable indirect savings in project implementation, but they cannot be reliably estimated.

Keywords: procurement, procurement follow-up, project management
UDC: 658.71 : 65.011.8

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KEY TERMS

Best practices	"Among the various methods and implements used in each element of each trade there is always one method and one implement which is quicker and better than any of the rest." (Frederick W. Taylor: The Principles of Scientific Management, p. 23)
Budget inquiry round	Carried out to establish cost estimates in the early stages of the project (feasibility or conceptual planning stage).
Construct	A product of construction process, an artefact producing solutions to explicit problem(s). This research: project manuals, procurement framework, and particularly procurement software
Construction	A building process to create a construct. This research: rewriting of project manuals, development of procurement framework and development of procurement software
Comparison of tenders	Makes the tenders comparable from all technical, commercial and other aspects, including normally also recommendations.
Inquiry issuing	All the activities in obtaining tenders from supplier candidates.
Inquiry specifications	General description of the inquiry subject, technical data and guarantees, delivery limits and necessary appendices.
Final inquiry round	A final inquiry round is arranged to initiate the purchasing negotiations aiming at delivery contracts. It is carried out with the most successful supplier candidates of the tender inquiry round.
Project	”A project is a temporary endeavour undertaken to achieve a particular aim and to which project management can be applied, regardless of the project’s size, budget, or timeline.” (PMI: What is a Project?)
Project implementation	“That part of the project life-cycle during which working drawings, specifications and contract documents are prepared, contracts are tendered and awarded, and the construction work undertaken.”…”The project phase develops the chosen solution into a completed deliverable.” (Wideman Comparative Glossary of Common Project Management Terms v3.1)
Project management	“Project management is the application of knowledge, skills, tools, and techniques to a broad range of activities in order to meet the requirements of a particular project.” (PMI: About the Profession)
Procurement	“A subset of project management that includes the processes required to acquire goods and services to attain project scope from outside the performing organisation.” PMBOK Guide 2000, p.191 This research: purchasing stages from inquiry specifications to contracting
Tender inquiry round	Carried out to screen the known suitable suppliers. This facility inquiring process is intended to clarify the supplier status in terms of its free engineering and production capacity, and delivery capability.

ACRONYMS

1GL	First-Generation Programming Language (machine language)
2GL	Second-Generation Programming Language (assembly language)
3GL	Third-Generation Programming Language
4GL	Fourth-Generation Programming Language
5GL	Fifth-Generation Programming Language
ACM	Association for Computing Machinery
ACWP	Actual Cost of Work Performed
ANSI	American National Standards Institute
BCWP	Budgeted Cost of Work Performed
BCWS	Budgeted Cost of Work Scheduled
BPR	Business Process Redesign (originally, Business Process Re-engineering)
CAD	Computer-Aided Design
CCPM	Critical Chain Project Management
CBS	Cost Breakdown Structure
CEO	Chief Executive Officer
CPM	Critical Path Method
CMC	Carboxylmethyl Cellulose
CPU	Central Processing Unit
DBMS	Database Management System
DOJ SDLC	United States Department of Justice Systems Development Life Cycle
DOS	Disk Operating System
DQL	Data Query Language
DS	Design Science
E-R (model)	Entity-Relationship (model)
EIP	Enterprise Information Portals
EPC	Engineering, Procurement and Construction
ERM	European Exchange Rate Mechanism
ESDLC	Expanded Systems Development Life Cycle
ERP	Enterprise Resource Planning
ETO	Engineer to Order, a production principle
EVA	Earned Value Analysis
FIM	Finnish Mark
GANTT	Bar chart presenting a schedule, developed by Henry L. Gantt (1861-1919)
GDP	Gross Domestic Product
GUI	Graphical User Interface
HVAC	Heating, Ventilation, Air-Conditioning
ICT	Information and Communications Technology
IMRAD	Introduction, Method, Results and Discussions, a research report model
ISO	International Organization for Standardization
ISO-9000	Quality assurance program, certified by ISO
IS	Information Systems, a discipline of science

ISSN	International Standard Serial Number, a unique code to identify a periodical publication
IT	Information Technology
KM	Knowledge Management
KMS	Knowledge Management Systems
LAN	Local Area Network
LISP	A program language family, the name derives from “List Processing”,
MCC	Motor Control Centre
MEI	Mechanical, Electronic and Instrumentation
MIT	Massachusetts Institute of Technology
MRO	Maintenance, Repair and Operating Materials
MS-DOS	Microsoft Disk Operating System
MS IIS	Microsoft Internet Information Services
MTO	Make to Order, a production principle
MTS	Make to Stock, a production principle
NLP	Natural Language Program
NT	(Windows) Network Technology, an operating system
OBS	Organisational Breakdown Structure
OGC	Office of Government Commerce, a British institution
OS/2	Operating System 2
PC	Personal Computer
PDF	Portable Document Format, an open standard file format developed by Adobe Systems
PERT	Program Evaluation and Review Method
PMBOK	Project Management Body of Knowledge
PMI	Project Management Institute, Inc.
PMO	Project Management Office
PRINCE	Projects in Controlled Environments
R&D	Research and Development
RAD	Rapid Application Development
RAM	Random-Access Memory
RFP	1) Request for Proposal (an inquiry for proposals from supplier candidates) 2) Request for Purchase (Pöyry Oyj: an inquiry for client’s permission to purchase)
RONA	Return on Net Assets
SDLC	System Development Life Cycle
SQL	Structured Query Language
SSG	Swedish Standardisation Group, Swedish pulp and paper industries’ technical co-operative organisation
TQM	Total Quality Management
UML	Unified Modelling Language
WBS	Work Breakdown Structure
WWW	World Wide Web

PREFACE

It has taken me more than a decade to carry out my doctoral studies. I started working with project management applications in the late 1980s. At that time, the applications were rigid and clumsy. They had to be used the way they were designed for and flexibility without the assistance of a programmer was unheard of. The applications were independent and were normally used for isolated tasks. Even slightest co-operation between software applications needed a middle-sized project to be accomplished. This doctoral dissertation concentrates on a particular project implementation problem: how to organise procurement in industrial plant projects. The dissertation presents software developed to support the procurement function in the project environment.

The practical part of my research was relatively easy to understand and carry out, but the scientific presentation of the research did not build up effortlessly. I had an unedited version of the work in 1995, but I never tried to publish that version. It was not that I was not interested in finishing my studies. It was more about time, the efforts needed, quality suspicions towards the work, and most of all – my post-graduate studies was not appreciated by my former employers. Some of them even stated that the doctoral dissertation was a waste of time and prevented productive work in the company.

During this ten-year time-out, I have renewed my thoughts of project management. I have seen the increase of stress in project management; the stricter timelines, the growth of reporting and increasing professional demands. At the same time, the project personnel have been minimised. All this points out to the same direction: the personnel should concentrate on their primary tasks and the rest should be automated as far as possible.

I have to admit that my current work is quite different from the unedited version I had in 1995. Different, but not necessarily much better. Some of the novelty aspects have gone because of the rapid development in information technology. Some of the theoretical background has also been grown outdated and vanished off the centre of interest. New hardware solutions have removed some severe obstacles in application development and provide new ways to organise project management. The mobility of IT solutions has given new answers to project management problems, but also delivered new challenges to be overcome.

I also suffered from the dual scientific nature of my research. This dual nature has caused confusion and makes this doctoral dissertation complicated. Even the language of business science and Information Systems differ annoyingly. The same words can mean different things depending on the discipline, and the exactly same phenomena might be described using different words. The dual nature most likely lengthened the research, but I it also improved my knowledge of the project management.

It has been a long and winding road to travel from the first hesitated efforts to write the program code lines to write and rewrite again in this doctoral dissertation. Sometimes, it is good not to know the number of the steps beforehand. The knowledge of the needed steps might prevent the journey, and therefore eliminate the achieving the goal.

Juha Vehviläinen, Lappeenranta 15 November 2006

1. INTRODUCTION

This work focuses on procurement and procurement follow-up in project management. The main idea of the work is to solve project problems with a database application, i.e. to develop software for procurement in project environments. The topic is studied from the viewpoint of an engineering and consultancy company. The selected viewpoint reflects my former employment at Pöyry Oyj, during which I became acquainted with procurement in large industrial plant projects. That work experience has contributed to the research in many ways. It guided the selection of the research subject and the defining of the research problem. Also, the project instructions of Pöyry Oyj had a heavy influence on the requirements of the procurement system. Finally, company decisions determined the software environment, platform and programming tools for the procurement software.

The empirical background of the work is industrial plant projects managed by an engineering and consultancy company. These projects are carried out to build complex, normally unique, factories and plants, which have to be engineered separately to meet the project stakeholders' requirements. To make things more complicated, the research has dual scientific nature; it belongs partly to business science (procurement and project management) and partly to Information Systems (development of procurement software and software itself). The goals and results of the research belong to business science and the science of Information Systems is represented as a tool to achieve the desired results. Both the disciplines belong to applied sciences, and design science approach is known in the both disciplines. The emphasis of the work falls into business science, whose terminology I have used, if nothing else is implied. As a dissertation, this work comes under the discipline of industrial engineering and management, although Information Systems has a significant role in the research.

I have used the constructive research method in my study. The method is approved in both fields of science, although there are slightly differences. Business science emphasises financial aspects more than Information Systems in evaluating the utility of the construct. The acceptance of the construct, as well as the acceptance of the research, is based on market tests which measure the potential applicability of the construct. Information Systems are more concerned that the best possible construct is created, evaluated and demonstrated to be useful.

The research supports and proposes improvements to the project management and procurement approaches described in the PMBOK[1]. The research suggests an enhanced framework for procurement in project environments. It provides an improved (i.e. automated) method to estimate the progress of the procurement, while the software follows redefined Pöyry procurement practices. The development process and the resulting artefact are described according to both business science and Information Systems. Business science[2, 3] states that the construction process produces a new construct, the procurement software, contributing knowledge in the process. The Information Systems discipline presents that building and evaluating of the research results adds new knowledge to knowledge base[4, 5]. Results include enhanced procurement practice (method), the descriptions of the procurement software (model) and the programmed software (instantiation).

Even the development work of the procurement software can be described from two angles; as a knowledge management task or a software engineering task. Knowledge management aspects are

1 PMI: A Guide to the Project Management Body of Knowledge (PMBOK Guide) (2000), 216 p.

2 Olkkonen: Johdatus teollisuustalouden tutkimustyöhön (1993) pp. 75-79

3 Kasanen, Lukka and Siitonen: The Constructive Approach in Management Accounting Research (1993) Journal of Management Accounting Research, Vol. 5, No. 3-4 (Fall 1993), p. 244

4 March and Smith: Design and Natural Science Research on Information Technology (1995) Decision Support Systems, Vol. 15, No. 4, pp. 251-266

5 Hevner, March, Park and Ram: Design Science in Information Systems Research (2004) MIS Quarterly, Vol. 28, No. 1, p. 85

emphasised in formulating the project manuals, which were rewritten to establish and disseminate best practices in industrial plant projects. The viewpoint of software engineering is stressed in designing, programming, testing and maintaining the procurement application.

The research has two types of results: practical and theoretical. The most important practical result of the research is the well-documented procurement software. The software has a well-structured procurement flow with automated procurement follow-up. Besides the achieved savings in procurement function, the software is useful forcing in the end-users to follow proper procurement practices. These standardised practices, followed in separate projects, help to use the automated data warehousing and to share supplier and cost information. The equally important practical results, the rewritten project instructions, have been used successfully in Pöyry Oyj since 1991.

The theoretical results provide an enhanced framework for procurement in project environments. Based on the framework, the procurement process was changed from a linear, three-staged model to a cyclical model supported with document flow management. Minor theoretical results include the estimation method of the procurement status based on working hour reporting (three-level-hierarchy in status calculations) and the enhanced method for the comparisons of tenders (computer-aided, item-structure-based comparison instead of manual comparison of item descriptions).

The structure of the doctoral dissertation follows the format suggested in the *Mayfield Handbook of Technical & Scientific Writing*[6]. The handbook covers all the key aspects of technical and scientific writing. It has been online and in use at Massachusetts Institute of Technology (MIT) since 1997[7]. The body of the dissertation covers the research from defining the research subject to results and discussions following roughly the IMRAD model (Introduction, Method, Results and Discussions). Also, Olkkonen recommends the IMRAD model for research reports in business science[8]. The research report is quite long (ca. 200 pages). The 15-year-time span of the research, the two-dimensional research problem and the iterative building process have all increased the number of pages. It takes time and space to describe the research I have done carefully. Thorough reports of complicated matters just tend to be lengthy.

This introduction chapter describes the research topic (research subject, literature survey, research problem and purpose of the research). This chapter also includes sections describing the design science approach followed, i.e. the research strategy, the constructive research method and the actual research work. Presentation of the dissertation structure, Figure 18, ends the chapter.

1.1. RESEARCH SUBJECT

I started the research in the late 1980s. At that time, procurement in project implementation looked quite a promising topic. There were not many published studies in the field and I supposed that I could make some contribution to the science. Also, the subject was considered mutually beneficial for Pöyry Oyj and me. The company would gain research results and I would learn the subject thoroughly. I felt that post-graduate studies would be an efficient way to improve my professional skills in the area. I thought of the dissertation as a profound follow-up course, which would cover project management, purchasing, information technology and software development.

6 Mayfield Handbook of Technical & Scientific Writing > Format of the Theses
(Perelman, Barrett and Paradis: Mayfield Handbook of Technical & Scientific Writing)
https://mit.imoat.net/handbook/th-form.htm (06.05.2005)

7 Perelman: The Mayfield Handbook: A Resource for Technical Writing (1997)
MIT Information Services and Technology Newsletter, Vol. 13, No. 1

8 Olkkonen: Johdatus teollisuustalouden tutkimustyöhön (1993)
pp. 112-114

In the beginning, the research subject was not clearly defined. I had a vague idea that the research would take place in procurement and project management areas, but the focus was missing. In that sense, my study is a fine example of a deepening understanding of the subject. Gradually I gained insights into project management and procurement activities in industrial plant projects, but I had to work in ERP (Enterprise Resource Planning) projects before I deeply understood the importance of well-structured workflows and follow-up.

In the end, the research subject, procurement in project implementation, was recognised as a multi-layered phenomenon consisting of two major development projects: (1) development of project management and procurement instructions, and (2) development of procurement application. These development projects are entwined; new project instructions set requirements to the procurement and the software creates needs for new project instructions. The development of project instructions meant rewriting and updating the existing Pöyry project manuals. The development of procurement software meant programming totally new software for procurement tasks, fulfilling the requirements of Pöyry project instructions. Both the project manuals and the software were expected to carry project practices worth disseminating through Pöyry subsidiaries and Pöyry-managed projects. The renewing and disseminating of the rewritten instructions and the introduction of the software made aspects of knowledge management and transfer significant.

In principle, the development of the procurement function comprised at least four overlapping design science studies: (1) development of project management instructions, (2) development of procurement instructions for project environments, (3) knowledge management and transfer of best practices, namely the above mentioned Pöyry project instructions, and (4) procurement software. The processing of each subtopic follows roughly Van Aken's description of design processes[9]. According to him, design science research might have five stages: (1) front end of the design process comprising the fuzzy front end, perceived and validated needs, and project definition, (2) project brief, (3) design project, (4) object and realisation design, and (5) realisation process.

I have written this doctoral dissertation believing that a holistic approach to procurement in project implementation would provide the best results. I consider that there is enough contribution to science in each part of the work, in each subtopic, to be included in this work. The other alternative would have been focusing on one of the topics and to write my dissertation on that topic.

Research Idea

The research idea evolved during my employment at Pöyry Oyj. At that time, Pöyry Oyj was streamlining its project business; the project instructions were rewritten and suitable tools for project tasks were sought for. Because it proved impossible to find suitable software for procurement tasks, it was decided to build up a company solution for the procurement. The new software was intended to solve procurement and project management problems. More precisely, the target of the research was to build up efficient, flexible and documented software for procurement and procurement follow-up. In principle, this meant using information technology to solve business problems.

The key idea of the research was to support the best available procurement practices with a procurement application. First, the best practices would be formulated and documented in the project instructions. They would be used as general requirements for software development. The procurement application would be programmed following the instructions and utilising networked data processing possibilities. In the end, the application would force project professionals to follow

9 Van Aken: The nature of organization design: Much like material object design, but very unlike in its working (2005) Organization Science, submitted manuscript (17.09.2005), 40 p.

company practices. As the desired result, the project management would receive accurate procurement status information from the procurement application.

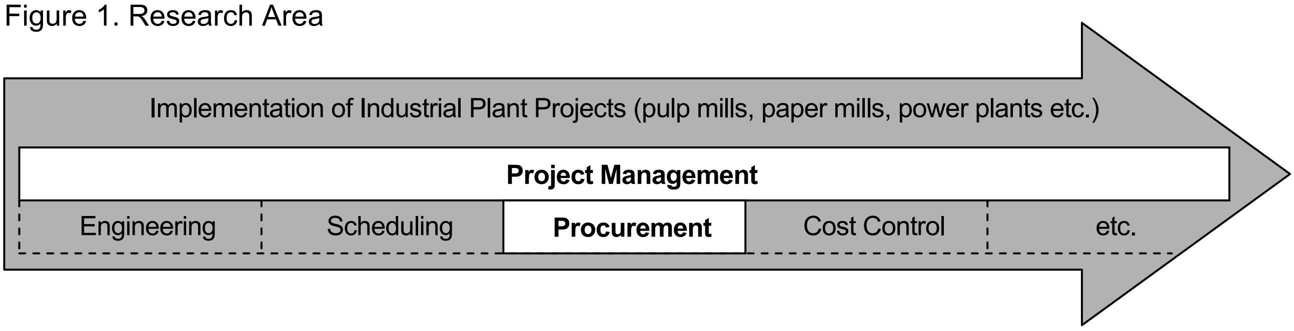
The application would be developed and delivered to project organisations. The projects would use the procurement software to run procurement activities. The gathered basic data would be saved and used in the following projects. At the same time, the application development would continue until satisfying functionality and efficiency was achieved.

Research Area

The research area is defined as a section of procurement and project management within the context of industrial plant projects. The research area brings up some special features in the procurement process. The on-going engineering has to be mastered in the information transfer, inquiring process and contracting. The suppliers are motivated to engineer their products for the project, which makes comparisons of tenders difficult. Finally, the progress of engineering limits the advancing of procurement tasks, which dictates the course of project implementation.

In this study, as illustrated in Figure 1, procurement is considered as a part of project implementation under project management. The procurement activities described in the research could cover all the purchases in the project, but this is seldom the case. Normally, minor purchases without engineering efforts are organised directly through the client's purchasing system. It is more convenient and cost-effective to avoid extra work of issuing inquiries and to do purchasing otherwise. Depending on the project, maybe 70-95 % of the total investment value is processed through the described procurement process. Therefore, Pöyry Oyj regularly states that the procurement policy is the main distinguishing factor of the project implementation methods.

Figure 1. Research Area

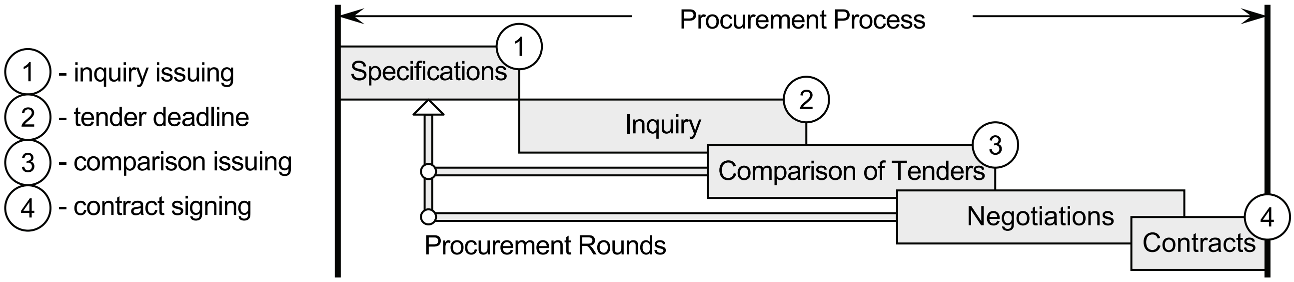


Research Scope

My work as a procurement engineer at Pöyry Oyj determined the research scope. My tasks comprised inquiry specifications, inquiries, tenders, negotiations and contracting. The research scope was adjusted to match these tasks. First, I was involved in the renewing of project manuals as a secretary. It was a very efficient way to learn the company practices and get to know the people. Later, I was engaged in programming the procurement software based on procurement instructions.

Figure 2 (on the next page) shows the research scope: procurement process. The procurement process takes place under uncertainty as concurrent engineering makes item specifications gradually more detailed. Particularly, each procurement round diminishes the uncertainty, because supplier candidates have opportunities to impact the design decisions. This iterative process is carried out for each item or service to be purchased at least once. Normally the process is repeated two to four times before the contract is signed.

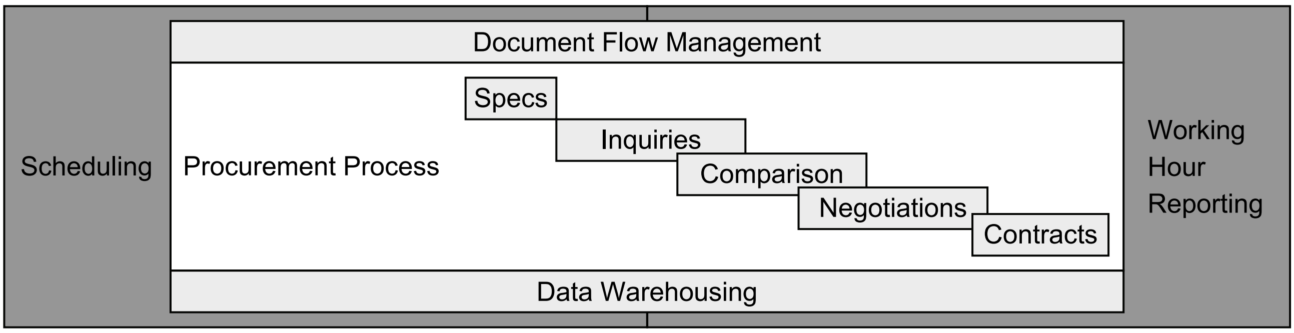
Figure 2. Research Scope: Procurement Process



In principle, the procurement process resembles a project life cycle[10] or a development initiative[11]. The life cycle begins with a specification stage, continues with implementation stages (inquiry, comparison of tenders and negotiations) and ends in the hand-over stage (contract signing). Some project professionals take advantage of the similarity between the procurement flow and the project life cycle. They define purchases of large and complex equipment as subprojects to ease the project management. Also, some programs guide to record each inquiry as a subproject to carry out procurement and procurement follow-up. For example, MFG/PRO[12] (international ERP software package from QAD, Inc.) uses project codes to track procurement costs in projects.

Gradually, the research scope extended. The users demanded new features to support procurement tasks in their projects. Data warehousing, scheduling, working hour reporting and document flow management were included in the scope. These features with in-built data transfer programs supported the practical target of the research: efficient and accurate tools for procurement. They were built as general solutions, i.e. they could be used independently without procurement flow. If they are used independently, the logic and manner of use must be planned separately. As the result, the software and research area grew significantly, as represented in Figure 3. Altogether, six development rounds were needed to realise these features in the procurement software.

Figure 3. Extended Research Scope



Originally, data warehousing meant storing project papers at Pöyry Oyj. The company had looked for more efficient ways to take advantage of addresses and cost data from previous projects. I realised that data warehousing must be integrated with the procurement process to change data warehousing from archiving to a supporting function. Whenever an address or a cost item is recorded, the information is available for everyone in the same database. The natural extension of data warehousing comprised the data transfers between the databases of the offices and the project sites.

10 Archibald: Managing High-Technology Programs and Projects (1976), 278 p.

11 Van Aken: The nature of organization design: Much like material object design, but very unlike in its working (2005) Organization Science, submitted manuscript (17.09.2005), 40 p.

12 QAD Product Suite, Global Materials Management Operations Guideline/Logistics Evaluation (MMOG/LE) (2006) http://www5.qad.com/Public/Documents/qad_mmog-le.pdf (12.07.2006)

Besides the purchasing flow, procurement includes the follow-up of the purchasing flow. The follow-up proved to be a twofold task with scheduling and workload calculations. The simple scheduling approach only compared planned dates to realised dates. The more complex approach pays attention to planned and realised workloads. It gives a more detailed and explanatory picture of procurement status. The workload follow-up necessitated integrated working hour reporting features. This makes sense from the management point of view; the same system both operates and follows up the process. The decision made the application compact, but increased the complexity of the software.

Earlier, document transfer from the engineering company to the client company and the potential suppliers were managed by paper lists. It was seen necessary to add the administration of these documents in the software and the research, because a steady flow of information among all parties is important for fluent project implementation.

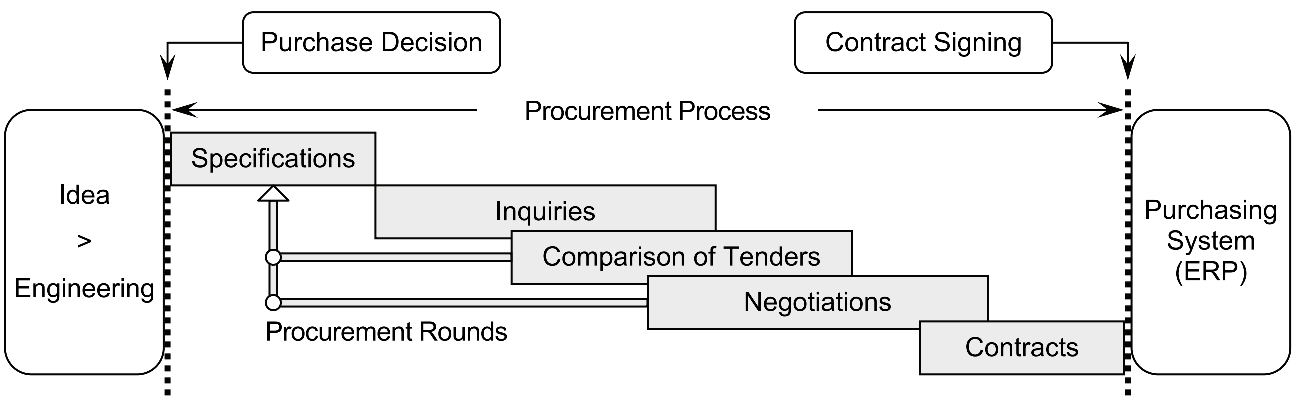
Focusing the Research

The research scope was defined, but I still had to limit the research work more rigorously. *Procurement in Project Implementation* is a short, pithy and clear name for a doctoral dissertation. It gives a clear idea of the area of the work, but the name does not define boundaries towards other project management tasks. It seemed natural to me that the research boundaries should match the intended construct, procurement application. I have to admit that the application was programmed before defining the boundaries of the research.

The most important decision of the focus established the boundaries of the procurement workflow; the start and the end of the procurement process. The defined procurement process established also the boundaries of the software and the research. The procurement process was seen to begin with inquiry specification. The starting-point of the procurement process is truly natural, because there is no purchasing task before inquiry specification.

The end of the procurement process was a more complicated decision. Finally, it was decided that the procurement process ends at contract signing. The decision based on the scope of the service contracts between Pöyry Oyj and its clients. At the contract-signing point, purchasing tasks are transferred from Pöyry's project professionals to the client's personnel and their ERP software. There are some purchasing stages in the procurement flow after contract signing (delivery, inspections, payment, guarantee etc.), but they were intentionally left out of the doctoral dissertation. The focus of the research is illustrated in Figure 4.

Figure 4. Boundaries of the Procurement Process in the Research



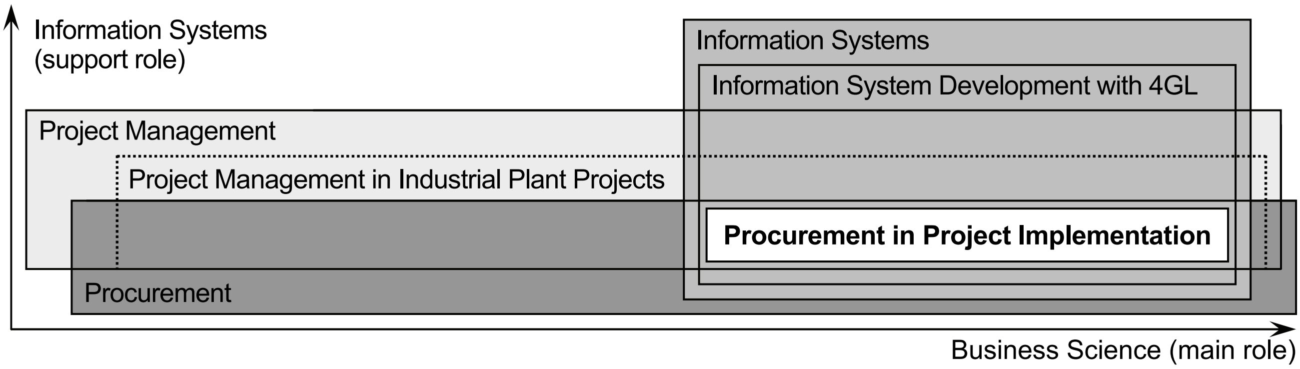
Nature of Research Subject

The nature of the research subject can be described a couple of competing ways. The research subject can be described either by wide cross-scientific concepts or a cross-section of established independent disciplines, in which the directions do not necessarily have the same weight.

First, the research subject can be seen to belong to knowledge management, business process redesign or end-user computing. Knowledge management aspects are emphasised in formulating project manuals, which were rewritten to establish and disseminate best practices in industrial plant projects. The outcome control mechanisms of knowledge management affect how knowledge is acquired, disseminated, interpreted and used to accomplish organisational goals[13]. The view of business process redesign becomes stressed in identifying and reshaping the procurement processes[14]. End-user aspects are brought out in designing, programming, testing and maintaining the procurement application by the people who have direct need for them in their work[15].

Second, the research subject can be said to have dual scientific nature, because it is described both from business science (main role; procurement in project environments) or Information Systems (support role; database application development) point of view. By the business science dimension the research belongs to project management and procurement, or more precisely, it belongs to the cross-section of project management and procurement. The research environment, goals and results belong to this cross-section. The dimension of Information Systems defines the research to information system development with 4GL tools. Information Systems provided tools for achieving the desired business science results, i.e. tools for building up the software and restructuring the procurement work in project sites. The positioning of the study is shown in Figure 5.

Figure 5. Fields of Science in the Research



When defining the research area above, I stated that the procurement function belongs totally to project management in this study. For fields of science, the situation is different. Most of procurement science does not belong to project management, although they both do belong to business science.

Importance of the Research Subject

The scientific importance of the subject arises both from the enhanced project instructions and the novelty of the procurement software (demonstrated in Section 1.2.). The rewriting of the project manuals was a company-wide knowledge management task capturing and disseminating the project

13 Turner and Makhija: The Role of Organizational Controls in Managing Knowledge (2006) Academy of Management Review, Vol. 31, No. 1, pp. 197–217

14 Hammer and Champy: Reengineering the Corporation: A Manifesto for Business Revolution (1993), 240 p.

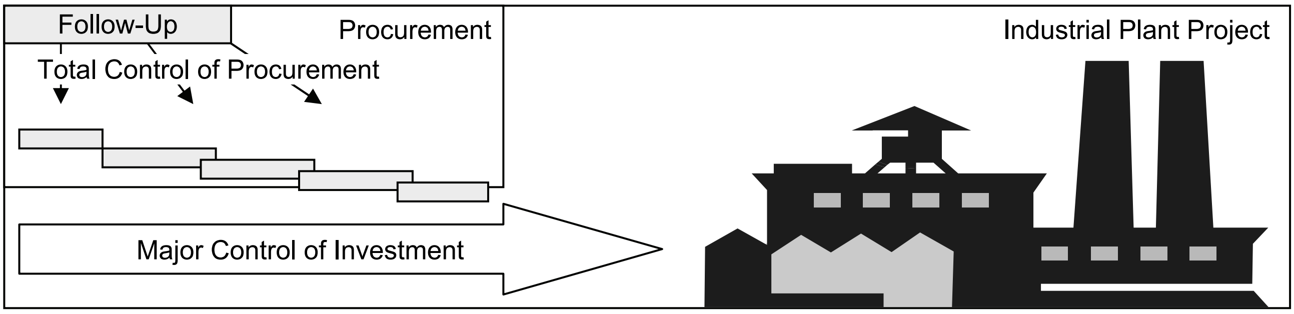
15 Brancheau and Brown: The Management of End-User Computing: Status and Directions (1993) ACM Computing Surveys, Vol. 25, No. 4 pp. 437-482

management knowledge at Pöyry Oyj. The procurement software brings improved knowledge of procurement processes (compared towards the manual procurement processes in 1990 and towards general project management programs in 2005) in industrial plant projects. The software includes automated procurement follow-up, which minimises project management costs without compromising the accuracy of the follow-up. The evaluation of the software proves that the utility of software, the goal of design science research[16], has been achieved.

The practical importance of the subject is justified by the financial volume of industrial plant projects. Typically, paper machines and pulp mills cost 250-500 million Euros, depending on the plant and existing facilities on the site. The success of the project implementation necessitates well-executed equipment deliveries. If procurement is carried out properly, i.e. the right equipment has been purchased at an acceptable price with precisely timed deliveries, the project has a good start. This has convinced Pöyry Oyj to emphasise the importance of procurement in project implementation.

The procurement software saves time and money in procurement tasks. Although the most important contracts are processed through the software, some local purchases might be managed manually. Additionally, the close follow-up of procurement status improves the tracking of the general project status significantly. Therefore, procurement follow-up is a part of managing risks in industrial projects. Procurement follow-up enables early recognition of delays and other delivery problem situations. The build-up of project control is illustrated in Figure 6.

Figure 6. Importance of Procurement Follow-Up



1.2. LITERATURE SURVEY ON THE SUBJECT

The literature survey had two target topics: procurement in project environments and procurement software designed for project environments. Because these topics overlapped significantly, I decided to make a combined survey for the both areas. In this combined literature survey, I searched articles from the selected publications for the both topics simultaneously.

I selected six renowned publications which I expected most likely to report advancements in procurement and in procurement software. Although both target topics were sought through at the same time, the literature related to procurement and project management was expected to be found most likely in: the (1) *Project Management Journal*, (2) *International Journal of Project Management*, and (3) *Journal of Supply Management: A Global Review of Purchasing & Supply* (called *International Journal of Purchasing and Materials Management* in 1993–1998 and J*ournal of Purchasing & Materials Management* in 1989–1990). Correspondingly, three IT publications were studied to find any matching procurement software: (1) *Byte*, (2) *Software Magazine*, and (3) *Information and Software Technology*. To cover the whole research period, I decided to study the years 1988–2005.

[16] Hevner, March, Park and Ram: Design Science in Information Systems Research (2004) MIS Quarterly, Vol. 28, No. 1, pp. 79-80

I also tried to find some additional material to support the positioning of my research. I tried to found overall articles of the target topics, i.e. articles of project management, procurement in project environments, project management software and procurement software. Finally, I made a market study to verify the novelty of the procurement software.

Literature Survey of Procurement in Project Environments

Although there are a lot of articles describing project management from various angles, the articles of procurement with concurrent engineering in industrial plant projects are rare. Three of the selected publications (*Byte*, *Software Magazine* and *Information* and *Software Technology*) did not publish any articles on procurement in project environments. They had various articles on IT projects, project management software and e-procurement, but nothing of procurement in industrial projects. The results are summarised in Table 1.

Table 1. Literature Survey of Procurement in Project Environments

Source	**Procurement in Project Environments (with Concurrent Engineering Approach)**
Project Management Journal (ISSN: 8756-9728) Contains advanced state-of-the-art project management techniques, research, theories & applications. Publisher: Project Management Institute, Inc. Frequency: 4 (03/1997–04/2005)	A series of project management articles; some articles treat also procurement in various project types. One article on concurrent engineering and iterative project implementation in R&D projects[17]. No articles on procurement in industrial plant projects.
International Journal of Project Management (ISSN: 0263-7863) Offers a wide and comprehensive coverage of all facets of project management; worldwide expertise in the required techniques, practices and research. Publisher: Elsevier Science Publishers B.V. Frequency: 8 (01/2001–08/2005) 6 (01/1995–06/2000) 4 (01/1988–04/1994)	Another project management article series; some articles discuss concurrent engineering in construction projects (buildings, roads, etc.). Three noteworthy articles of EPC -projects[18, 19, 20] (engineering, procurement and construction). The Yeo and Ning's article[21] is the closest to my research. The article suggests a framework to procurement in projects integrating supply chain and critical chain, but does not cover procurement tasks or follow-up of procurement in projects.
Journal of Supply Chain Management: A Global Review of Purchasing & Supply (ISSN: 1523-2409) Original articles dealing with concepts from business, economics, operations management, information systems, the behavioural sciences contributing knowledge in purchasing and materials management. Publisher: Blackwell Publishing Ltd. Frequency: 4 (01/1988–04/2005)	A lot of articles on procurement, some articles on procurement supporting R&D projects, but only two noteworthy articles on concurrent engineering[22, 23]. No articles on procurement in industrial plant projects.

17 Denker, Steward and Browning: Planning Concurrency and Managing Iteration in Projects (2001) Project Management Journal, Vol. 32, No. 3, pp. 31-38

18 Mahmoud-Jouini, Midler and Garel: Time-to-market vs. time-to-delivery: Managing speed in Engineering, Procurement and Construction projects (2004) International Journal of Project Management, Vol. 22, No. 5, pp. 359-367

19 Lampel: The core competencies of effective project execution: the challenge of diversity (2001) International Journal of Project Management, Vol. 19, No. 8, pp. 471-483

20 Love, Gunasekaran and Li: Concurrent engineering: a strategy for procuring construction projects (1998) International Journal of Project Management, Vol. 16, No. 6, pp. 375-383

21 Yeo and Ning: Integrating supply chain and critical chain concepts in engineer-procure-construct (EPC) projects (2002) International Journal of Project Management, Vol. 20, No. 4, pp. 253-262

22 Dowlatshahi: Purchasing's Role in a Concurrent Engineering Environment (1992) International Journal of Purchasing & Materials Management, Vol. 28, No. 1, pp. 21-25

23 O'Neal: Concurrent Engineering with Early Supplier Involvement: A Cross-Functional Challenge (1993) International Journal of Purchasing and Materials Management, Vol. 29, No. 2, pp. 3-9

Artto and Wikström[24] have made an interesting literature study to clarify the meaning and importance of project business. Their study concludes that projects belong to general business practices, but they do not report any articles of delivery projects, i.e. having an operation management content. They emphasise that discussion and theoretical views on delivery projects are scarce. Last, they suggest that the management of delivery projects is not an extensive application area in industry.

In conclusion, I claim that procurement in the context of the large-scale industrial plant projects is not a widely studied area and the scientific articles are scarce. The published articles on the procurement function have different focus and viewpoints and do not cover all the aspects of my research.

Literature Survey on Procurement Software

In the late 1980s, the project professionals at Pöyry Oyj were not aware of any procurement software for industrial plant projects. It seemed that the business niche was too small and demanding to attract software companies. I believed my colleagues (justifiably as their insight was accurate), and I carried out only non-systematic literature survey collecting articles related to the topic. Besides, the literature survey on the subject was not necessary for the programming of procurement software. The lack of literature study was well-compensated by available practical knowledge inside the company.

Later, Järvinen[25] proposed that I verify the novelty of the procurement software by performing a literature study afterwards. I followed his advice and studied the issues of the selected publications from the years 1988-2005. The scant results are summarised in Table 2.

Table 2. Results of Literature Survey on Procurement Software

Source	Issues 1988 – 2005
Byte (ISSN: 0360-5280) For knowledgeable PC users of business and personal applications. Emphasis on new technology and previews of major new hardware and software products. Publisher: CMP Media LLC Frequency: 52 (01/1999–29/2005) 12 (01/1988–07/1998)	Advertisements and software assessments of project management programs with features for scheduling, resource and cost allocations. Two articles covering project management software choices, in 1988[26] and in 1992[27]. No matching software for procurement in industrial plant projects.
Software Magazine (ISSN: 0897-8085) Aimed at managers of corporate software resources. Publisher: Wiesner Publishing Inc. Frequency: 6 (01/1996–02/2002)	Several software assessments of project management programs with diverse features for scheduling, resource and cost allocations. No matching software for procurement in industrial plant projects.
Information and Software Technology (ISSN: 0950-5849) International archival journal focusing on research and experience that contributes to the improvement of software development practices. Publisher: Elsevier Science Publishers B.V. Frequency: 15 (01/97–98–15/2005) 12 (01/1991–12/1996) 10 (01/1988–10/1991)	No articles of procurement software in industrial plant projects.

24 Artto and Wikström: What is project business? (2005) International Journal of Project Management, Vol. 23, No. 5, pp. 343-353

25 Järvinen: Written instructions to enhance this doctoral dissertation (2006)

26 Wood: The Promise of Project Management (1988) Byte, Issue 11/1988, pp. 180-192

27 Yahdav: Tracking the Elusive Project (1992) Byte, Issue 11/1992, pp. 119-126

I studied the articles in these journals using article databases (*EBSCO Research Database* and *ScienceDirect)*. Moreover, I studied the volumes of *Byte* for advertisements of procurement software. This was possible, because Lappeenranta University of Technology has been subscribing the magazine since the early 1980s and the university library has archived the issues of the magazine. The magazine had a lot of advertisements of diverse project management software, but none of them were intended for procurement in project environments.

Four of the selected publications (*Information & Software Technology*, *Project Management Journal*, *International Journal of Project Management* and *Journal of Supply Management: A Global Review of Purchasing & Supply*), have not published any articles on procurement software in project environments. Outside the scope of the literature survey, I noticed two interesting articles of the use of the project management software in the *Project Management Journal*.

The first article reported a survey[28] which gathered some historical and baseline information about project management software and the use of modelling techniques. Pollack-Johnson and Liberatore revealed in their study that the percentage of those not using any software had dropped to less than 10% in 1998, while the percentage of professionals using some software for all of their projects had grown to over 50%.

Fox and Spence's survey in the *Project Management Journal* confirms that there are literally dozens of project management tools on the market[29]. Although each project management tool is marketed and advertised as providing various features that other tools may not have, they focus on the basic project management tasks of planning, scheduling, tracking and controlling. Despite the large number of the project management tools, a majority of project managers tend to use only a few of these tools, the most widely used being Microsoft Project. Project managers also tend to rely on ordinary office programs, such as Microsoft Excel.

The general notion is that most of the project management software is capable of managing the scheduling of projects, calendars, activities and resources. They have diverse features for scheduling, such as GANTT, Project Evaluation and Review Technique (PERT) and Critical Path Method (CPM) and they typically manage resource and cost allocations with levelling. Also, they might master some additional functionality, e.g. for project meetings, depending on the market niche of the software, but there were no project management software targeted to procurement tasks.

Altogether, the results of the literature survey for procurement software were negligible; no matching software was found. None of the project management software presented in *Byte* or the *Software Magazine* come close to the created procurement software. The surveys of the *Project Management Journal* imply that project managers prefer flexible, understandable and reliable software even with limited project features.

Market Study

After the fruitless literature study of the procurement software, I decided to investigate the procurement software situation also from the business point of view. The market study was aimed at verifying the novelty of the software. Proha Oyj helped in the market study and I am deeply grateful of their invaluable assistance. Proha Oyj has also reviewed and approved this subsection.

[28] Pollack-Johnson and Liberatore: Project Management Software Usage Patterns and Suggested Research Directions for Future Developments (1998)
Project Management Journal, Vol. 29, No. 2, pp. 19-28

[29] Fox and Spence: Tools of the Trade: A Survey of Project Management Tools (1998)
Project Management Journal, Vol. 29, No. 3, pp. 20-27

Proha Oyj[30] is the leading global provider of portfolio and project management solutions. The company supports several major project management packages. The strategy of Proha Oyj is to operate globally, but in a narrow market where it can realistically act as a market leader. Proha Oyj[31] develops and maintains cost-effective packaged software and services to meet the needs of large and medium-sized organisations. The software solutions help the customers carry out their strategies, allocate their resources productively, and control their project operations as profitably as possible. In 2004, the net sales of Proha Oyj were 65.7 million Euros, approximately 90 % of which came from outside Finland. The Proha Group employs over 500 people, 80 of them in Finland. In 2006, Proha Oyj decided to sell out its entire share capital (53.3 %) of its subsidiary Artemis to US based software company Trilogy, Inc[32].

The business of Proha Oyj covers the applicability area of the research construct; the use of procurement software in project environments. Therefore, I assumed that Proha Oyj would support, or at least, would know the software competing with the construct of this research. I contacted Proha Oyj and they decided to help in my market study. They introduced their project management solutions and provided material of their software packages.

We noticed easily that ProcuMent was the closest software of Proha Oyj compared with the construct of this research. Proha Oyj even held a presentation of ProcuMent to help me point out similarities and differences with the construct of this research. After the presentation we discussed project management software and my research. Understandably, they were careful not to claim to know every project management tool in the world. They confirmed that they did not know any procurement software resembling the construct of this research. Specially, the use of a fixed process seems to differentiate the construct from the other software. They agreed that a fixed process as a specific solution for a limited area provides a neat solution, but with limited applicability[33].

I decided to test the similarities between the construct of this research and the project software packages of Proha Oyj. I placed four criteria to identify the similarities of the procurement software: (1) the software takes care of procurement, (2) fixed work flow, (3) procurement status estimation, and (4) hierarchical tender structures. I excluded requirements of the supplier correspondence layouts, because they could be arranged, for example, using MS Word and batch scripting. I did not include document flow management or data warehousing, because they are supporting processes of procurement function.

First, it was imperative that the software was able to support the procurement flow before the point of purchase. Second, the software had to have the fixed WBS (work break-down structure) for the procurement process. The fixed WBS guides inexperienced project workers in procurement tasks and forces undisciplined ones to follow standardised procurement processes. Third, the similar software had to have automated procurement status follow-up. No extra work was accepted for estimating the progress of procurement. Fourth, tenders had to be recorded as hierarchical priced item structures.

Similarity tests were made with ProcuMent, CMPro 5, ValuePoint, Artemis 7 and Safran, all well-known project management solutions. The tests were carried out on the material that Proha Oyj delivered for the market study. The results are summarised in Table 3 on the next page.

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[30] Proha
http://www.proha.com (28.03.2006)

[31] Proha > Investor Relations > Annual Reports > Annual report -2004 > Business Review 2004 (.pdf)
http://www.proha.com/sijoittajap/2004Eng_Business%20Review.pdf (07.09.2006)

[32] Proha > Proha accepted offer to purchase shares of its subsidiary Artemis (March 13, 2006 at 9.15)
http://www.proha.com/tiedotteet/tiedote256.htm (28.03.2006)

[33] Aatola, Proha Oyj: Discussions of procurement software in project environments (2006)

Table 3. Competing Project Management Programs

<table>
<tr><th rowspan="2">Software</th><th colspan="4">Similarity Tests</th></tr>
<tr><th>Proc. flow</th><th>Fixed WBS</th><th>Proc. status</th><th>Tender structure</th></tr>
<tr><td rowspan="2">ProcuMent, a procurement solution for construction projects, is designed for the planning and execution of purchasing. Report templates support reporting. The software is integrated to Planet (scheduling program), email, MS Word and PDF Writer.

The procurement process is defined to comprise:
1) Planning purchasing, tasks and events
2) Invitations to bid
3) Bid comparison
4) Orders and contracts</td><td>Yes</td><td>No</td><td>No</td><td>No</td></tr>
<tr><td colspan="4">So far, this software resembles the created construct most.

The main difference to the construct of the research is that there are no individual tenders, only two-level invitations to bid, to which the tenders should be referred.</td></tr>
<tr><td rowspan="2">CMPro 5, a product family for project cost control, has two-dimensional hierarchical breakdowns: work packages describing purchases/supplies for internal control and cost accounts for external reporting describing positions.

General features include:
• Cost estimating of upcoming projects with various options and tender creation for contractors
• Cost control using work breakdown structure (WBS), cost breakdown structure (CBS) and organisational breakdown structure (OBS) and organising budget based on cost estimate and breakdown structures
• Income control
• Unit price contract management
• Project portfolio management</td><td>No</td><td>No</td><td>No</td><td>Yes</td></tr>
<tr><td colspan="4">Cost control software, not procurement software.

Pöyry Oyj uses CMPro 5 for cost control in projects.</td></tr>
<tr><td rowspan="2">ValuePoint, a project management tool for distributed organisations, is a groupware designed for internal use. It is planned for budgeting and calculating actual and forecast cashflows. It includes work and travel cost reporting. Cashflow graphs are presented on one screen, making it easier for users to compare and create reliable forecasts.

General features include that the program begins from the user's home page, user transactions, project cost control and cost centre cost control.</td><td>No</td><td>No</td><td>No</td><td>No</td></tr>
<tr><td colspan="4">Cost control and cashflow control software, not procurement software.</td></tr>
<tr><td rowspan="2">Artemis 7, an investment planning and control software package, supports the key business processes and roles associated with industry focused solutions, and enables deployment of multiple solutions on a common platform, ensuring seamless integration, consolidation and analysis of all investments.

Artemis 7 is programmed on role based processes. The features include several management areas: investment portfolios, demand and initiatives, financial planning and budgeting, programs and projects, resources, work, and collaboration and documents.</td><td>No</td><td>No</td><td>No</td><td>No</td></tr>
<tr><td colspan="4">Investment software, not procurement software.</td></tr>
<tr><td rowspan="2">Safran, a scheduling and resource management tool, consists of Safran Planner (interactive bar charts integrated with resource histograms and a spreadsheet-like table for data entry), Safran Project (earned value based project management tool), and Safran for MS Project (integration tools with Microsoft Project)</td><td>No</td><td>No</td><td>No</td><td>No</td></tr>
<tr><td colspan="4">Earned value based project management tool, not procurement software.</td></tr>
</table>

All scheduling and cost control programs were excluded of the market study, because they do not fulfil the first criteria in the similarity tests. For example, Microsoft Project does not have any procurement features. The market study confirmed that there was no software which would compete directly with the construct of the research, the procurement software. Even the closest software, ProcuMent, differs in many ways. ProcuMent does not have hierarchical tender structures, nor does it use workload calculation to estimate the procurement status. ProcuMent does not have cyclical procurement flow either, but it can be replaced by repeating the procurement process as many times as necessary by copying and typing the needed information.

Conclusions from the Literature Survey

The conducted literature study confirms that the results of the research (project instructions and procurement software) are unique. Even the procurement literature is scarce in project environments and nearly non-existent in the specified context. The literature study (particularly the market study) confirms that there is no matching commercial procurement software available. This points out that the novelty aspects of the design science research will be achieved.

Most of the novelty is a consequence of the research context. Although projects are common practice in management, large-scale industrial plant projects are relatively rare. Particularly, projects resulting in unique plants with concurrent engineering efforts from both the client and the supplier side are rare. In this environment, suppliers are encouraged to do engineering to achieve the best possible plant. These engineering efforts have a heavy impact on the success of the project, and consequently, the mill. This engineering contribution from the suppliers distinguishes industrial plant projects from other resembling business branches, such as construction and shipbuilding industry. For example, in construction business the suppliers deliver the goods according to item specifications, which the architect or the construction planning office has designed.

According to my literature study, the closest articles describe EPC projects. Naturally, these articles contain valid knowledge for industrial projects. Due to the different background, they miss some crucial features of industrial projects, for example the supplier's engineering efforts and their impact on projects. Consequently, there is no matching article on the procurement process or the follow-up of the procurement function in industrial plant projects. Therefore, I claim that this work includes enhanced knowledge of procurement in implementing large industrial plant projects.

The unique nature of the software was demonstrated by studying the procurement software situation both in the early 1990s and in 2005. In the early 1990s, project professionals in Pöyry Oyj did not know of any similar software. It seemed that the procurement software had been the first of its kind. Years have gone and the situation has changed, but only slightly. Procurement software for industrial plant projects with fixed work break-down structure seemed to be undocumented even in 2005. A common practical solution is to divide the research are to two parts: (1) the project management part is carried out with general project applications, and (2) the actual procurement tasks take place in ERP systems with aid of manual processes. To my mind, this kind of solution is not equal to the programmed procurement software.

I admit that it is impossible to gain all information of procurement instructions and software. The confidential information of proprietary procurement systems was out of reach. Companies do not describe their systems in detail, because they include key company knowledge establishing their competitive edge. The 15-year time span of the research increased candidates for similar procurement systems, i.e. project instructions and software. For example, there were roughly 100 commercial project management packages[34] already in 1988 and the number is still increasing.

1.3. RESEARCH PROBLEM

My research started with a practical problem of Pöyry Oyj. The company was looking for more efficient ways to handle projects. In the beginning, the development initiative was targeted to upgrade two project manuals: the *Project Management Manual* and the *Procurement Manual*. At the same time, the introduction of 4GL tools on the PC platform made software development

[34] Wood: The Promise of Project Management (1988)
Byte, Issue 11/1988, p. 180

economical enough also for temporary project environments. Together these two circumstances initiated the development of procurement software. As a result, my research had two mainly consecutive, but sometimes entwining, research problems (or research initiatives): knowledge management and software development.

Capturing the company knowledge was the first part in solving the knowledge management problem. It aimed at formulating best practices in project management and procurement in the business context of Pöyry Oyj. The knowledge management initiative continued by disseminating the captured knowledge through Pöyry companies worldwide. This internal knowledge transfer constituted the latter part of the knowledge management initiative.

The rewritten instructions relied on the skills and professionalism of the project workers. The task descriptions concentrated on the outputs, typically a paper document or a report, not actual tasks to achieve the outputs. Variations in the projects were handled with ad hoc solutions, placing the requirements of the flexibility on the projects workers. This outcome-controlled method[35] in managing projects focuses on the outcomes of tasks or the specific outputs desired by the organisation. Most distinctively, the method specifies explicit outcome requirements for employees' work.

The software development formed the second major development initiative. It consisted of the programming of useful and efficient database software for procurement tasks following the rewritten project manuals. The software development continued with the idea that procurement follow-up could be automated and existing manual procedures with paper files could be replaced with electronic data warehousing and document flow management. The research problem for the software development part can be formulated as: "Is it possible to build cost-effective yet efficient and high-quality procurement software for large-scale industrial plant projects?"

Formally, a software development problem can be defined with the differences between the target state and the current state of a system[36]. The software development problem in my research had several sub-problems. The most significant sub-problems included procurement follow-up, data warehousing and document flow management. These subordinate research problems were intended to be solved by a single solution, the procurement software.

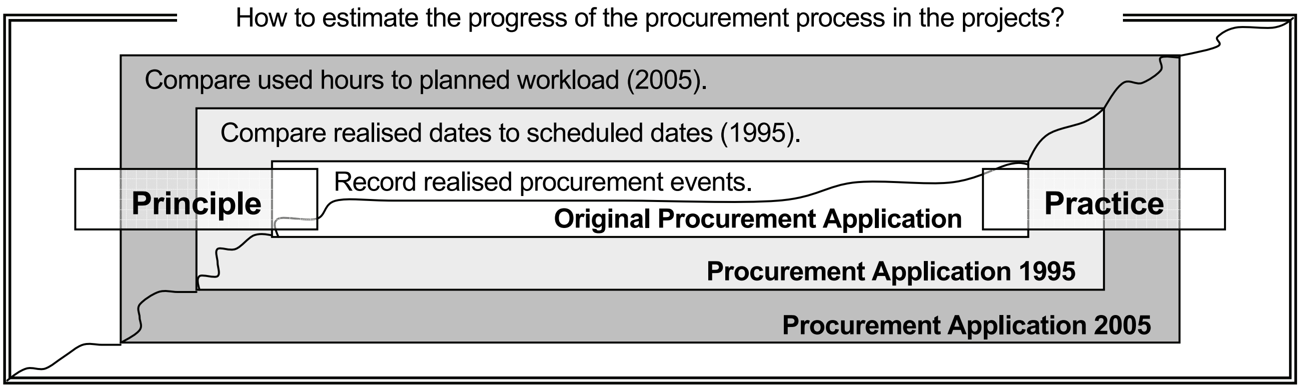
The core of the procurement software, the programming of the procurement flow proved out to be a challenging task. The procurement instructions described procurement as a linear, continuous three-stage-process with multiple tasks. Although the instructions described the procurement processes, the descriptions were not easily transformed to requirements for procurement software. Especially the change from a linear procurement model to a cyclical one took a lot of time and effort.

The first sub-problem, procurement follow-up and status estimation also turned out to be a demanding software feature. The problem itself has stayed virtually the same for all these years: how to reliably estimate the progress of the procurement process in the projects? In the beginning of the research, the progress was merely followed by realised dates with no comparison. The next step introduced comparisons of actual dates towards procurement schedules. The last improvement enabled the progress follow-up of procurement based on the workload calculations. The progress is measured by dates, although only actual work for procurement tasks will advance the procurement status. The development of procurement status estimation is illustrated in Figure 7 on the next page. Naturally, all the solutions are available in the final version of the procurement software.

[35] Turner and Makhija: The Role of Organizational Controls in Managing Knowledge (2006) Academy of Management Review, Vol. 31, No. 1, pp. 203–207

[36] Hevner, March, Park and Ram: Design Science in Information Systems Research (2004) MIS Quarterly, Vol. 28, No. 1, p. 85

Figure 7. Development of Procurement Status Estimation



Data warehousing was a different problem. Pöyry Oyj had a lot of papers from hundreds of projects in binders, but information was not easily exposable. The information existed, but binders did not give an easy access to the needed information. The data warehousing sub-problem focused on gathering and sharing the information of the previous projects for reuse in future projects.

The last sub-problem, organising document flow management, was seen important in streamlining the document transfer processes. Before the software development, the procurement documents were managed by paper lists, which were created to follow the document transfer both between the engineering company and the client company and between the engineering company and potential suppliers. The management of procurement documents was seen necessary to include in the procurement software and research, because a steady information flow between all the parties is important for fluent project implementation. The document flow management problem focused on linking the appropriate documents to their events with minimal work. The management of documents should satisfy the quality assurance programs, such as ISO-9000.

In principle, all the sub-problems are software engineering problems. They represent challenging tasks in designing and programming software with required features. Except redefining and implementing the procurement flow, the resulting software is supposed to solve specific knowledge management problems (follow-up, data warehousing and document flow management).

Last, if I had strictly followed the scientific method, my research hypothesis (claim, research problem or research question) would have been formed something like: "It is possible to build effective and efficient procurement software with data warehousing, document flow management and automated procurement status follow-up. The software to be constructed would minimise the workload and improve the output of the procurement function following the redefined project instructions."

1.4. PURPOSE OF THE RESEARCH

A doctoral dissertation[37] is a very special kind of research. It is documentation that the candidate has made independent research and that there is a contribution to knowledge. It is a once-in-a-career effort to write an extended research report on a theoretical, experimental or design project[38]. My research belongs to design science and it describes the development of project instructions, the development of procurement software, and evaluates the instructions and the software.

[37] Davis: Writing the Doctoral Dissertation (1997)
p. 15

[38] Mayfield Handbook of Technical & Scientific Writing > Format of the Theses
(Perelman, Barrett and Paradis: Mayfield Handbook of Technical & Scientific Writing)
https://mit.imoat.net/handbook/thesis.htm (07.05.2005)

Efficient procurement makes strategically important benefits possible. To gain competitive advantage over its rivals, Pöyry Oyj (or any company) has to perform its activities at a lower cost (overall cost leadership) or perform them in a way that enables differentiation at a higher price (differentiation) or focus on a particular market segment[39]. The primary economical purpose of the research was to decrease the costs in project management. The costs were supposed to be reduced through the rewritten project instructions and new procurement software. They were expected to streamline the procurement flow and minimise the needed man hours, provide total control of procurement tasks, and minimise errors in procurement. The secondary economical purpose is to gain a competitive advantage over other project management companies through service differentiation with better procurement tools. The focus of the company business was not expected to change.

The purpose of the research is to streamline procurement function in industrial plant projects. The streamlining of the procurement processes includes organising the procurement process, procurement status estimation, data warehousing and document flow management. Originally, the problem was supposed to be solved by (1) describing best project practices, (2) programming a database application following the best practices for procurement, and (3) documenting the software.

Practical Motivation

Pöyry Oyj was looking for more efficient ways to manage projects in order to prosper in project business. First, the target was to upgrade project instruction manuals to meet the hard international competition. At the same time, the IT development provided compelling possibilities to be utilised in project management. PCs, networks and particularly laptops promised processing power for project professionals, which were easy to relocate according to project needs. The problem in the early 1990s was that there were not suitable applications for procurement in industrial plant projects.

Pöyry Oyj had tried to acquire commercial software for procurement. It proved out that the commercial applications were not designed for engineering and project business in the line of Pöyry Oyj. The features of the software did not satisfy the needs of the company. They were able to record purchase contracts and place purchase orders, but they were not able to follow the progress of the engineering and the documentation flow before the purchase contracts.

The possibility to achieve cost reductions through an IT solution was a heavy enough reason to initiate the internal software development at Pöyry Oyj. The idea was not entirely new. Ström told me of a previous attempt to create a procurement tool, but it had failed so badly that the application was never taken into use[40]. My supervisors even told me directly not to study this previous attempt to build procurement application. They said that there was nothing to learn in that program.

Scientific Motivation

The scientific motivation arose from the improvements in knowledge management and information technology to achieve business goals. Knowledge management was used in capturing and disseminating the company knowledge. This part of the research resulted in an enhanced framework of procurement in project environment. It was followed by software development, creative utilisation of information technology. Information technology[41] has been noticed to change the nature of products, processes, companies, industries, and even the competition. Dramatic reductions in the costs of

[39] Porter: Competitive Strategy (1980)
pp. 34-46

[40] Ström, Pöyry Oyj: Discussions of procurement and cost control software (1991)

[41] Porter and Millar: How Information Gives You Competitive Advantage (1985)
Harvard Business Review, Vol. 63, No. 4, p. 149

obtaining, processing and transmitting information has changed the ways of business. The procurement software changed procurement in industrial plant projects. Also, the software altered the competitive position of Pöyry Oyj through cost reductions and service differentiation.

The first goal was to rewrite project manuals. It was a serious attempt to enrich the project knowledge accumulated at Pöyry Oyj. The upgrading of the project instructions were targeted at redefining the workflows of project management and procurement, the documents needed to carry on projects, and recommendations for engineering. The upgrading focused on developing the manuals to match the technical development in machinery, controlling devices, and especially in information technology. The rewriting project also aimed at creating project instructions, which would minimise the information format-related work and maximise the actual project work. The upgrading project included that the professionals had to be persuaded to accept the instructions.

The second goal was to implement procurement software along with the manuals and document the software adequately. The key features of the procurement software comprise cost estimate inquiries, tender inquiries, final tender inquiries, procurement status follow-up, data warehousing and document transfer management. Due to cost-efficiency, the software should operate with a minimal workload and the procurement tasks should be automated, if possible. Similarly to the use of project instructions, the end-users of the software would have to accept the software.

The goals of this dissertation are to demonstrate that (1) the instructions describe an enhanced procurement method in project environments, and (2) the procurement software is a new artefact and useful in its area. It is an imperative condition that the project instructions were rewritten and the procurement software was programmed. These goals have driven me to meticulously describe project management, procurement, and building and evaluating of the procurement software.

Goals for the Procurement Software

The ultimate goal of the procurement software was to save money in project implementation. Savings were expected to be achieved through using the procurement application. The costs were supposed to be reduced in direct and indirect ways. The direct savings would be achieved via a decreased workload (and consequently, decreased labour costs in project management). The indirect savings would be gained through better, more cost-efficient decisions in project implementation. The decisions would be based on knowledge provided by the procurement software.

The software should fulfil the functional requirements mentioned in the project instructions. The software should include the necessary printouts to carry out the full procurement task chain. The procurement application is supposed to operate on a PC platform with MS-DOS or Windows. The application is expected to be networked and to operate as a real-time application. The software manuals should present all the programs and the screens.

1.5. RESEARCH STRATEGY

My research follows the design science approach, which is quite common in business science. Business science[42, 43] itself is generally regarded as an applied and normative science, which doed not aim to explaining or to describing the world, but more at describing what it can be. The general idea of the design science approach is to create a better solution than anything before. The design

[42] Olkkonen: Johdatus teollisuustalouden tutkimustyöhön (1993) pp. 18-20

[43] Niiniluoto: The Aim and Structure of Applied Research (1993) Erkenntnis 38, p. 14

science research process follows, more or less, the spiral research model, because the research work tends to be situation-reactive, iterative and collaborative. In Information Systems, the design science paradigm[44] has also characterised much of the research in the field.

My research has features from business science and Information Systems. The research goals and results enter into business science. A part of research belongs to Information Systems, because I programmed procurement software to achieve the desired results. Thereby, it is reasonable to say that I have used tools from Information Systems to implement my research in business science. This kind of view to information systems is called the tool view, which is described in Subsection 1.5.2.

Although my research belongs to business science, or its subfield of industrial engineering and management, Information Systems has an important supportive role. For more IT minded persons I have described research methods of Information Systems briefly. The terminology follows the field of science, i.e. the business science subsection uses the vocabulary of business science and Information Systems uses the terminology of Information Systems. Last, the research method selection and the reasoning for the method are described in this section.

1.5.1. DESIGN SCIENCE APPROACH

Design science[45] studies artificial artefacts and it involves a search process to discover an effective solution to a problem. Problem solving uses available means to achieve desired goals while satisfying existing laws in the environment. Designing[46] is a task and process within and across traditional disciplines. The purpose of designing is to take a specification setting needs (an idea for a new or revised process or product, and a set of statements of performance and constraints) and transform it into full instructions for manufacturing a product and/or implementing a process. The design process includes frequently repeated subprocesses of problem solving. Iterative working modes are nearly inevitable, because the products, processes or services to be designed are usually difficult to understand fully at once.

Cross has advocated design sciences and the understanding of them. To diminish confusion and controversy over the nature of valid design research, Cross places some criteria for proper design science research[47]:

- Purposive (based on an identified issue or problem worthy and capable of investigation)
- Inquisitive (seeking to acquire new knowledge)
- Informed (conducted from an awareness of previous, related research)
- Methodical (planned and carried out in a disciplined manner)
- Communicable (generating and reporting testable results which are accessible by others)

According to Cross, the list describes good research in any discipline. Cross[48] continues that design research has to concern the development, articulation and communication of design knowledge. He has given three sources of design knowledge: people, processes and products. Based on these sources of design knowledge, Cross has developed taxonomy of design research.

44 Hevner, March, Park and Ram: Design Science in Information Systems Research (2004)
MIS Quarterly, Vol. 28, No. 1, p. 75

45 Simon: The Sciences of the Artificial (1996)
pp. 4-6, 111-138

46 Eder: Developments in Education for Engineering Design: Some Results of 15 Years of Workshop Design-Konstruktion Activity in the Context of Design Research (1994)
Journal of Engineering Design, Vol. 5, No. 2, pp. 135-136

47 Cross: Design as a Discipline (2002)
The Inter-Disciplinary Design Quandary Conference, 13th February 2002, De Montfort University

48 Cross: Design Research: A Disciplined Conversation (1999)
Design Issues, Vol. 15, No. 2, pp. 5-9

Cross' taxonomy of design research is the following:

- Design epistemology (study of designerly ways of knowing)
- Design praxiology (study of the practices and processes of design)
- Design phenomenology (study of the form and configuration of artefacts)

According to Cross, design knowledge resides firstly in people: in designers especially, but to some extent in everyone. Designing is a natural human trait. Many of the most valued achievements of humankind are works of design, including anonymous, vernacular design as well as the "high design" of professionals. Therefore, the human ability to design is an immediate subject of design research. It is strongly related to considerations of how people learn to design and how to teach designing.

Design knowledge resides secondly in its processes. A major part of design research focuses on methodology: the study of the processes of design and the development and application of design techniques. Computers have stimulated a wealth of research into design processes, enabling new practices in industries such as concurrent engineering.

Thirdly, it cannot be forgotten that design knowledge resides in the products themselves. Knowledge is displayed in the forms, materials and finishes which embody design attributes. A lot of everyday design work comes from using precedents or previous exemplars, not because of designers' laziness but because the exemplars actually contain knowledge of what the product should be.

Finally, Cross states that it would be foolish to disregard or overlook this informal product knowledge simply because it has not been made explicit yet. It is a task of design research to make implicit product knowledge explicit. Furthermore, he states that there is a need for a distinction between works of practice and works of research. He says that normal works of practice cannot be regarded as works of research. Cross declares that the whole point of doing research is to extract reliable knowledge from either the natural or the artificial world, and make knowledge available to others.

Spiral Research Model in the Design Science Approach

Design science research[49] is inevitably iterative. The search for the best, or optimal, design is often intractable for realistic solutions. Heuristic search strategies produce feasible, good designs for implementations in their environment. Design is essentially a search process to discover a suitable solution to a problem. Simon[50] proposes that problem solving can be viewed as utilizing available means to reach desired ends while satisfying laws existing in the environment. He describes the nature of the design process as a cycle of generating alternatives and testing the generated alternatives, as illustrated in Figure 8.

Figure 8. Design as a Search Process

Hevner et al: Design Science in Information Systems Research, MIS Quarterly 28:1 (2004), p. 89 (adapted)

49 Hevner, March, Park and Ram: Design Science in Information Systems Research (2004) MIS Quarterly, Vol. 28, No. 1, pp. 88-89

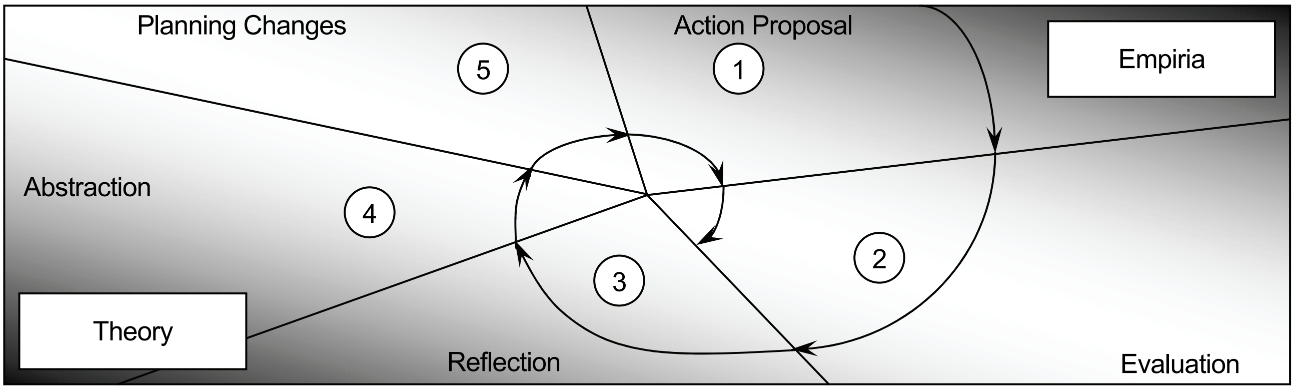
50 Simon: The Sciences of the Artificial (1996) pp. 128-130

Simon states that abstraction and representation of appropriate means, ends and laws are crucial in design science research. These factors are problem and environment-dependent, invariably involving creativity and innovation. The means are the set of actions and resources available for constructing a solution. The ends represent goals and place constraints on the solution. The laws are uncontrollable forces in their environment. Effective design requires knowledge of both the application domain (e.g. requirements and constraints) and the solution area (e.g. technical and organisational).

Simon continues that design science research often starts with a simplified problem presenting only a subset of relevant means, ends and laws, or by decomposing a problem into simpler subproblems. The research progresses iteratively as the scope of the design problem clarifies. When the means, ends, and laws are refined and become more realistic, the design artefact becomes more relevant and valuable. Spiral research models are common in design science, because research work is not easy to plan in detail beforehand. It can even difficult to decide which data to collect. The researcher must be prepared to change plans when the investigation deepens the understanding of the issue and the shift to the iterative approach[51] is necessary. Iteration, returning to an earlier stage of the research process, makes the research process resemble a spiral rather a linear succession of decisions.

The development spiral[52] can be regarded to consist of a repetitive cycle: (1) action proposal, (2) evaluation, (3) reflection, (4) abstraction, and (5) planning changes, as illustrated in Figure 9. The action proposal is expected to improve in each development round of the spiral. The development spiral continues until an acceptable result is found, or the resources are exhausted.

Figure 9. Development Spiral



Routio: Arteology, http://www2.uiah.fi/projects/metodi/120.htm#intrinsc (31.05.2005) (adapted)

Resulting Knowledge of Design Science

Using Van Aken's terminology, the resulting knowledge[53] of design science concerns with three designs: (1) object-designs, (2) realisation-designs, and (3) process-designs. The object-design knowledge comprises the design of the intervention or the artefact. The realisation-design knowledge consists of the ability to plan the implementation of the intervention or the building of the artefact. The process-design knowledge includes the professional's own plans for the problem solving. In other words, it involves methods to be used to design solutions to problems.

51 Arteology > Models for Research Process
Routio, Pentti (The University of Art and Design Helsinki)
http://www2.uiah.fi/projects/metodi/144.htm#tyo (25.05.2005)

52 Arteology > Action Research
Routio, Pentti (The University of Art and Design Helsinki)
http://www2.uiah.fi/projects/metodi/120.htm#intrinsc (31.05.2005)

53 Van Aken: Management Research Based on the Paradigm of the Design Sciences: The Quest for Field-Tested and Grounded Technological Rules (2004)
Journal of Management Studies, Vol. 41, No. 2, pp. 226-228

Prescriptions (technological norms in Olkkonen's terminology) are an important category within each three types of design knowledge. The logic of a prescription follows the idea "if you want to achieve Y in situation Z, perform action X". There are algorithmic prescriptions, which operate like a formula. They are typically in a quantitative format and they can be proven through deterministic or statistical generalisation based on observations. However, many prescriptions in design science are heuristic by nature. They can rather be formulated as "if you want to achieve Y in situation Z, then something like action X will help". "Something like action X", presents a design exemplar. A design exemplar is a general prescription, which has to be translated to the specific problem at hand. To solve a problem, one has to design a specific variant of that design exemplar.

According to Olkkonen[54], technological norms are used in business science to describe normative clauses, recommendations, in order to improve decision-making in organisations. They promote scientification of human practices and constitute knowledge in given situations. Olkkonen claims that technological norms form the ideological core of the research philosophy in normative research.

Successful Research in the Design Science Approach

The fundamental principle of design science research is that knowledge and understanding of a design problem and its solution are acquired in building and applying the artefact. Seven guidelines, presented in Table 4, have been developed to instruct on how to carry out proper design science research[55]. These guidelines are supposed to apply in constructive research. Researchers' creative skills and judgment determine when, where, and how to apply these guidelines. Reviewers, editors, and readers will later decide how nicely the research satisfies the intent of the guidelines. The used terminology is according to Information Systems.

Table 4. Design Science Research Guidelines

Guideline	Description
1. Design as an artefact	Design-science research must produce a viable artefact in the form of a construct, a model, a method, or an instantiation.
2. Problem relevance	The objective of design-science research is to develop technology-based solutions to important and relevant business problems.
3. Design evaluation	The utility, quality, and efficacy of a design artefact must be rigorously demonstrated via well-executed evaluation methods.
4. Research contributions	Effective design-science research must provide clear and verifiable contributions in the areas of the design artefact, design foundations, and/or design methodologies.
5. Research rigor	Design-science research relies upon the application of rigorous methods in both the construction and evaluation of the design artefact.
6. Design as a search process	The search for an effective artefact requires utilising available means to reach desired ends while satisfying laws in the problem environment.
7. Communication of research	Design-science research must be presented effectively both to technology-oriented and management-oriented audiences.

Hevner et al.: Design Science in Information Systems Research, MIS Quarterly 28:1 (2004), p. 83

54 Olkkonen: Johdatus teollisuustalouden tutkimustyöhön (1993)
p. 56-58

55 Hevner, March, Park and Ram: Design Science in Information Systems Research (2004)
MIS Quarterly, Vol. 28, No. 1, pp. 82-83

1.5.2. VIEWS TO INFORMATION SYSTEMS

Orlikowski and Iacono have made a literature research to investigate scholar views towards information systems[56] (terminology according to Information Systems). Their study is based on the articles published in *Information Systems Research* in the 1990s and in the early 2000s. They have classified 188 articles and identified 14 specific conceptualisations. On the basis of commonalties and differences they have distinguished five metacategories in information system research: 1) tool view, 2) proxy view, 3) ensemble view, 4) computational view, and 5) nominal view.

1) Tool view

   The tool view represents the common, received wisdom about technology and its meaning. Technology is the engineered artefact and expected to do what the designers intend it to do. The view represents information systems as tools for labour substitution, enhancing productivity, information processing and changing social relations. The conceptualisations share the view that information systems are relatively unproblematic computing resource, and treat information systems as a primary independent variable.

2) Proxy view

   The proxy view cluster focuses on one or a few key elements that are understood to represent or stand for the essential aspect, property, or value of information technology. The proxy view makes the assumption that the critical aspects of information systems can be captured by surrogate, often quantitative, measures. The proxy view studies information systems from the point of view of perception, diffusion or capital.

3) Ensemble view

   The ensemble view presents information systems as “packages”. The technical artefact may be a central element in how we conceive of technology, but it is only one element in a “package”. The whole includes the components required to apply that technical artefact to some socio-economic activity. Variants of the ensemble view see technology as a development project, production network, embedded system, or structure.

4) Computational view

   The computational view embraces the capabilities of the technology to represent, manipulate, store, retrieve, and transmit information, thereby supporting, processing, modelling, or simulating aspects of the world. The two types of the computing view are algorithm development to demonstrate the computational power of technology and model creating to represent or simulate specific social, economical, or informational phenomena.

5) Nominal view

   The nominal category presents articles that invoke technology in name only, but not in fact. The conceptual and analytical emphasis is somewhere else. IT artefacts are not described, conceptualised, or theorised. The technology is essentially absent.

Orlikowski and Iacono suggest that theorising about IT artefacts might take many forms, and they propose premises for starting-points. IT artefacts are not natural, neutral, universal, or given. They are designed, constructed, and used by people. The artefacts are shaped by the interests, values and assumptions of a wide variety of communities of developers, investors, users etc. IT artefacts are always connected to some time, place, discourse and community. Their materiality is bound with the historical and cultural aspects of their ongoing development and use, and these conditions cannot be ignored, abstracted or assumed away.

Moreover, IT artefacts are usually made up of fragile and fragmentary components. Their interconnections could be partial and provisional and require bridging, integration, and articulation in order for them to work together. IT artefacts should seldom be considered as single, seamless and stable entities. They are neither fixed nor independent. They emerge from ongoing social and

[56] Orlikowski and Iacono: Research Commentary: Desperately seeking the “IT” in IT Research – a Call to Theorizing the IT Artifacts (2001)
Information Systems Research, Vol. 12, No. 2, pp. 121-134

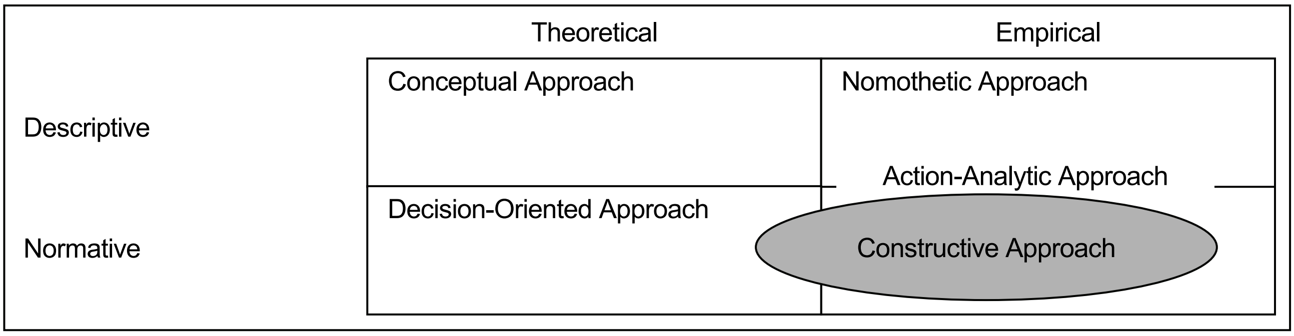
economic practices. As human inventions, artefacts undergo various transitions over time from idea to development to use to modification, which leads coexisting and co-evolving multiple generations of the same or new technologies at various points in time. IT artefacts are not static, nor unchanging; they are dynamic. Even if a technological artefact appears to be fixed and complete, its stability is conditional. New materials are invented, different features are developed, existing functions fail and are corrected, new standards are set, and users adapt the artefact for new and different purposes.

1.5.3. RESEARCH METHODS IN BUSINESS SCIENCE

In business science, the objectives[57] aim at results, which can be useful in companies. The results are applied in company functions, such as manufacturing, marketing, purchasing and accounting. Examples include cost calculation methods, ERP systems and scheduling solutions.

The Kasanen-Lukka-Siitonen classification[58] is probably the most noted research method presentation in Finnish business science. It groups research methods in business science in five approach categories: conceptual, decision-oriented, nomothetic, action-analytic and constructive approaches. Mäkinen's study[59] summarises these five research approaches. The classification is illustrated in Figure 10. The research methods are presented by their objective type (descriptive or normative research) and the nature of resulting knowledge (theoretical or empirical).

Figure 10. Research Methods in Business Science



Kasanen et al: Konstruktiivinen tutkimusote liiketaloustieteessä, Liiketaloudellinen aikakauskirja 40:3 (1991), p. 317

The conceptual approach is used to build new concepts, renew old theoretical frameworks, or build new hypothesis. The approach is mainly directed at describing reality, not attempting to understand it. Therefore, it is characterised as a descriptive research method. The focus of the approach is on thinking, theoretical research and creating theories. Although the approach normally uses current theories and doctrines to build new concepts, empirical material may be used for testing.

The decision-oriented approach is normally focused on solving a particular problem or a situation in real life. The research aims at building a model that solves the problem at hand. Decision-oriented research typically uses simulation models and mathematical formulae. The decision-oriented research approach is established and accepted in current doctrines as knowledge of interdependencies between certain variables. Finally, the approach constructs a

[57] Olkkonen: Johdatus teollisuustalouden tutkimustyöhön (1993) pp. 19-20

[58] Kasanen, Lukka and Siitonen: Konstruktiivinen tutkimusote liiketaloustieteessä (1991) Liiketaloudellinen aikakauskirja, Vol. 40, No. 3, pp. 301-329

[59] Mäkinen: A Strategic Framework for Business Impact Analysis and Its Usage in New Product Development (1999) Acta Polytechnica Scandinavica, No. 2, pp.15-17

model through thinking and logic. Empirical material is used at least in testing and validating the resulting model. The logic of the model and the validity of the results are evaluated. The applicability of the results is also evaluated but in lesser detail.

The nomothetic approach is linked to the traditional positivistic research and uses the methods of natural sciences. The use of empirical material and statistical analysis are hallmarks of this approach. The nomothetic approach also regards the reality as objective, observable, and independent of the observer. Extensive field material is used to achieve reliability and validity of the results. The approach seeks causal relationships and trends in the real world. The downside of this approach is that the results tend to average. The averaging reduces the applicability of the results in the real world where companies face problems with different conditions in varying environments.

The action-analytic approach aims at understanding the reality tied to the observer. This leads to abandoning the paradigm that the reality is objective and independent. The approach rather sees the reality as a part of the environment where the researcher or the observer is one of the subjects and has influence on phenomena in the real life. This means that the researcher is obligated to report his interests and attitudes and their impacts on the achieved results in more detail than in the other approaches. Empirical material has a limited but important role in the research. Normally only a few subjects are studied, leading to applicability and generalisability problems. The loss of generalisability is the cost that the approach pays for a deep understanding of certain phenomena.

The constructive approach has a goal to build a solution to an explicit problem. The approach includes a goal-oriented and innovative building process and a final product, a construct. The construct may be a model, plan, scheme, or other construct solving management problems. The results are evaluated according to the newness and applicability of the construct. Demonstration and validation of practical usability are important in evaluating the research results. The research is usually carried out with limited empirical material, which leads to problems in generalisability and applicability considerations (like in the action-analytic approach). Otherwise, the detailed study gives a profound understanding of the subject and enables demonstrating accurate observations of the phenomena.

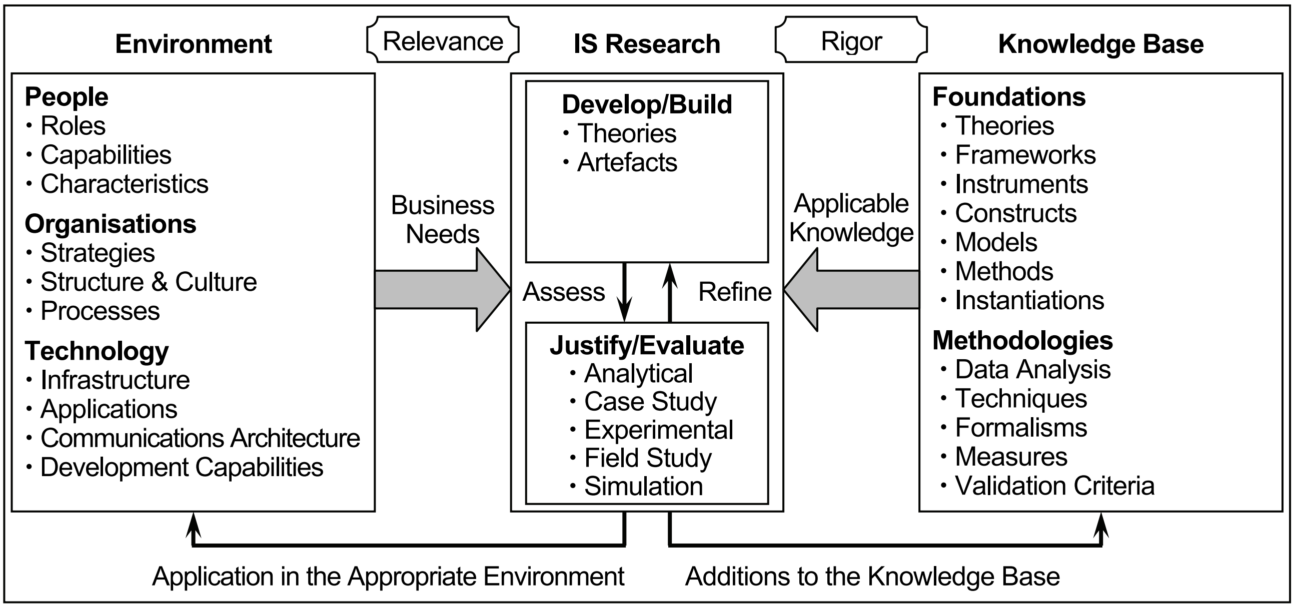
1.5.4. RESEARCH METHODS IN INFORMATION SYSTEMS

In Information Systems, two paradigms characterise a lot of the research: behavioural science and design science[60]. The behavioural science paradigm seeks to create and verify theories that describe, explain or predict human or organisational behaviour. The aim of behavioural science research is the truth. Design science paradigm addresses the developing and evaluating of artefacts designed to meet identified business needs. Utility is the goal of design science research. Figure 11 on the next page presents this conceptual framework for research in Information Systems.

Hevner et al. state that design science is seen as a problem solving process. The fundamental principle of design science research is that the knowledge and understanding of a design problem and its solution are acquired in the building and using of an artefact. It requires the creation of an innovative, purposeful artefact for a specified problem domain. Because the artefact is supposed to be purposeful, it must yield a solution or utility for the specified problem. Thorough evaluation of the artefact is crucial. Novelty is similarly important, since the artefact must be innovative, solving a heretofore unsolved problem, or solving a known problem in a more effective or efficient manner. The artefact must be rigorously specified, formally represented, coherent and internally consistent.

[60] Hevner, March, Park and Ram: Design Science in Information Systems Research (2004) MIS Quarterly, Vol. 28, No. 1, pp. 75-82

Figure 11. Information System Research Framework



Hevner et al: Design Science in Information Systems Research, MIS Quarterly 28:1 (2004), p. 80

March and Smith[61] have presented a two-dimensional framework for IT research, illustrated in Figure 12. Essentially, March and Smith's framework is included in the framework of Hevner et al. presented above. In March and Smith's framework, the first dimension represents research activities: build, evaluate, theorise and justify. The second dimension is based on output types of research or artefacts of research: constructs, models, methods and instantiations.

According of March and Smith, design-science research presumes that problems must be properly conceptualised and represented, appropriate techniques for their solution must be constructed, and the solutions must be implemented and evaluated using appropriate criteria. The building of the artefact, and often the artefact itself, incorporates or enables a problem solving process. The search process includes a defined problem space and a mechanism posed or enacted to find an effective solution. Finally, the results must be communicated both to a technical and managerial audience.

Figure 12. Two-Dimensional Framework for IS Research

		Research Activities			
		Build	Evaluate	Theoritise	Justify
Research Outputs	Constructs				
	Model				
	Method				
	Instantiation				

March and Smith: Design and Natural Science Research on Infor…, Decisions Support Systems 15:4 (1995), p. 255

Since "design" is both a noun and a verb, design is both a process (set of activities) and a product (artefact)[62]. This dual nature describes the world as acted upon (processes) and the world as sensed (artefacts). It implies that a design theory must have two aspects; one for the process of design and one for the product of design. These aspects cannot be entirely independent, since the design process has to yield the product to be designed.

61 March and Smith: Design and Natural Science Research on Information Technology (1995) Decision Support Systems, Vol. 15, No. 4, p. 251

62 Walls, Widmeyer and El Sawy: Building an information system design theory for vigilant EIS (1992) Information Systems Research, Vol. 1, No. 1, p. 42

Iivari[63] has created a research classification system, which has become quite popular in Information Systems. He has divided research methods into three groups: constructive, nomothetic and idiographic research. The constructive methods carry out the special character of information systems and computer science as applied sciences not describing any existing reality, but aiming at creating new ones. The nomothetic approach emphasizes the importance of basing the research upon a systematic protocol and technique similar to natural sciences; testing hypothesis and supporting or rejecting general laws or theories. Idiographic approaches are based on the view that the social world can be understood only by obtaining first-hand knowledge of the subject.

1.5.5. RESEARCH METHOD SELECTION

I have decided to use the constructive research method. I saw the constructive research method as the most appropriate, because my research is empirical, normative and aiming to build new software, which is, in essence, a new construct. In addition, this selection was supported by my supervisors at Pöyry Oyj and Lappeenranta University of Technology.

I agree that my former employment at Pöyry Oyj affected the selection of the research method. The research matched my tasks nicely; I was employed to develop new tools for procurement in the project environment and my research aimed to develop new work methods and procurement tools in project environments. The research results would have been directly applicable and benefit the company. The constructive research method gave me an opportunity to develop procurement software as a part of my research and my tasks at Pöyry Oyj. Last, but not least, using the constructive research method I had a sponsor for my post-graduate studies.

A more difficult selection was the selection of the viewpoint of my research. The cross-disciplined research could not be located entirely under one discipline without suffering some content losses. In the first hand, I tried to keep business science and Information Systems as equal disciplined in my research, although this meant some additional work. Later, I discovered that it is better to select the field of science having the most importance as a guiding discipline. I recognised that business science and its branch industrial engineering and management characterised my research work best. Therefore, the methods and nomenclature follow the guidelines of business science. The other discipline, Information Systems, has a supportive role.

I could have used the case study approach, if I had limited the work to describe the formulation of best practices in procurement. An exploratory or a normative case study would have given a detailed picture of procurement tasks in one environment. However, I still feel that a case study would have been a somewhat incomplete approach. Case studies describe a situation and maybe give improvement suggestions, but they do not deliver tools to apply improvement ideas to practice.

On the other hand, business science acknowledges action-analytic research, which was another possible research approach. The action-analytic approach is used to achieve an understanding of the reality that is tied to the observer and the observer is a part of the phenomena. This would have forced me to abandon the research paradigm that reality is objective and independent and it would have raised questions of my interests in the results. The action-analytic method, as business science understands it, is primarily a deductionist research method. It can be used to seek new theories and to form foundations for more detailed studies. Therefore, it is not very applicable for inventing or to developing new constructs and it did not match the overall target to develop new software.

[63] Iivari: A Paradigmatic Analysis of Contemporary Schools of IS Development (1991) European Journal of Information Systems, Vol. 1, No. 4, pp. 249-272

The action research method might have been suitable for my research method, but I abandoned it. Information Systems accepts the method and it is used to parallel build-and-evaluate-application situations. Many features of my research are similar to action research, but I do not believe that my research is really action research. First, I did not constantly review my research target or evaluate application towards the needs of the project personnel as action research proposes to researcher the do. Second, I did not encourage the project personnel to develop the procurement operations independently, as I would have been supposed to do in true action research. Actually, it would have been contrary to the original goal to force all the projects to use the same work methods.

1.6. CONSTRUCTIVE RESEARCH METHOD

The basic idea of constructive research[64] stems from the pragmatic philosophy of science. Constructive research is assumed to produce innovative constructs intended to solve real world problems, while making a contribution to the theory of the discipline in which it is applied. Constructive research is based on the belief that profound analysis of practice can make a significant contribution to theory. By developing a construct, something new is created that differs from anything existing before. The new constructs create, by definition, new reality. It characterises a lot of the research that the constructs are invented and developed, not discovered.

I have used the constructive research method in my research. The constructive research method is a well-defined and generally accepted research method in both business science and Information Systems. Because of the dual nature of my research, I have ended up to describe the constructive research method from the views of both disciplines. The constructive research method is similar in business science and Information Systems in many ways. The general idea of constructive research is roughly the same in both disciplines: to build-up a better solution than in any previous attempts. In both disciplines, the research aims to create a new construct to solve a problem, and research work is situation-reactive, iterative and collaborative.

The frameworks have differences, however. The most notable and confusing differences are the naming of the method and the subject of the method. In business science, the term “constructive research” means creating and evaluating a “construct”, which can be an innovation of any kind (see the next subsection). In Information Systems, “constructive research” is often called design science research. Furthermore, constructive research with close co-operation between the researcher and the client organisation is called “action research”. To finalise the naming differences, a group of artefacts (vocabulary and symbols) are called “constructs” in Information Systems (see Subsection 1.6.2.).

1.6.1. CONSTRUCTIVE RESEARCH APPROACH IN BUSINESS SCIENCE

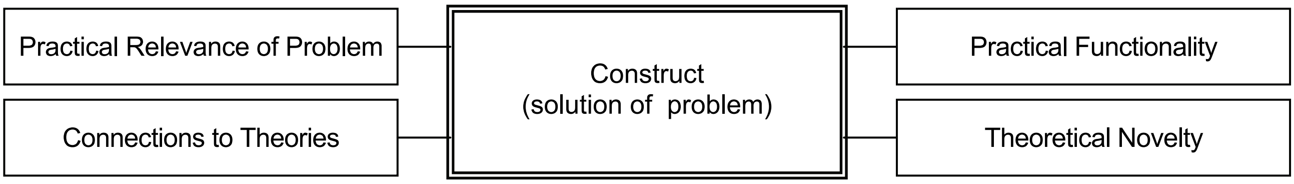
In business science, the constructive research approach[65] means problem solving through the construction of models, diagrams, plans, organisations, etc. Constructs refer, in general terms, to entities producing solutions to explicit problems. By developing a construct, something new is created, differing profoundly from anything existing before. It is important that the usability of the constructs can be demonstrated through implementation of the solution. Constructs are managerial solutions, because they solve problems that emerge in running business organisations. The constructive approach is a research procedure for producing these constructions. Not all problem-

64 Adapted from http://www.metodix.com (written by Kari Lukka)
http://www.tukkk.fi/tjt/TUTKIMUS/seminaari/konstr-m%C3%A4%C3%A4ritelmi%C3%A4.htm (31.05.2005)

65 Kasanen, Lukka and Siitonen: The Constructive Approach in Management Accounting Research (1993) Journal of Management Accounting Research, Vol. 5, No. 3-4 (Fall 1993), p. 244

solving passes as constructive research, an essential part of constructive research is to tie the problem and its solution to accumulated knowledge, as illustrated in Figure 13.

Figure 13. Constructive Research Model

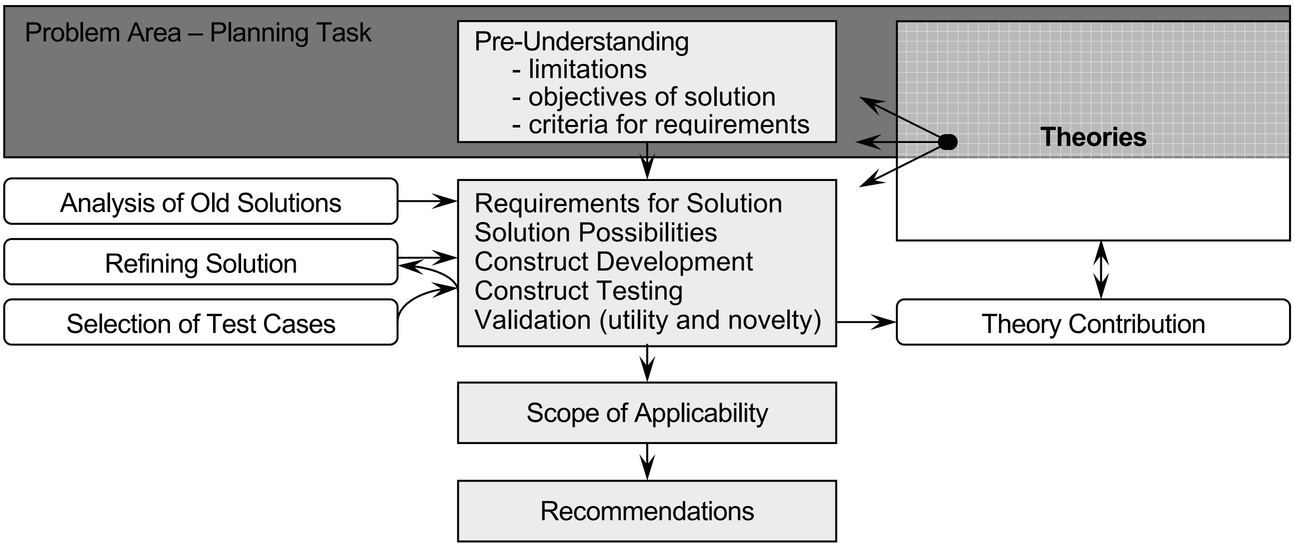


Kasanen et al: Konstruktiivinen tutkimusote liiketaloustieteessä, Liiketaloudellinen aikakauskirja 40:3 (1991), p. 306

Lukka[66] defines constructive research as a research procedure for developing innovative constructs intended to solve practical problems and aiming to contribute to the theory of applied discipline of science. The central notion of this approach, the novelty (construct), is an abstract notion with an infinite number of potential realisations. Lukka claims that all human artefacts are constructs, such as models, diagrams, plans, organisation structures, commercial products and information system designs. The main features of constructive research[67] are that (1) it produces an innovative and theoretically warranted solution to a relevant real world problem, (2) the suggested solution works in practice, and (3) the solution would be potentially adequate more generally.

Olkkonen[68] has presented a general model to describe the structure of constructive research, illustrated in Figure 14. Furthermore, Olkkonen states that constructive research is a normative method. Olkkonen's model shows the research phases and the connections between theories and empiria. It emphasises a creative, innovative and heuristic approach to research work. Creativity and innovativity are needed especially in solving a research problem. The heuristic features are evident in developing, improving and testing the new construct step by step. This includes the notion that the construct is demonstrated to work.

Figure 14. Progress of Constructive Research



Olkkonen: Johdatus teollisuustalouden tutkimustyöhön (1993), p. 79

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66 Adapted from http://www.metodix.com (written by Kari Lukka)
http://www.tukkk.fi/tjt/TUTKIMUS/seminaari/konstr-m%C3%A4%C3%A4ritelmi%C3%A4.htm (31.05.2005)

67 Kasanen, Lukka and Siitonen: Konstruktiivinen tutkimusote liiketaloustieteessä (1991)
Liiketaloudellinen aikakauskirja, Vol. 40, no. 3, p. 328

68 Olkkonen: Johdatus teollisuustalouden tutkimustyöhön (1993)
pp. 76-79

According to Olkkonen, constructive research begins with defining a practical problem and aiming to solve it, or develop a method to solve it. Thus, constructive research follows the demarcation of science used in design sciences. It is the utility of the solution, which validates the research in the design sciences. The scientific value of constructive research depends on the increase of the general knowledge and theories in solving similar problems.

Constructive Research Process in Business Science

Finnish business science honours two constructive research process descriptions, which partly origin from the same source. The Kasanen-Lukka-Siitonen –model has six major research process phases and the enhanced Lukka –model seven major phases.

Kasanen-Lukka-Siitonen –model[69]:

1) Search for relevant problem
   The first task in constructive research is to find a practically relevant problem, which also has research potential.
2) Pre-understanding
   Obtaining a general and comprehensive understanding of the topic. Both practical and theoretical pre-understanding should be achieved.
3) Innovation
   The construct building phase, where the research idea is implemented. This phase is critical for the constructive research method. If the suggested solution is not innovative, there is no point to continue the research process.
4) Demonstration
   The innovation and demonstration phases can be and often are entwined. The demonstration phase validates constructive research. The validation should be performed in industrial settings, whenever possible – to ensure practical relevance. Validation often employs other techniques, such as action research and case studies to show that the solution works.
5) Theoretical connections and research contribution
   Novelty is crucial, but it can be achieved in many ways. The construct can be based on an entirely new idea, sharing cross-domain knowledge, existing idea, implementation, solution or interesting research approach. Knowing the research field is crucial to the novelty and theoretical considerations.
6) Scope and applicability of the solution
   Scope and applicability considerations are carried out to seek the limits of the validity of the construct. The considerations can form a hypothesis for further testing.

Later, Lukka[70] has presented a slightly modified model for constructive research. He has added a new phase to the research process model, "Search of Research Co-Operation", which emphasises the importance of collaboration between the researcher and the target organisation. The second notable difference is that the last two phases have changed places.

In practice, research work can be carried out exactly the same way following either of the models. The differences would be noted in the structure of the research report. Lukka states that a constructive study is thus experimental by nature. It is targeted to develop and implement a new construction, which should be regarded as a test instrument in an attempt to illustrate, test, or refine a theory, or develop an entirely new one.

[69] Lassenius, Soininen and Vanhanen: Constructive Research (Methodology workshop 26.11.2001) http://www.soberit.hut.fi/~mmantyla/work/Research_Methods/Constructive_Research/constructive_research.ppt (31.05.2005)

[70] Lukka: The Key Issues of Applying the Constructive Approach to Field Research (2000) Publications of the Turku School of Economics and Business Administration, A-1:2000, pp.113-128

Lukka's model:

1) Search of a practically relevant problem having potential to a theoretical contribution
2) Search of long-term research co-operation
3) Theoretical and practical pre-understanding of the topic
4) Innovation process
5) Implementation and tests of how the construct works
6) Scope of applicability of the solution
7) Theoretical connections and research contribution

Evaluation in Business Science

The general evaluation criteria[71] for constructive research can be derived from the evaluation of any scientific research. The subject has to be relevant and have potential for a scientific contribution. In the constructive study, there should be both a practical and a theoretical contribution. It implies that the researcher has to be familiar with the (potential) ex ante -theories of the area. Next, the course of the research should be clear and fruitful. However, there has to be some allowances in the constructive research because of the creative and partly heuristic nature of the process. The implemented study has to be credible. The study should be conducted so that issues of validity and reliability are dealt with in a satisfactory manner. The study should be demonstrated to be a solid and careful empirical work.

The validity of construct[72] can be tested by market tests. This market-based validation rests on the concept of innovation diffusion, in which the constructs compete in the market of solutions. Market tests are carried out to prove the practical usefulness of the constructs, which raises issues of relevance, simplicity and easiness to use. Kasanen et al. have stated that already a weak market test is very strict and only a few constructs will pass it. The market tests comprise:

1) Weak market test
   A financially responsible manager is willing to apply the construct in his decision-making.
2) Semi-strong market test
   The construct becomes widely adopted by companies.
3) Strong market test
   Business units using the construct produce systematically better results than others.

Kasanen et al. state that constructive research requires that the applicability of the construct is studied, i.e. whether the construct could be applied in other areas, making the results more general. They propose that a solution working in one company is likely to be useful in other similar companies.

1.6.2. CONSTRUCTIVE RESEARCH APPROACH IN INFORMATION SYSTEMS

Because of the important role of Information Systems in my research, I have decided to describe the constructive research approach also from the viewpoint of Information Systems. Constructive research is usually called design science in Information Systems. In his book[73], Järvinen differentiates between (1) deriving deductively a new normative method, (2) deriving inductively a new normative method, and (3) an implementation of an innovation.

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71 Lukka: The Key Issues of Applying the Constructive Approach to Field Research (2000)
Publications of the Turku School of Economics and Business Administration, A-1:2000, pp 121-122

72 Kasanen, Lukka and Siitonen: The Constructive Approach in Management Accounting Research (1993)
Journal of Management Accounting Research, Vol. 5, No. 3-4 (Fall 1993), p. 253

73 Järvinen: On Research Methods (2004)
pp. 98-127

According to March and Smith[74], design science research has four research activities: (1) build, (2) evaluate, (3) theorise, and (4) justify (see Figure 12). “Build” refers to the construction of the artefact and demonstrating that such an artefact can be constructed to perform specific task(s). Later, the artefact becomes the object of study, since the artefact must be evaluated. “Evaluate” refers to the development of criteria and the assessment of the performance against chosen criteria. The artefact is evaluated in order to determine, whether any progress has been made in the research. The activity “Theorise” refers to the construction of explaining theories and “Justify” to theory proving. The first two activities have design science intent and the last two activities natural science intent.

March and Smith classify artefacts as constructs (vocabulary and symbols), models (abstractions and representations), methods (algorithms and practices) and instantiations (implemented and prototype systems). In my research, the design (description) of the procurement software is a model, the programmed software is an instantiation and the developed procurement practice is a method.

Design science research includes a special variation of the constructive research method: the action research method. While the constructive research method normally comprises the activities to build and evaluate the artefact in a sequence, in the action research method both building and evaluating closely activities belong to the same research process[75]. Another distinctive feature of the action research method is the significant amount of co-operation between the researcher and the target organisation. Later, Järvinen has demonstrated in his study[76] that action research and design science could be considered similar research approaches.

Construction in Information Systems

The construction process[77] is normally based on existing knowledge and new technical, organisational etc. advancement. Especially, the results of basic research can be applied to solve a problem situation or to improve existing solutions, which makes it a search process to find one or more solutions to the problem. The motivation behind building a new innovation is either a lack of a corresponding artefact or the poor quality of existing artefacts. Sooner or later, the utility of the new innovation is evaluated to verify the superior quality of the artefact.

In principle, building an artefact is a search process, normally following a particular development model. The building process constructs an innovation for a specific purpose. The desired target state of the innovation can be derived in many ways. There are four main strategies for determining information system requirements[78]. The requirements of the desired target state can be specified by (1) asking, (2) deriving from an existing information system, (3) synthesis from characteristics of the utilising system, and (4) discovering from experiments with the evolving system. It must be understood that each user has his or her desired target state for the information system. It does not matter how the requirements are determined, the ideas of the ideal system will differ from each other – sometimes more, sometimes less. It is a hard task to find generally acceptable system requirements for all parties. In any case, it is valuable to achieve a generally accepted description of the desired target state; it helps in every phase of the construction process.

[74] March and Smith: Design and Natural Science Research on Information Technology (1995)
Decision Support Systems, Vol. 15, No. 4, p. 251-266

[75] Järvinen: On Research Methods (2004)
p. 124

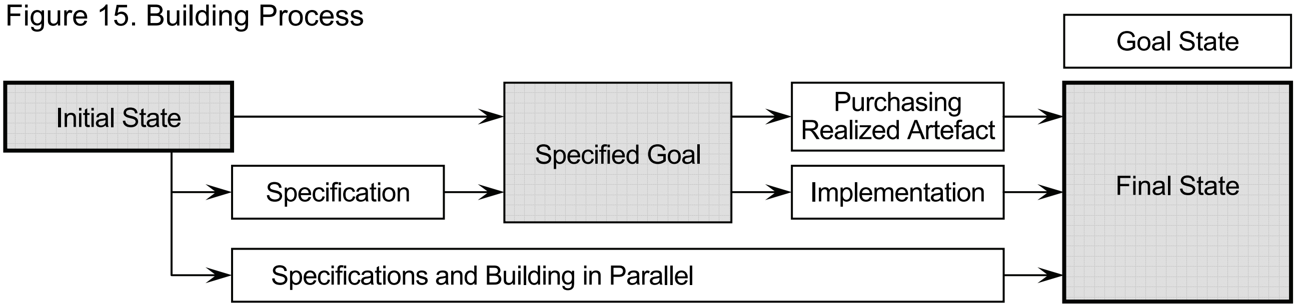
[76] Järvinen: Action Research as an Approach in Design Science (2005)
University of Tampere, Department of Computer Sciences, Series of Publications D – Net Publications
http://www.cs.uta.fi/reports/dsarja/D-2005-2.pdf (05.07.2006)

[77] Järvinen: On Research Methods (2004)
pp. 98-111

[78] Davis: Strategies for Information System Requirements Determination (1982)
IBM Systems Journal, Vol. 21, No 1, pp. 4-30

The building process is targeted to achieve a transition from the initial state to the target state while satisfying the requirements of the environment. The target state can be defined either before the building process or parallel with the building process. The building process can be replaced by purchasing a ready-made artefact, if such one exists and is available at a competitive price. It is also possible that the target state will not be totally achieved. The final state might still satisfy the users of the artefact. The satisfaction of the users is a clear utility sign of the innovation and proves that the research process is properly carried out. The process is presented in Figure 15.

Figure 15. Building Process



Järvinen: On Research Methods (2004), p. 103

Evaluation in Information Systems

In general, constructive research is driven with usefulness aspects. The utility of the artefact for its users should be evaluated. The environment establishes the requirements upon which the artefact is evaluated[79]. The evaluation is carried out to determine how well the artefact actually performs.

There are two cases in the evaluation: (1) the artefact is a totally new outcome, or (2) the artefact competes with old outcomes. For new outcomes, evaluations are not required. The outcome itself is regarded as the merit, but the potential importance of the construct could be evaluated. The originality of the solution should be demonstrated. If the construct has predecessors, i.e. the solution already exists in a certain form, March and Smith recommend evaluating the research in the following way:

> "The significance of research that builds subsequent constructs, models, methods, and instantiations addressing the same task is judged based on "significant improvement", e.g. more comprehensive, better performance."[80]

Järvinen[81] recommends that even a new artefact be evaluated by considering the utility of the artefact. He suggests using an evaluation question to test the superiority of the new outcome, i.e. the researcher asks how the new artefact is better than the old ones at least in some sense.

1.7. ACTUAL RESEARCH WORK

My general approach in this study is very pragmatic. It is said that the colour of the cat does not matter, if it hunts mice. The saying describes my attitude towards my construct, the procurement software. There were hectic times, when I was maintaining the software in one project, generating the next software version, and trying to find the logic for new application features. Without using any profound scientific reasoning, I applied available working solutions to practical problems.

[79] Hevner, March, Park and Ram: Design Science in Information Systems Research (2004) MIS Quarterly, Vol. 28, No. 1, p. 85

[80] March and Smith: Design and Natural Science Research on Information Technology (1995) Decision Support Systems, Vol. 15, No. 4, p. 260

[81] Järvinen: On Research Methods (2004) p. 109-110

My research is based on the idea that it is possible to program procurement software following upgraded project instructions. The software would ease procurement in project environments and solve problems in (1) procurement, (2) project management, and (3) data management. Therefore, the research can be seen either as a thorough software engineering or as a knowledge management task. The software engineering tasks in this research are supported by the theories of information system life cycle, software development and software maintenance. Knowledge management was needed in gathering experiences from successful projects and sorting out the best practices in the projects. Based on the project experience, instructions, standards and sample documents were provided to support project implementation.

The procurement problems were supposed to be overcome by programming procurement software following standardised practices in procurement and project management. The software comprised all three inquiry round types, the necessary supplier and client correspondence documents, document flow management and reporting. Project management problems focused on the progress estimations of each purchase item and the accumulated over-all procurement status in projects. The progress calculations needed a better method than manual calculations based on the accumulated contract figures. Data warehousing features of the procurement software were seen as a part of knowledge management disseminating the existing knowledge within the company.

In the wide perspective of science, the research follows the design science approach. It seeks better solutions to the procurement function than the existing ones. It makes the research empirical, applied and value-laden. The research is empirical, because it concerns practical matters, seeking useful answers to real problems. It is applied research, because it applies theories of business science and Information Systems into practice. It is value-laden (or normative in Olkkonen's terminology), because it aims at improvements; it seeks a more efficient way to carry out the procurement function in industrial plant projects. My study was not intended to follow the iterative spiral research model, but in practice it did; six development rounds were needed to achieve the final version of the procurement software.

1.7.1. RESEARCH MATERIAL

As discussed in Subsection 1.5.5., I consider my research as constructive research. I admit that there are case-study features in the beginning of the research. The knowledge management tasks for Pöyry Oyj, especially disseminating the gathered information, resemble a single-case study (one company, Pöyry Oyj). The other knowledge management task, rewriting of the project manuals, can be understood as a multiple-case study (many projects).

In principle, the analysis of problems before software development matches Yin's idea of a case study[82]. He has defined the scope of a case study as an empirical inquiry that investigates a contemporary phenomenon in its real-life context when boundaries between the phenomenon and the context are not evident. He states that the case study method allows retaining the holistic and meaningful characteristics of real-life events, for example of individual life cycles, organisational and managerial processes, and neighbourhood change.

The research material was gathered from professionals of Pöyry Oyj. Not all projects were studied for the rewriting of the project instructions, only the most successful ones. It has to be remembered that the major mill reference list comprised nearly 300 projects already in 1991. The other factor influencing the selection of projects was the availability. If the key project professionals were

[82] Yin: Case Study Research: design and methods (2003) pp. 2-16

available, their experience was used in formulating the project instructions. Later I extended the research to cover procurement status calculations as well. I developed a workload based progress follow-up, when I supervised the programming of the ERP modifications (I worked for ERP solution providers Tietonauha Oy, Minerva Suomi Oy,Tieto-Enator Oyj and Sentera Oyj, respectively).

Finally, I consider a project as a basic unit of analysis in my research, not a company. Even the software was required to manage several projects simultaneously. Therefore, I see that the number of projects rules out the single-case study option. I agree that my research can be considered to have been a multiple-case study before the programming of the procurement software started.

1.7.2. GOALS OF THE ACTUAL RESEARCH

In the beginning, the research concentrated on practical goals placed on developing the procurement function in large industrial plant projects. The practical goals were defined for: (1) the upgrading of the project manuals, and (2) the development of the procurement software. The improved project manuals were expected to meet current standards in project management, particularly in industrial plant projects. The procurement software was aimed to decrease the cost of the procurement function in project implementation and produce savings in the project implementation. The costs were supposed to reduce directly through the decreased workload (decreased labour cost) and indirectly via cost-efficient decisions in project implementation. Both the project instructions and the procurement software were expected to be used in all Pöyry companies.

The scientific contribution arises from the usefulness and the novelty of the project instructions and the procurement software. Design science research[83] concerns through the building and evaluating of innovations against identified needs, and aims at the utility of the developed artefacts. Because the artefact has a purpose, it must be useful in its domain and it should solve a specified problem. A similarly crucial requirement for proper research is novelty. The artefact must be innovative, solving an unsolved problem or solving a problem better than any other solution before.

In business science, the constructive research approach[84] means problem solving through the construction of models, diagrams, plans, organisations, etc. From the view of business science, the project instructions and the procurement software are the constructs. The project instructions were expected to guide the project implementation in future projects. The software was targeted to help in carrying out procurement tasks in large industrial plant projects and minimise the workload, particularly in procurement status estimation and data warehousing. The use of the software was assumed to produce savings in project implementation.

From the view of Information Systems, the situation has more subtleties. The expected results[85] are grouped as constructs, models, methods and instantiations. In my research, the design (description) of the procurement software is a model, the programmed software is an instantiation (a realisation of an artefact in its environment) and the developed procurement practice, preferably applied with the procurement software, is a method.

I placed several success criteria to the research, as listed in Table 5 on the next page. It should be born in mind here that my role as an apprentice in the developing of project instructions differs radically of my role in software development. In software development, I was responsible for all the

[83] Hevner, March, Park and Ram: Design Science in Information Systems Research (2004) MIS Quarterly, Vol. 28, No. 1, pp. 75-105

[84] Kasanen, Lukka and Siitonen: The Constructive Approach in Management Accounting Research (1993) Journal of Management Accounting Research, Vol. 5, No. 3-4 (Fall 1993), p. 243

[85] March and Smith: Design and Natural Science Research on Information Technology (1995) Decision Support Systems, Vol. 15, No. 4, p. 258

development stages. My success criteria can be seen to derive from the success criteria of design science[86] (cf. Table 4 in Subsection 1.5.1.). My criteria follow the guidelines for design science, although I hesitated to include the requirement of the viable solution. I easily agree that it is the precondition for successful research that the solution works, but I just cannot see non-working software as an IT solution. For me, non-working software is an IT problem.

Table 5. Success Criteria of the Implemented Research

Design Science Guideline	**Project Instructions**	**Procurement Software**
1. Design as an artefact • a viable construct	Project instructions are rewritten.	Software is programmed with adequate features and documented.
2. Problem relevance • solutions to relevant business problems	Procurement and its follow-up is a vital part of any industrial plant project.	
3. Design evaluation • utility, quality and efficacy of a design artefact must be rigorously demonstrated	Project instructions are used in industrial plant projects (multiple-case study).	Software is used in industrial plant projects (multiple-case study).
4. Research contributions • clear and verifiable in design, design foundations and/or design methodologies.	Project instructions provide an enhanced framework for project management and procurement function.	Software supports the rewritten project instructions and produces savings in procurement function. Software estimates procurement status and gathers background information for the following projects.
5. Research rigor • both in construction and evaluation	Construction: - gathering of company knowledge - structuring project instructions Evaluation: - market tests	Construction: - requirement determination - entity-relationship model - business process redesign Evaluation: - market tests - financial impact of software - requirements compared to software
6. Design as a search process • utilising available means to reach desired ends while satisfying laws in the problem environment	Rewriting of project instructions implies cyclical development of the instructions, which have continued for decades.	Software has been implemented and taken into use. Based on user experiences, the software has been developed further.
7. Communication of research • both to technology-oriented as well as management-oriented audiences	Documents and presentations: - project manual - procurement manual - marketing material of project services	Documents and presentations: - user interface manual - software manuals - marketing material of the software

1.7.3. COURSE OF THE ACTUAL RESEARCH

My research consists of business process development and application development. These main research phases overlap, but the chronological order followed roughly this order. The general course of the actual research is illustrated in Figure 16 on the next page. The actual timing and order of the research tasks is discussed in the following subsection.

The business process development comprised knowledge management and company practice formulating tasks, which were carried out to revise project instructions. The knowledge management approach was used to formulate company practices in project management and procurement. These

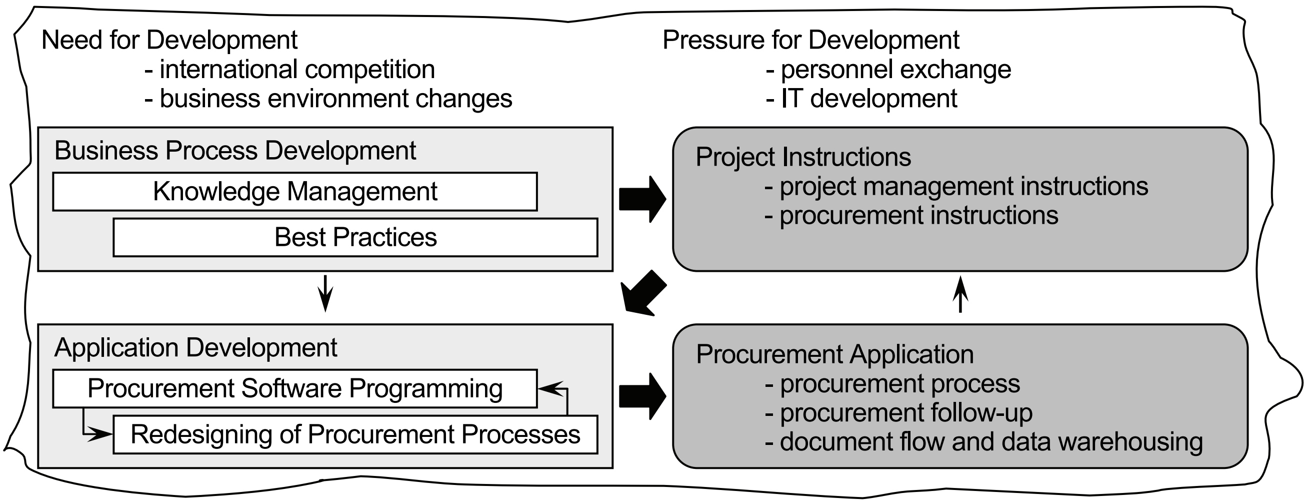
86 Hevner, March, Park and Ram: Design Science in Information Systems Research (2004) MIS Quarterly, Vol. 28, No. 1, pp. 82-83

practices were described in project instructions. The project manuals were generally assumed to describe the state-of-art in project management and procurement in industrial plant projects.

After the rewriting of the project manuals, the development of the procurement software begun. The rewritten manuals were considered as application requirements, because they described the procurement function and the environment of the software. The software was programmed along project management ideas discovered and created in the company. The first two software revisions were programmed before the redesigning of the procurement processes using a linear model of procurement flow. The redesigning of the procurement software enabled more efficient solutions for procurement tasks by making the procurement flow circular.

Right after the introduction of the first procurement software version, the documentation of the software was organised. The created construct was described in user manuals: *User Interface Guide*[87], *General Programs*[88] and *Purchasing Manager*[89]. Internal training courses were held to familiarise project workers with the software. Finally, it was recognised that the software changed the procurement tasks and the impact of the software had to be taken into account in project instructions.

Figure 16. Actual Course of Research



Business Process Development

Pöyry Oyj decided to develop its business processes to meet international competition. The development of procurement processes included searching of best practices, standardisation of procurement and project management tasks, and organising knowledge management for the procurement function. The renewed project and procurement instructions, published as project manuals, were the significant results of the process.

The knowledge management approach gives a wide picture of managing knowledge within the company. It was applied in documenting the most recommendable project practices. The term "knowledge management" was never used, because the term was not in common use at that time. However, the principles of knowledge management were present and they were intuitively used. In retrospect, knowledge management was used in gathering experiences from successful projects and sorting out the most successful practices of these projects. Project instructions were written, standards were created, and sample documents were provided to support project management.

87 Vehviläinen, Pöyry Oyj: User Interface Guide (1990, re-edited in 2005), 32 p.
88 Vehviläinen, Pöyry Oyj: General Programs (1991, re-edited in 2005), 36 p.
89 Vehviläinen, Pöyry Oyj: Purchasing Manager (1991, re-edited in 2005), 55 p.

The best practices approach was used in restructuring the project instructions, which was started to improve the company's competitiveness. Practices in several projects were studied and they were evaluated. Based on this benchmarking, the most promising work methods were used as basic material for the rewriting of the project instructions. The rewritten project instructions were regarded to comprise the most recommendable practices in project implementation.

Software Development

The idea of harnessing the knowledge with software arose after revising the project and procurement instructions. The software was targeted to support the procurement tasks. The software was expected to automate some business correspondence and reporting, and to enable fast, justified decision-making based on gained experience. The company goal was to decrease the needed working hours and professional skills in project implementation producing time and cost savings. Finally, the software would force project professionals to follow the formulated best practices.

The software development can be divided to three, partly overlapping, major stages: (1) software development following directly the rewritten project instructions, (2) redesigning the procurement software, and (3) software development following the redesigned procurement flow. I was appointed to make the software development from design to programming and documenting. For testing I got some assistance from my colleagues in the procurement department at Pöyry Oyj. My supervisors motivated me to high-quality software development by arguing that I might end up using the software myself. In principle, it makes the software development as some kind of end-user computing.

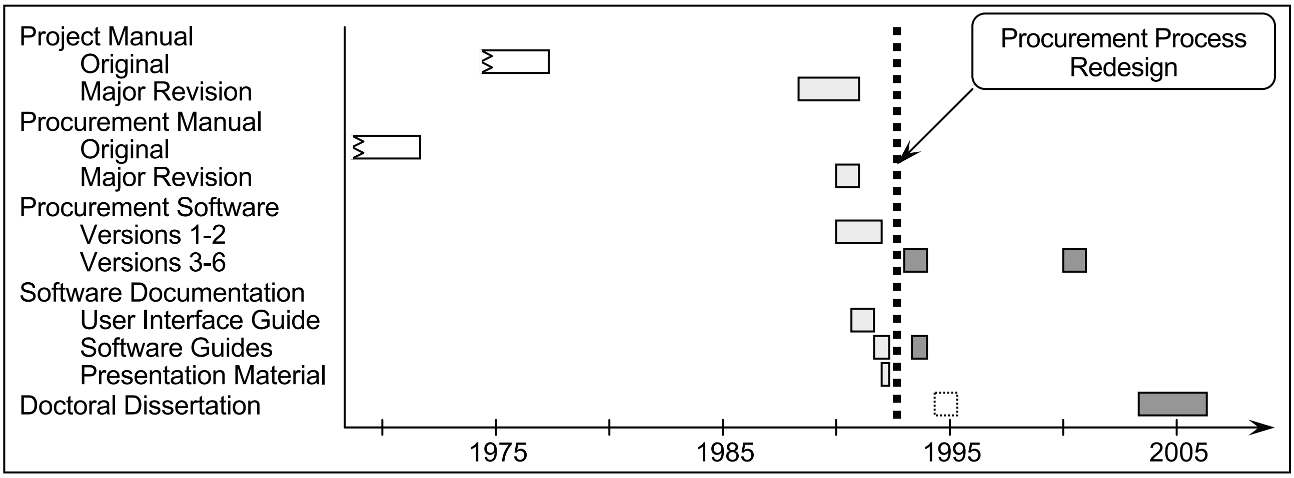
The major stages consist of the development cycles of the procurement software, resulting in the corresponding software version. The first major stage produced software versions 1 and 2. The second major stage, redesigning of the software, took place during the third development cycle, which introduced software version 3. The third major stage covers software versions 4, 5 and 6. The first software version was able to carry out all the required purchasing tasks, but there were no interfaces to other systems. The second version introduced an interface to scheduling programs and data warehousing. The third and fifth application versions were programmed to utilise new features of the database engine. The fourth version brought document flow management to the procurement application. Finally, the sixth version solved the problem of procurement status estimation.

1.7.4. PROGRESS OF THE ACTUAL RESEARCH

I did not work at Pöyry Oyj in the 1970s, when Paul Talvio wrote the Pöyry project manuals. I respect his work and I consider his manuals as a preliminary step for my research. The revising of his project manuals started the actual research. I was appointed to the task as a secretary, mostly responsible for graphical illustrations in the manuals. I was supposed to acquire the necessary background information of procurement tasks in the revising of the project instructions.

Soon after revising the project manuals, I was appointed to program the procurement software following these manuals. The first and second software versions were programmed directly according to the procurement instructions. The versions were not very successful, because they did not satisfy the user needs well enough. It took time to recognise the problem. It was even more difficult to become convinced that the document-based models of the project instructions were not an ideal starting-point to application development. A shift of thinking was necessary; I replaced the document-based models with process models. The process models helped understand procurement and combine the processes of budget inquiries, tender inquiries and final inquiries. The process model also helped in automating the follow-up of the procurement process. In retrospect, it is easy to understand that the document-based models of the manuals did not provide proper programming definitions. The time span of the research with Talvio's work is shown in Figure 17.

Figure 17. Actual Progress of the Research



Actual Design Process

Simon[90] describes design to be concerned with things that ought to be, with devising artefacts to attain goals. He sees the nature of the design process as a cycle, in which alternatives are generated and the generated alternatives are tested until a satisfying solution is found. He also brings up two levels of cost-effectiveness in the design process: (1) cost-effectiveness of design work, i.e. using resources sparingly in designing, and (2) designing economical artefacts with a high cost-benefit -ratio. The required cost-effectiveness of the research explains some features of my research. I did not program competing procurement software versions and select the best version based on end-user satisfaction. This was impossible, because of the limited time, funding and human resources.

Instead of programming several alternatives, it is customary (at least in ERP business) that the design of the software continues until a working solution is found. The scarcity of time and money causes that any working solution satisfying the software requirements is acceptable as long as it is a better solution than the competing manual solutions. At that moment, all the other possibilities are abandoned. The selected idea is programmed (at least prototyped) and the program is introduced to the users. This first solution will be developed further, if there are weaknesses or improvement possibilities in the solution. On the basis of the first version, the users propose improvements. The improvements are programmed and the next software version is presented to the users and so on, until satisfactory software is implemented. After each selection, the other possibilities are neglected and they are not documented, just like design and programming errors are not documented. This principle of minimum documentation[91] saves time and money in software development.

Floyd et al. have presented a similar approach to software development, called STEPS[92] (Software Technology for Evolutionary Participative System Development). It stresses the necessity to continuous co-ordination between developers and end-users. The model describes software

[90] Simon: The Sciences of the Artificial (1996)
pp. 111-138

[91] Pressman: Software Engineering: a practitioner's approach (2001)
p. 807

[92] Floyd, Reisin and Schmidt: STEPS to Software Development with Users (1989)
ESEC'89 - 2nd European Software Engineering Conference, Lecture Notes in Computer Science no. 387, pp. 48-64

development as a learning process, which puts emphasis on evolution and on collaboration among the participants of the development work. STEPS recommends that software is given to use in order to gather experience of using software. Developers and end-users exchange their views of the current and the ideal system which is expected to ensure that the software is developed to the right direction. The basic philosophy of the model supposes that participants get a common understanding of the development process and its goals. STEPS matches Järvinen's parallel process of determining software specifications and building the software[93] (see Figure 15 in Subsection 1.6.2.).

As a result, I have no alternative programs or alternative designs to report. The amount of work ruled out alternative solutions. The alternatives would have required, for example, six month work just to be discarded and cost-aware managers did not accept that. It was totally out of question at Pöyry Oyj. In the end, I have only documented the realised design. I admit that it might be a shortcoming in the research.

Actual Programming

I have to say that my understanding of procurement deepened a lot during the programming rounds. The programming followed, more or less, the spiral development model, because quite often the newly programmed features were decided to be inadequate or to require some improvement or additional features. I think that the programming was situation-reactive, iterative and collaborative. I had to reprogram the procurement software three times to satisfy the user demands of new features (scheduling, management of procurement documents and work load based progress estimation).

I made my first feeble attempts to program the procurement software in 1989, and the first version was published in 1990. I had to program the software twice (in 1991 and in 1994) to introduce new features enabled by IT development. I made use of the development PC hardware (memory management, mouse as a pointer device), operating systems (folders, cut-and-paste –feature) and DataEase (windowing of related records). This IT development gave new possibilities to build better software; all in search of more powerful and convenient fulfilment of PC user needs. As a result, the procurement software was in the end better than originally planned. I programmed the sixth version in 2000-2001 using the final MS-DOS version of DataEase.

I also suffered from the fast IT development. For a while, the IT development threatened to make the procurement software obsolete. Microsoft Windows 95 and its successors made my application with character user interface look outdated. Luckily, the 4GL tool owner, DataEase Ldt, saved me. The DataEase user group was large enough to make it profitable to invest on a new generation of DataEase and they finally introduced a 32-bit Windows version of DataEase in 2002.

1.7.5. ACTUAL EVALUATION OF THE CONSTRUCT

Both business science and Information Systems appreciate the usefulness of the constructs. The superiority of the new constructs (project instructions and procurement software) should be demonstrated. The evaluation should be made in the intended environment of the construct[94].

In business science, market tests are used to validate the research. The market tests are assumed to reveal the appeal of the constructs, and the applicability of them. The use of the project instructions and the software in industrial plant projects demonstrates the validity of the research.

[93] Järvinen: On Research Methods (2004)
p. 103-104

[94] Hevner, March, Park and Ram: Design Science in Information Systems Research (2004)
MIS Quarterly, Vol. 28, No. 1, p. 85

The instructions are evaluated by their diffusion through the project business. The usefulness of the procurement software is demonstrated by the achieved savings. The benefits of automated procurement status estimation are explainable. A calculation method calculating the current procurement status without any work (automatically) cannot be beaten in efficiency or in minimising work. The evaluation proved that viable constructs were developed.

In Information Systems, the evaluation is slightly different. First, to demonstrate the quality of the construct building process in my research, I have described the whole construction process. Second, to demonstrate the quality of the constructs, I have described the project instructions and procurement software and their benefits in industrial plant projects.

1.8. DISSERTATION STRUCTURE

My previous tutor in post-graduate studies, Professor Pitkänen, reminded me of the idea of conducting constructive research[95]. He stated that the whole approach demands a logically consistent research process; every step has to be justified, even if the outcome is a practical solution to a specified business problem.

First, the body of this doctoral dissertation follows the complex IMRAD –model, which is a variation of the renowned and recommended IMRAD –model. Paltridge's study[96] has been presented the model as a basic structure of doctoral dissertations and it is not totally unheard of in business science or Information Systems[97], either. Every main area of the research has a dedicated chapter. Before the first section of the topic, each chapter has a short preview to set the scene to this particular topic. The introducing literature is presented in the first section of each chapter. Although not all the research topics are theory-driven, the second section concentrates on the key literature of the topic. The third section describes the actual work carried out around the topic. The review collects up the research topic.

Second, the structure of the doctoral dissertation matches the advance of the research process, following the chronological order of the research. The advance of this research is discussed in Subsections 1.7.3. and 1.7.4. The research phases overlapped in several occasions, but the structure of this doctoral dissertation matches roughly the chronological order of the research. General views and background information are presented before details and actual research work

Third, I have structured the body of my doctoral dissertation to match the constructive research process as the Kasanen-Lukka-Siitonen –model describes it (see subsection 1.6.1.). Research subject-related sections are located in Chapter 1. The pre-understanding of the research topic is demonstrated in Chapters 2-6. The innovation phase is described in Chapters 7-9. The demonstration phase is illustrated in Chapter 10. Theoretical connections, research contribution and scope are discussed in Chapters 11 and 12.

In design science reports, like my dissertation, empiria and the researcher's efforts are sometimes difficult to separate from each other, because of heavy relations between the empiria and the practical problem solving. Therefore, my illustration of the general structure of this doctoral dissertation points out the nature of the section, classified into three categories: theory, empiria and researcher's efforts. The empiria –group comprises the descriptions of the phenomena in the

95 Pitkänen, Lappeenranta University of Technology: Discussions of research work (1992)

96 Paltridge: Thesis and Dissertation Writing: An Examination of Published Advice and Actual Practice (2002) English for Specific Purposes, Vol. 21, No. 2, pp. 125-143

97 McMahon: Planning a PhD Thesis http://www.computing.dcu.ie/~nmcmahon/essays/planning_a_thesis.html (30.01.2006)

research area. The researcher's efforts –group contains my development work in this research. I decided to include the descriptive interpretations in the empiria, even if I had heavily restructured the presentations. I included in the researcher's efforts –group only the parts which I have reasoned, invented or developed. The general structure of this dissertation is presented in Figure 18.

Figure 18. Structure of the Doctoral Dissertation

Front Matters	Title Page
	Abstract
	Table of Contents
	List of Figures
	List of Tables
	Nomenclature (key terms and acronyms)

Body: **Chapters (X.)**	**Section 1:** **X.1. Overview**	**Section 2:** **X.2. Key Literature**	**Section 3:** **X.3. Actual Research**	**Section 4:** **X.4. Review**
Preface				
1. Introduction*	Research Topic: • subject • literature survey • problem • purpose	DS Research: • research strategy • constr. method	Research Work: • actual	Dissertation: • structure
2. Research Background*	Background: • Pöyry • business environmt • IT development			Review
3. Business Process Development	Knowledge Management	Best Practice Approach	BP Development at Pöyry	Review
4. Project Management	Project Management Overview	Project Mgmt by PMBOK	Project Mgmt by Pöyry	Review
5. Procurement in Project Environment	Procurement Overv. in Project Env.	Procurement by PMBOK	Procurement by Pöyry	Review
6. General Planning of Information Systems	Managing Information Systems	General Planning Stages	General Planning for Procuremt Software	Review
7. Direct Software Development	System Developmt Life Cycle (SDLC)	Software Developmt in Waterfall SDLC	Software Versions 1-2	Review
8. Procurement Process Redesign	Business Process Redesign Overview	Software Redesign	Procurement Software Redesign	Review
9. Software Development after Redesign*			Software: • versions 3-6 • user interface • characteristics	Review
10. Evaluation*			Evaluation: • business science • IS • personal • practical	
11. Results				
12. Discussion and Conclusions*			Disc. and Concl.: • contribution • generalisability • recommendations	

End Matters	Acknowledgments
	Bibliography

Legends:
- Theory
- Empiria
- Researcher's efforts
- Not applicable

* The section numbering of these chapters follows the subtopics (marked with •)

2. RESEARCH BACKGROUND

This work acknowledges the importance of the environment in development work. This chapter covers the company background, the economical position of Pöyry Oyj and the IT development during the research. My aim in Section 2.3. is to convince the reader that the research is modern and valid from the IT point of view in 2005. Moreover, the section describes how the research has followed the development of its background.

My research origins from the business process development implemented at Pöyry Oyj in the late 1980s and in the early 1990s. Neither Pöyry Oyj nor my research could escape recession at that time. At the time, IT development provided lucrative new tools and work methods to manage projects. Networked personal computers and 4GL application development tools enabled totally new kinds of procurement tools at a reasonable price. I consider the severe international competition and economical depression as a pushing force for the development of the procurement software. Moreover, I regard the fast IT development with compelling possibilities as a pulling force needed to initiate the software development.

This chapter begins with the company background of the research. The chapter includes also the historical development of the business environment in the 1990s and the main development lines of information technology, i.e. the development of programming languages, databases and PC operating systems. Last, I describe the development of DataEase (the used 4GL tool).

2.1. PÖYRY OYJ

My doctoral dissertation is based on original research I carried out at Pöyry Oyj. The research has many touching points to the business realities of an engineering company. There have been many changes at Pöyry Oyj during the last 15 years, but the core business today is very similar to the business in the early 1990s. The company and its business are described below as the company presents them.

Pöyry Oyj has grown from a two-man engineering company in 1958 to today's well-known international consultant and engineering company. The company has found its position as a trustworthy counsellor in global pulp and paper industry. Pöyry Oyj is known of its expertise in forest and energy industries. It is repeatedly stated to be the leading independent engineering and consultancy company in its field. In 2005, Pöyry Oyj could offer local services to clients through more than a hundred offices, combining knowledge of local conditions with global resources and expertise. The following presentation[98] of the company has been quoted from their web site.

> **Jaakko Pöyry Group**
>
> “Jaakko Pöyry Group is a client- and technology -oriented, globally operating consulting and engineering firm. It has three core areas of expertise: forest industry, energy and infrastructure & environment. The Group employs 5200 experts in 40 countries.
>
> The Group’s business concept is based on early involvement in its clients’ business development. The Group offers services related to consulting, project development and implementation, and operations management and maintenance planning in all of its business sectors.

[98] Jaakko Pöyry Group
http://www.poyry.com/en/index.html (01.02.2005)

Mission

The Jaakko Pöyry Group's mission is to anticipate and fulfil its clients' requirements in order to improve their long-term competitiveness. This objective is pursued by providing clients globally with a full range of leading-edge solutions and services within consulting, project development and implementation, operations improvement and maintenance engineering.

The Jaakko Pöyry Group aims at attracting people with drive and ability to work towards the company's objectives. Employees are offered a challenging international working environment in an expert organisation emphasising quality and continuous development.

Jaakko Pöyry Group aims at securing a competitive long-term return for its shareholders by actively managing and integrating the Group's resources, know-how and operations, and by safeguarding its leading position in selected business areas. The target is to reach an average operating margin of 8% and to invest in continuous growth of the core business areas on a sustainable basis.

Business Concept

The Jaakko Pöyry Group’s business concept is based on early involvement in its clients’ business development, the provision of innovative and value-added solutions, and a full range of services from individual consulting and engineering assignments to management and implementation of complex projects.

Services are provided through the Group’s own resources in key areas of consulting, technology, engineering and project management, supplemented by partnerships and alliances.

Business Groups

The Jaakko Pöyry Group consists of three business groups: Forest Industry, Energy and Infrastructure & Environment.

The Forest Industry business group provides consulting, investment planning and implementation, maintenance planning and operations improvement services in all phases of its client companies’ development.

The Energy business group’s services cover the entire lifecycle of energy projects, from strategic planning, project development and implementation to power plant operations, and maintenance services.

The Infrastructure & Environment business group offers consulting and engineering services, building and project management services, operation and maintenance expertise, and services related to technology transfer.

Lifecycle Engagement

The Jaakko Pöyry Group's business is based on a deep understanding of its clients' core business processes. Mastering the entire lifecycle of an investment project, the Jaakko Pöyry Group adapts its services to meet each client's individual needs, including business development and financial and cost analyses, selection of appropriate technology, and development and implementation of investment projects.

The Group's core expertise includes operations management and maintenance planning, and other after-sales services. Relying on its project-oriented business approach, the Jaakko Pöyry Group offers its clients a comprehensive range of services - locally and globally.

Key Change Forces

Key change forces influencing the Jaakko Pöyry Group's business operations are:

Consolidation	Client companies continue to consolidate. The consulting and engineering business is also being consolidated.
Networking	Networking will promote co-operation through partnership agreements and alliances. It will create new business opportunities and expand the Group's service mix.
Digital revolution	The digital revolution makes information management and utilisation increasingly important. Information is no longer seen as a production factor dependent on time and place.
Speed of change and volatility	The business environment is changing faster and becoming more volatile.
Scarcity of resources	The scarcity of natural resources, such as fibre, energy and water, increasingly guide investment decisions in several market areas.
Competition for talent	Talent is an important competitive advantage of any company.
Cost-effectiveness	Success in international competition requires continual improvement of operations and competitiveness."

The importance of IT has not decreased. On the contrary, I am convinced that IT today has more to offer than it had 15 years ago. The biggest change in using IT solutions has not happened in solutions, it has been realised in the software users. They have learnt to use IT, they are used to solving software-related problems, and they are more willing to seek new ways to utilise IT in their every day work. The importance of IT has also been declared in the business review of Jaakko Pöyry Group.

> "To support its project-oriented activities, the Jaakko Pöyry Group continuously develops product and service concepts based on integrated IT solutions. Effective information management is a cornerstone of the Group's project business. A key success factor is the ability to make the right information available, in the right format, to the right persons at the right time."[99]

2.2. BUSINESS ENVIRONMENT

Some origins of the research can be traced to the financial difficulties of Pöyry Oyj in the early 1990s. International competition had set high standards to project management. The competition had shortened project time spans and downsized project organisations. Projects had to be finished with fewer people without compromising the quality. Old work methods were automated, less critical tasks were minimised, or even eliminated, and more result-oriented processed were developed.

[99] Jaakko Pöyry Group > Financial publications > Annual reports > Annual Report: Business Review 2003 http://www.poyry.com/linked/en/press/Business_review2003.pdf (02.02.2005)

At the same time, the first symptoms of the coming economic depression hit the company hard. The suffering clients did not order new projects as earlier. The business situation worsened gradually and corrective actions were necessary. One action to improve the company's competitiveness was the restructuring of the project instructions to meet the business requirements of the 1990s.

General Economical Environment in Finland

The Finnish economy met an unexpected and exceptionally deep recession in the beginning of the 1990s[100]. The economic crisis was preceded by debt-financed financial boom in the latter half of the 1980s. With higher than expected interest rates the boom came to an end. The disintegration of the Soviet Union pushed the Finnish economy even more towards a recession. The prospects for the future became gloomier when Finland went into a deep recession in 1991 and the Finnish economy started to shrink. A three-year period of high interest rates, falling outputs and collapsing asset prices was followed by debt-deflation, financial, banking and currency crises. The Finnish GDP shrank by 10 % in 1991-1993 and employment rate decreased by 20 %. As a consequence, the unemployment rate rose from moderate 3 % to 17 % between 1990 and 1994.

The government linked the Finnish Mark (FIM) to the European Exchange Rate Mechanism in summer 1991, but this failed to stabilise the currency[101]. Consequently, the government was forced to devalue the currency twice, in 1991 and 1992. The crash in the value of the Finnish Mark and a bank crisis shook the whole financial world in Finland and increased the economical panic. In autumn 1992 Finland's economic situation was extremely weak. Thousands of firms had gone bankrupt and the unemployment was rising rapidly. Domestic demand fell, and construction work dropped to under half of what it had been during the boom years. The unemployment rose to over half a million in 1994.

High Noon of Pöyry

The beginning of the 1990s was a difficult time for any engineering company, and Pöyry Oyj did not make an exception. Forest industry companies froze their mill projects undermining the engineering business in the branch. Billing rates came down, causing severe profitably problems for Pöyry Oyj. At the same time, Pöyry Oyj made substantial real estate investments and the interest rates started to rise. As a result[102], the profits of Pöyry Oyj fell negative; the company made losses of 29 million FIM in 1991 and 45 million FIM in 1992.

Pöyry Oyj started streamlining the company. The number of employees was reduced to cut costs, offices were closed and the company group was reorganised. The thread of bankruptcy was declined in December 1993, when KOP, SYP and Postipankki (major Finnish banks at that time) converted loans worth of 120 Million FIM to subordinated loans. Moreover, the banks gave 48 Million FIM bonds with warrants to Pöyry Oyj to strengthen the financial situation of the company[103]. In 1994, thanks to the floating Finnish Mark, the currency was devaluated and the forest industry recovered rapidly from the economical depression. The business situation of Pöyry Oyj appeared much better.

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[100] Kiander: The Evolution of Finnish Model in the 1990s: From Depression to High-Tech Boom (2004)
VATT Discussion Papers, No. 344
http://www.vatt.fi/julkaisut/k/k344.pdf (08.04.2006)

[101] SAK (The Central Organisation of Finnish Trade Unions) > Through the Recession
http://www.sak.fi/englanti/aikajanaeng.shtml?3493 (02.02.2005)

[102] Rauta-aho: Puujalka ei kanna konsulttiakaan (1993)
Talouselämä, Vol. 56, No. 9, pp. 24-27

[103] Sahiluoma: Nöyrtynyt voittaja (1999)
Kauppalehti Optio, Issue 1999/9, pp. 40-41

To strengthen the financial background, the ownership base was decided to be rearranged. In principle, the shares of Pöyry Oyj was exchanged to the B-shares of Finvest Oy for the worth of 238 million FIM, and the overpricing costs of Finvest's shares (ca. 50 million FIM) were carried by the seller. After the stabilisation of the ownership, Pöyry Oyj went public in Helsinki Stock Exchange in December 1997. Jorma Eloranta (the CEO of Finvest Oy at the time), regards the acquisition of Pöyry Oyj as a highlight of his business carrier. He states that Pöyry Oyj was not performing well. The equity capital of Pöyry Oyj was negative and the market value of the company was ca. 30 million €. Despite the negative facts, he believed the company and its leadership in its business segment[104].

In 2004, Pöyry Oyj was a highly profitable company with a good financial standing. Using IFRS reporting figures of the year, the net sales had risen to 473.9 million € and the operating profit was 29.9 million €[105]. The balance sheet of company totalled 312.6 million €[106]. The market value of the company had boomed to 463.4 million € in the end of the year 2005[107].

2.3. IT DEVELOPMENT

The aim of this section is to convince the reader that the construct of the research is technically valid even in 2005. I performed two small studies (PC operating systems[108] and DataEase[109]) to convince my supervisor of the validity of the software. The studies describe their subjects and their development until 2005. Only the PC operating systems MS-DOS, OS/2 and Windows are discussed in the report, because the used 4GL tool (DataEase) is designed to operate on them.

I have described the main development lines of programming languages, databases, PC operating systems and the used 4GL tool (DataEase) in this research report. I have limited the presentations to these four views, but I think they provide sufficient background to my research from the IT perspective. These four development lines are entwined and it would be quite difficult to describe one without mentioning the other. I admit that there are other ways to describe IT development. Especially hardware development would have been interesting to include in this work.

No doubt, the development of information technology has been astounding. The technologies have advanced in various directions, but the motivation behind has remained the same: greater productivity, faster connectivity and better communications, only to name some. The development started with mainframes, continued to personal computing with PCs, and goes on with Internet applications. Computers[110] have continued their trend toward a smaller size, working their way down from desktops to laptops (fitting in a briefcase) to palmtops (pocket-sized computers).

Moreover, the IT development affects competition[111] in business in three vital ways: (1) it changes the industry structure and, in doing so, alters the rules of competition, (2) it creates competitive advantage by giving companies new ways to outperform their rivals, and (3) it spawns new businesses, often from within a company's existing operations.

[104] Pakarinen: Jorma Eloranta – toiminnan mies (2004)
Omistaja ja sijoittaja, Issue 1/2004, p. 8

[105] Jaakko Pöyry Group > Investors > IFRS > Statement of Income
http://www.poyry.com/investor/investor_10_1.html (03.03.2006)

[106] Jaakko Pöyry Group > Investors > IFRS > Balance Sheet
http://www.poyry.com/investor/investor_10_2.html (03.03.2006)

[107] Kauppalehti > Pörssi ↳Jaakko Pöyry > Tulostiedot
http://www.kauppalehti.fi/4/0x20/porssi/osake/tulostiedot.jsp?stoid=JPG1V&comid=JPG (03.03.2006)

[108] Vehviläinen, Lappeenranta University of Technology: Development of PC Operating Systems (2005), 27 p.

[109] Vehviläinen, Lappeenranta University of Technology: 4GL Tool - DataEase (2005), 33 p.

[110] Jones Media and Information Technology Encyclopedia > Technology Trends > Computers: History and Development
http://www.jonesencyclo.com/article.cfm?artid=1316 (02.02.2005)

[111] Porter and Millar: How Information Gives You Competitive Advantage (1985)
p. 150

2.3.1. PROGRAMMING LANGUAGE GENERATIONS

The development of programming languages had advanced to 4GL tools at the time I started my research. Because 4GL tools had also been introduced into PC environments, it was easy to accept DataEase as a development tool for the procurement software. From this point of view, the selection of DataEase is still reasonable and the programmed software is easy to accept as modern.

Programming languages[112] provide basic building blocks for all software. All programming languages contain an individual set of symbols and rules that are used to write the program code. The syntax of the programming language dictates how the symbols have to be arranged to have a meaning. All programming languages in each generation have one thing in common. Ultimately, they have to be translated to machine language to be executed.

Programming languages are considered to have evolved in generations. The five increasingly sophisticated "generations", are called machine language, assembly language, procedural languages, non-procedural languages, and intelligent languages, which aim to use natural languages in programming. Natural programming languages seem to be a moving target. New inventions will improve programming languages gradually, but will programming language ever reach the level of any continuously evolving natural language and produce a true 5GL programming tool?

1GL[113, 114, 115] (machine language, machine code, native code) was (and still is), the lowest level programming language. Machine language is the native language of the computer on which the program is run. It consists exclusively of bit strings, i.e. of 1s and 0s, which correspond to the on and off electrical states of the computer. The advantage of the 1GL code is that it runs very efficiently, because the CPU directly executes it. The drawback of 1GL is that it is very difficult to learn and use. It is also very difficult to edit, if a program should be changed. Furthermore, the 1GL code is computer dependent, because the machine language for one computer can significantly differ from the machine language of another computer.

2GL (assembly language)[116] represents instructions and data locations by using mnemonics, or memory aids, which people can use more easily. Assembly is a human-readable notation for the machine language which a specific computer architecture uses. There is very closely a 1-to-1 correspondence between simple assembly and machine language, which means that assembly is also computer dependent. To work, 2GL programs need an assembler, which translates the assembly-language program into machine language. The assembler accepts a source program as input and produces an object program as output.

3GL (procedural language)[117] tells the computer how a task is done. It sets forth precise procedures, or series of instructions, to solve a problem. Programs are written in an English-like manner, thus making them more convenient to use and much easier to write, read and modify. As a result, a programmer can accomplish more with less effort and the programming can solve more complex tasks. 3GLs are designed to be CPU and machine code independent.

[112] Turban, Leidner, McLean and Wetherbe: Information Technology for Management: Transforming Business in the Digital Economy (2006), Technology Guide 2, Software, p. T2.17-T2.18

[113] Parsons: Introduction to Compiler Construction (1992) p. 1

[114] Turban, Leidner, McLean and Wetherbe: Information Technology for Management: Transforming Business in the Digital Economy (2006), Technology Guide 2, Software, p. T2.16

[115] Brookshear: Computer Science: An Overview (1997) p. 184-186

[116] Brookshear: Computer Science: An Overview (1997) p. 185

[117] Turban, Leidner, McLean and Wetherbe: Information Technology for Management: Transforming Business in the Digital Economy (2006), Technology Guide 2, Software, p. T2.18-T2.19

3GL can be translated into machine language either by a compiler or an interpreter. A compiler is a program that translates the source code into an object code. The compiler converts the high-level language programs into machine language before the computer executes the program. The object code can be saved and executed later. An interpreter converts high-level language statements into machine language and executes statements immediately, making programs easier to develop. Compilers, on the other hand, need some time before an executable program emerges. However, compiled programs run faster than the same programs executed by an interpreter.

4GL (non-procedural languages)[118] share some characteristics. They consist of report generators, query languages, application generators and database management system (DBMS) programs. 4GLs are result-oriented and they emphasise what instead of how. The users define only what they want the computer to do and do not provide the details of how it is supposed to be done. Therefore, 4GL programs improve productivity; applications are easy to write and change, the demands of the hardware and program structure are shielded from the users, and minimal training is needed for programmers. Most 4GLs are designed for a specific purpose, such as development of commercial business software.

SQL (Structured Query Language)[119] is the most popular relational database language. Technically, SQL is a set-based, declarative programming language used with relational and "quasi-relational" databases. SQL combines data definition and data manipulation. As the name implies, SQL is designed for a specific, limited purpose - it is designed for querying data contained in relational databases. The development of SQL is summarised in Table 6.

Table 6. Evolution of SQL

Period	Development
1970s	Relational model DRMS prototypes First relational DBMS
1980s	SQL-86 (SQL-87) first published by ANSI. Ratified by ISO in 1987. SQL-89 addendum, minor revision. ANSI embedded SQL
1990s	SQL-2 (SQL-92), major revision SQL/CLI SQL/PSM SQL:1999 (SQL-3)
2000s	SQL:2003

Calero et al: An ontological approach …, Computer Standards and Interfaces, Articles in press, 2005 (adapted)

5GL (intelligent languages)[120] or natural language programming languages (NLPs) are supposed to be the next evolutionary step in programming. Translation programs to transform natural languages into a structured, machine-readable form will be extremely complex and will require a large amount of computer resources.

118 Brookshear: Computer Science: An Overview (1997) p. 185

119 Calero, Ruiz, Baroni, Brito e Abreu and Piattini: An ontological approach to describe the SQL:2003 object-relational features (article in press, 2005) Computer Standards and Interfaces, Articles in press

120 Turban, Leidner, McLean and Wetherbe: Information Technology for Management: Transforming Business in the Digital Economy (2006), Technology Guide 2, Software, p. T2.18-T2.19

2.3.2. DATABASES

The databases have developed along with the programming languages. The development towards more sophisticated data structures has not replaced or made obsolete the old database models, which are still very much in use. The new data structure models have brought new possibilities to process data within them. DataEase was an advanced relational database engine in the 1980s, which made the selection of the development tool very understandable. The selection was still valid in 2005 and the used 4GL tool does not make the construct obsolete.

Databases are defined to be an organised collection of logically related data. Databases are usually but not necessarily computer-based.[121] They are used in applications, spanning virtually the entire range of computer software. Database applications vary for needs and purposes, from small user-oriented tools such as an address book, to huge enterprise-wide systems for tasks like accounting. Database sizes range from a simple table stored in a single file to very large databases with many millions of records, stored in rooms full of disk drives. Nowadays, databases can be used to collect and organise nearly any kind of data. Databases are especially useful for searching specific pieces of information saved in them. The saved information covers nearly all aspects of human life.

The most useful way to group databases is to use the underlying data structure. A possible taxonomy based on the data structure comprises table, network, hierarchical, relational and object database models. Historically, the relational model was the first formally defined database model. After the relational model, formal models for hierarchical and network databases were created.

Flat file (table) databases[122] consist of a single, two-dimensional array of data elements. The presented data is "flat", as it would be in a sheet of paper. All values of a given column are assumed to be similar, and all values of a row are supposed to relate to each other. The columns of the table are often associated with the data type, like character, date, time, integer, or floating point number. All the information is stored in plain text files, one record per line. Each record (line) is divided into fields using delimiters or at fixed column positions. Typical table databases are found in spreadsheet applications, such as a phone number list consisting of two fields: “Name” and “Phone Number”.

Network databases[123] have a more flexible structure than the hierarchical or relational models, but pays for it in processing time and specialisation of sets of data records. Each file may be associated with an arbitrary number of files. The network model allows multiple tables to be used together through pointers (or references). Some columns contain pointers to different tables instead of data. Thus, the tables are related by references, which can be viewed as a network structure.

Hierarchical databases[93] are a subset of network databases. In the hierarchical model the relationships are limited to a tree structure, in which data is presented in a nested, one-to-many set of relations. The top file of the “tree” is called the root, the bottom files are called leaves, and intermediate files have one and only one owner file and one or several children files. For example, an order is owned by only one customer.

[121] McFadden, Hoffer and Prescott: Modern Database Management (1999) p. 4
[122] TheFreeDictionary.com by Farlex ↳ Flat file database http://encyclopedia.thefreedictionary.com/Flat+file+database (27.07.2004)
[123] McFadden, Hoffer and Prescott: Modern Database Management (1999) pp. 282-284

Hierarchical databases were widely used in the first database systems. However, due to their restrictions, they often cannot be effectively used to describe structures that exist in the real world. Hierarchical relationships between different sets of data can make it very easy to describe some data structures, but very difficult to some others. If the one-to-many relationship in the database is violated (e.g. a patient can have more than one physician) then the hierarchy becomes a network.

Relational databases[124] were invented by E. F. Codd at IBM. His data model became widely accepted as the definitive model for relational database management systems. He presented his ideas in a seminar paper published in June 1970.

A relational database[125] is usually designed as a collection of several related tables. Each row of the tables presenting data is equivalent to a record, and each data column is equivalent to a field. In the relational model terminology, a row is called a tuple, and a column is called an attribute. In relational databases, data can be accessed or reassembled in the table in many ways without having to reorganise the database. Unlike the hierarchical and network models, there are no explicit pointers whatsoever in the relational model. (The data in the hierarchical and network models is accessed specifying an access path from pointer to pointer embedded in the data.)

Object-oriented databases[97] are designed to store complex data types, such as graphics, video and sound, as easily as simple data types. Attributes and methods operating on these attributes are encapsulated in structures called object classes. The relationships between object classes are shown, in part, by nesting or encapsulating an object class with another. An object-oriented program allows objects of the same type to behave differently, as long as they have the same interface (polymorphism), which does not belong to the characteristics of relational databases.

Database management systems (DBMS)[126] are applications for creating and maintaining databases. A minimal database management system at least defines a database which stores and accesses data. It also retrieves and displays or prints data in response to a user request. Furthermore, it maintains data in the database (insert, read, modify and delete -functions) and it maintains the integrity of the stored data according to defined structure and constraint rules.

2.3.3. PC OPERATING SYSTEMS

The development of PC operating systems differs a lot from the advance of programming language generations and databases. While the programming language generations and databases tend to find their niche to survive, new PC operating systems tend to replace the old ones. The PC operating systems development is deeply involved with hardware and programming language compatibility. From the PC operating system point of view, DataEase survives, but not with flying colours. The character based user interface and the use of “Command Prompt Window” in Windows environments makes the construct old-fashioned.

Operating systems[127] are programs responsible for the direct control of computers and networks. They control the execution of other programs running on the computer, communication of peripheral devices and use of disc space and other system resources. Additionally, operation

[124] Codd: A Relational Model of Data for Large Shared Data Banks
Communications of the ACM, Vol. 13, No. 6, (June 1970), pp. 377-387.

[125] Turban, Leidner, McLean and Wetherbe: Information Technology for Management: Transforming Business in the Digital Economy (2006), Technology Guide 2, Software, p. T3.13-T3.15

[126] Everest: Database Management System (1998)
In Cooper and Argyris (eds.): The Concise Blackwell Encyclopedia of Management, pp. 148-149

[127] Alter: Information Systems: foundation of e-business (2002)
p. 370

systems provide a foundation upon which to run applications such as spreadsheets, word processing programs and web browsers. The operating system ensures that the applications are able to use memory, input and output devices and have access to the file system. If more than one application is running, the operating system schedules all processes to have sufficient processor time whenever possible and prevents the processes from interfering with each other.

It is possible to use DataEase 4.53 (which I used to program the final version of the procurement software) with the following operating systems: MS-DOS 3.0 - 6.22, all OS/2 versions and Windows 95 - 2003, NT and XP. Windows environments are available through the “Command Prompt Window”. In 2005, the most attractive upgrade path to procurement software was an upgrade 4GL tool to DataEase 6.52. It requires Windows 98 (or higher) or Windows NT4 (SP 6 or higher) as the operating system.

2.3.4. THE USED 4GL TOOL – DATAEASE

I programmed the procurement application with DataEase, which is also the DBMS for the application providing the needed facilities to the application. DataEase followed and sometimes even led the development of relational databases in PC environments. Originally, DataEase was designed for 16-bit DOS environment. It was one of the first 4GL tools ever released for the PC platform. DataEase provides a menu-driven programmer interface for users who dislike programming, but would like to create database applications.

I programmed the first two versions of the procurement software with DataEase 2.53. Then I upgraded the 4GL tool to version 4.24 and finally to DataEase 4.53. The current version of the procurement software has a character user interface, but it can be converted to use a graphical user interface by replacing DataEase 4.53 with DataEase 6.52 and converting the database to use the new version of the 4GL tool. It provides the graphical user interface with Windows features and Internet facilities.

DataEase 4.53[128] was a real 4GL tool in DOS environment. It was one of the finest DOS database engines ever conceived and released for general use. DataEase 4.53 used SQL and client/server technology in networking, but the programming with the menu driven interface made it easy to use. It is a powerful tool as a fully networked DOS-based DBMS with SQL.

Although, DataEase 4.53 was designed for DOS environments, it can also operate under Windows. The Windows versions provide a “Command Prompt Window”, where the user can run his DOS applications. The DOS -box exists in all Windows versions (9x, NT, 2000, 2003 and XP). DataEase 4.53 can be used even in some Unix environments.

DataEase 6.52[129] was released in 2004. It is shipped with Web Publisher, a read-and-write solution for MS IIS version 4 and above web servers. Web Publisher makes DataEase applications open to everyone with a web browser. A developer can web-publish DataEase forms and reports without writing a single line of code, simply by making choices and clicking buttons. DataEase 6.52, as all the DataEase 6.x versions, is a truly 32-bit software designed for Windows environments. It gives all the benefits of a graphical user interface and collaboration with other Windows software.

[128] Winkler: The DataEase Relational Database System, A Brief History
http://www.plmconsulting.com/ubb/Forum9/HTML/000007.html (21.09.2004)
[129] DataEase International > DataEase > DataEase 6.5
http://www.dataease.com/dataease/dataease65.php (18.10.2004)

2.4. REVIEW

The research background includes the company environment (Pöyry Oyj), the business environment in the 1990s and the IT background. I have described them to illuminate the starting-point of the research and the development of the research environment. The background includes the harsh international competition, which made pressure to develop new practices and tools for project management. At the same time, the IT development provided new lucrative tools to manage projects. On the one hand, I consider the economical situation of the company as a pushing force for the development of the procurement software. On the other hand, I regard the fast IT development with compelling possibilities as a pulling force needed to initiate the software development.

Financial difficulties of Pöyry Oyj preceded the research in the very beginning of the 1990s. In order to overcome the difficulties, Pöyry Oyj started restructuring the project instructions to meet the business requirements in the 1990s. During the development project, rewritten instructions were considered necessary, but not sufficient means to carry out efficient project management. If the project management tools are badly outdated, the brightest ideas might be deteriorated to an unacceptable level by poor implementation. Modern tools are needed and have to be utilised as far as possible. The situation can even turn upside down; modern tools might provide new or improved best business practices. All this led to a decision to develop better and more efficient tools for project management.

Networked personal computers and 4GL application development tools enabled totally new kinds of information systems (including procurement software to be programmed) at a reasonable price. In retrospect, the used 4GL tool was an excellent choice. DataEase was based on the relational database model and had a DQL (superset of SQL) for data queries. Furthermore, it provided a networked user environment and stable operational environment.

During the software development, Pöyry Oyj terminated my employment, but I kept improving the application. I felt that there might be some scientific interest and I still regarded it as a way to improve my skills. My own intellectual curiosity and ambitions made me to program software twice for Metsä-Serla Chemicals in a CMC –plant project and the last time for project management in large ERP –projects.

I have presented the development lines of programming language generations, databases, operating systems and DataEase in order to convince the reader that the construct of the research has stayed technically valid. Although the procurement application has a character user interface, it can be converted to use a graphical interface by upgrading the DataEase version. The conversion would make the software more appealing with a graphical user interface. Moreover, modern Windows and Internet features could be introduced into the software.

3. BUSINESS PROCESS DEVELOPMENT

My research includes business process development features, such as search of the most recommended practices and organising the knowledge dissemination in the company. The best project management practices were, and still are, pursued at Pöyry Oyj. The company has sought for best practices in the project business and proper ways to share them, because international project management lays down hard conditions, which in turn demands the utilisation of the best available knowledge, tools and personnel. The Pöyry way to produce project instructions, allegedly resulting in the state-of-art in project management, is introduced in this study. Therefore, the research can be seen as a business process development project.

Business process development is defined as a systematic approach to help any organisation make significant changes in their ways to do business and achieve commercial results. Business process development is concerned with the performance, development and effectiveness of organisations. Systematic approaches are needed, because clearly formulated methods help and aid organisations to carry out significant improvements in their business.

The goal of business process development can be either a radical, revolutionary change in the performance of an organisation (re-engineering project) or a series of incremental evolutionary changes (development process)[130]. In this chapter, I describe the evolutionary part of the business process development, resulting in the rewritten project instructions. The project management instructions and procurement instructions are presented in Chapter 4 and Chapter 5, respectively. Later, a dedicated chapter (8. Procurement Process Redesign) concentrates on more revolutionary measures to improve the procurement application.

My goal in this chapter is to describe the reformulating process of Pöyry project instructions. I regard the rewriting of the manuals as a knowledge management task. It was carried out to support evolutionary development in the key project management processes. In principle, knowledge management is carried out as a single-case study following the business aims of Pöyry Oyj, based on the company situation and material and concentrating on fulfilling the needs of the company. Personally, I regard knowledge management as a necessary preliminary phase in acquiring the pre-understanding of the subject. It gave me a wider picture to the procurement tasks than learning the trade directly from the manuals. This chapter includes general descriptions of knowledge management and the best practices approach. The implementation of the framework consists of the re-editing process of the project manuals, which followed these broad general ideas.

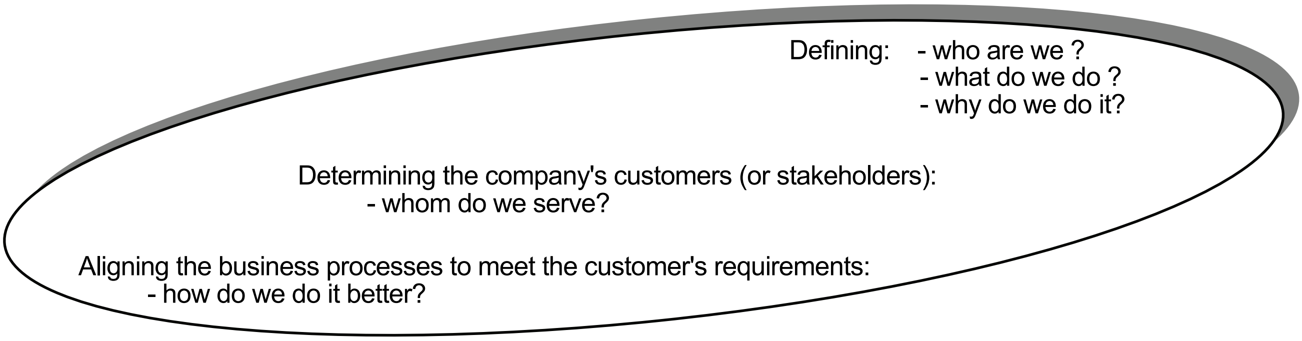
Business Process Development in a Nutshell

Business process development[131] can be regarded to comprise three key steps: (1) defining the strategic goals of an organisation, (2) determining the customers (or stakeholders) of an organisation, and (3) aligning the business processes to meet the customers' (or stakeholders') requirements. The first step in business process development is to analyse the current situation: refind or define the company's mission, existing structure and processes. Next, the current process owners in the company should determine what outcomes would add value to the company's mission and objectives. Once the outcomes are determined, the company should to be reshaped to meet the missions and objectives. The benchmarking, including cost control, should be put into place. The process is illustrated in Figure 19 on the next page.

[130] Stoddard and Järvenpää: Business process redesign: Tactics for managing radical change (1995) Journal of Management Information Systems, Vol. 12, No. 1, pp. 81-107

[131] Hammer and Champy: Reengineering the Corporation: A Manifesto for Business Revolution (1993), 240 p.

Figure 19. Business Process Development in Nutshell



Hammer and Champy have also suggested general principles for business process development. Their ideas provide sound advice for anyone streamlining business processes:

1) Focus on the customer
   Many organisations fail to do this, because routines overwhelm them. Resources within the organisation start to be allocated according to political needs rather than business or policy needs. Meanwhile, customer needs may have changed to the point that the organisation may no longer effectively serve the customer.

2) Justify activities by outcomes, not routines
   Business process development should be organised around outcomes, not the specific tasks required to reach the outcome. Organisations improving the processes seek to eliminate the emphasis on routine that may not work well in an ever-changing political, business or legal climate.

3) Clarify optimal processes first, do not automate existing processes
   Information processing is not meant to be a substitute for process development. An automated but inefficient system does not adequately meet customer requirements and might only worsen the situation.

4) Benchmark regularly
   A company must frequently determine whether the costs of performing a business process outweigh the benefits. Therefore, it must establish benchmarks, or standards, against which the process will be measured. The measures must be quantifiable, attainable and realistic.

5) Establish who owns and is responsible for a business process
   Specific people, process owners, must be placed in charge of a business process. They must be responsibility for the performance and changes in the process. Ultimately, they carry the responsible for the success or failure of a process. Without personal responsibility, the process may fail.

6) Build control into a process
   The process must be controllable. The process owners and customers/stakeholders must have means to measure whether the process meets the benchmarks. This may include the halting possibility of the process if it fails to meet realistic benchmarks.

7) Standardise processes
   Without planning, temporary solutions take places and use scarce resources. Standardised processes save time, effort, staff hours and money. Process standardisation can take place in three forms: (1) process activity and flow standards, (2) process performance standards, and (3) process management standards[132].

8) Make changes whenever they are justified
   The processes should be under examination repeatedly, not merely once. Postponing the change in the hope of the perfect solution later means that the development has stagnated.

[132] Davenport: The Coming Commonditization of Processes (2005)
Harvard Business Review, Vol. 63, No. 6, pp. 101-108

3.1. KNOWLEDGE MANAGEMENT

Knowledge management[133] (KM) is a process that helps organisations to identify, select, organize, disseminate, and transfer information and expertise that are part of the organisation's memory. The structuring of knowledge enables effective and efficient problem solving, dynamic learning, strategic planning and decision-making. Knowledge management initiatives focus on identifying knowledge, the ways it can be shared in a formal manner, leveraging its value through reuse. KM can help in problem solving and promote organisational learning. Finally, KM is needed to terminate the use of incorrect or outdated knowledge.

> "Knowledge Management caters to the critical issues of organisational adaptation, survival, and competence in face of increasingly discontinuous environmental change" ... "Essentially, it embodies organizational processes that seek synergistic combination of data and information processing capacity of information technologies, and the creative and innovative capacity of human beings." Yogesh Malhotra[134]

Hansen, Nohria and Tierney suggest that knowledge can be managed by using two main strategies: codification and personalisation[135]. The codification strategy focuses on codifying organisational knowledge, storing it in a way that it can be accessed and used by anyone in the company. Information technology is used to enhance the quality and speed of knowledge creation and distribution. The personalisation strategy emphasises the sharing of knowledge through direct personal contacts. The strategy emphasises building social environments or communities to facilitate the sharing of knowledge. Both strategies can be used effectively in the same company.

3.1.1. NATURE OF KNOWLEDGE

When discussing knowledge and knowledge management, it helps if we make a distinction between data, information and knowledge. Maglitta[136] suggests that data is raw numbers and facts, information is processed data, and knowledge is "information made actionable". Having knowledge implies that it can be used to solve a problem, whereas having information does not carry the same idea.

Knowledge[137, 138] can be divided further to tacit and explicit knowledge. Nonaka has proposed definitions for these two knowledge dimensions. He suggests that explicit or codified knowledge refers to knowledge which is transmittable with a formal and systematic language. It deals with more objective, rational and technical knowledge. According to Nonaka, tacit knowledge is highly personal and difficult to formalise. It is deeply rooted in action, commitment and involvement in a specific context. Polanyi[139], a pioneer conceptualising and distinguishing tacit knowing and tacit knowledge, suggests all knowledge is either tacit or rooted in tacit knowledge.

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[133] Aronson: Knowledge Management (2002)
In Turban , McLean and Wetherbe (eds.): Information Technology for Management: Transforming Business in the Digital Economy, p. 388

[134] The Knowledge Management Network > What Is Knowledge Management
http://www.kmnetwork.com/WhatIsKM.html#whatis (15.12.2004)

[135] Hansen, Nohria and Tierney: What's Your Strategy for Managing Knowledge? (1999)
Harvard Business Review, Vol. 77, No. 2, pp. 106-116

[136] Maglitta: Smarten Up! (1995)
Computerworld, Vol. 29, No. 23, pp. 84-86.

[137] Hildreth and Kimble: The duality of knowledge (2002)
Information Research, Vol. 8, No. 1
http://informationr.net/ir/8-1/paper142.html (18.09.2006)

[138] Nonaka: A Dynamic Theory of Organizational Knowledge Creation (1994)
Organization Science, Vol. 5, No. 1, pp. 14-37

[139] Polanyi: The Tacit Dimension (1966), 108 p.

3.1.2. ORGANISATIONAL DIMENSION OF KNOWLEDGE

Explicit organisational knowledge[140] includes policies, procedures, software, products, documents, strategies etc. It is codified, or documented, so that it can be shared, used or transformed without interpersonal interaction. Tacit organisational knowledge lies in the domain of subjective, cognitive and experiential learning. It is diffused, unstructured, without a tangible form and therefore difficult to codify. It typically involves expertise or high skill levels. Tacit organisational knowledge encompasses the cumulative store of corporate know-how, expertise, experiences, insights, etc. Explicit organisational knowledge is sometimes called leaky knowledge[141], because it easily leaves an individual, document or organisation, since it is readily and accurately documented. Tacit organisational knowledge is called sticky knowledge, because it is hard to pull out from its source.

I use Nonaka's Spiral of Organisational Knowledge Creation –model and Cook and Brown's Bridging Epistemologies –model to describe the organisational dimension of knowledge. These models illuminate the ownership (individual or group) of knowledge and co-existence of separate knowledge modes. The nature and ownership of knowledge are used to explain difficulties in knowledge transfer. Both models are largely supported, though they present opposite views to knowledge transformation. Cook and Brown assume that tacit knowledge cannot be transformed to explicit knowledge, while Nonaka's model (rather controversial to some) presents that the transformation is possible. The popularity of the models (28.04.2006) has been illustrated in Table 7.

Table 7. Popularity of the Organisational Dimension Models

	Spiral of Organisational Knowledge –model (Nonaka) "A Dynamic Theory of Organizational Knowledge Creation"	**Bridging Epistemologies –model (Cook and Brown)** "Bridging Epistemologies: The Generative Dance Between Organizational Knowledge and Organizational Knowing"
EBSCO Business Source Elite	469 citations	58 citations
Elsevier Search in References	256 references	22 references
The ACM Digital Library	29 hits	2 hits
Google Search	ca. 27800 hits	ca. 288 hits

The knowledge transformation question is interesting, but not having a great effect on my research. The rewritten project manuals comprise explicit organisational knowledge. I am satisfied to claim that the procurement software presents explicit organisational knowledge, because the software encourages, i.e. nearly forces, project workers to follow the procurement flow as described in the project manuals. Moreover, the software can transfer information within and between projects.

Spiral of Organisational Knowledge Creation

Nonaka[142] has presented a dynamic theory of organisational knowledge creation. He suggests that there are four modes of knowledge conversion: (1) from tacit to tacit knowledge, i.e. socialisation, (2)

[140] Aronson: Knowledge Management (2002)
In Turban , McLean and Wetherbe (eds.): Information Technology for Management: Transforming Business in the Digital Economy, pp. 388-392

[141] Alavi: Managing Organizational Knowledge (2000)
In Zmud (ed.): Framing the Domains of IT Management, p. 18

[142] Nonaka: A Dynamic Theory of Organizational Knowledge Creation (1994)
Organization Science, Vol. 5, No. 1, pp. 14-37

from explicit to explicit knowledge, i.e. combination, (3) from tacit to explicit knowledge, i.e. externalisation, and (4) from explicit to tacit knowledge, i.e. internalisation. While each knowledge conversion can create new knowledge independently, the most interesting idea is the dynamic interaction between the conversion modes in creating new organisational knowledge.

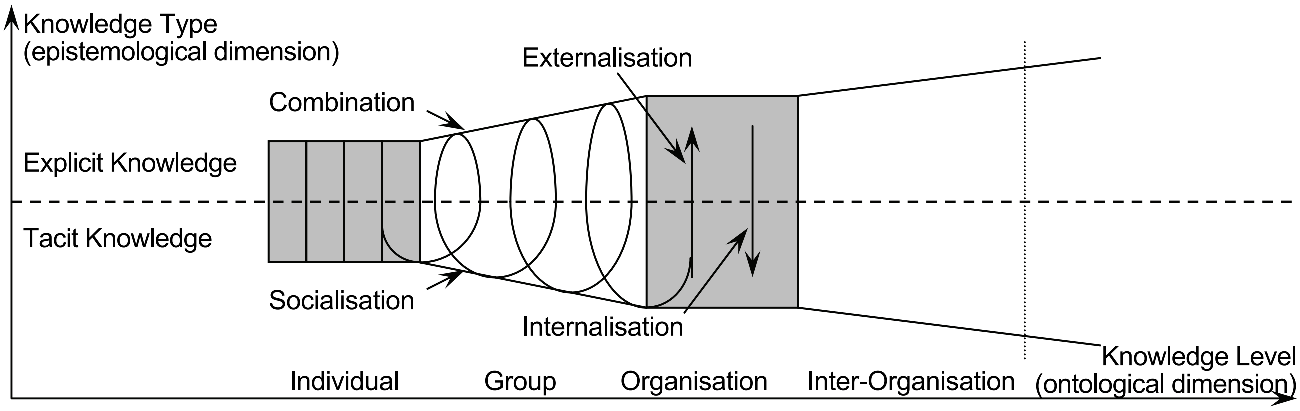
The socialisation process creates tacit knowledge through shared experiences. Apprentices work with their masters and learn the craftsmanship by observation, imitation and practice. The key to acquiring tacit knowledge is experience. Without shared experience, it is extremely difficult to share and understand other people's thinking processes.

The combination process accumulates the explicit knowledge of individuals and uses social processes to create new explicit knowledge. Individuals exchange and combine knowledge through meetings, conversations, reports etc. The restructuring of existing information through sorting, adding, grouping and recontextualising can produce new knowledge.

The externalisation and **internalisation** processes are related to conversions involving both tacit and explicit knowledge. These conversions capture the idea that tacit and explicit knowledge are complementary and they can expand over time through mutual interaction. The conversion of tacit knowledge to explicit knowledge is called externalisation and the opposite conversion internalisation. The internalisation bears some resemblance to the traditional notion of "learning".

Nonaka uses a spiral model, illustrated in Figure 20, to describe organisational knowledge creation. The spiral model illustrates the continuous dialogue between tacit and explicit knowledge. As an idea resonates around the surrounding individuals and organisations, it develops and becomes clarified. Gradually, the idea obtains more approval and becomes crystallised.

Figure 20. Spiral of Organisational Knowledge Creation



Nonaka: A Dynamic Theory of Organizational Knowledge Creation, Organization Science 5:1 (1994), p. 20

Bridging Epistemologies

Cook and Brown have presented organisational knowledge using the Bridging Epistemologies – model[143], presented in Figure 21 on the next page. They identify four types of knowledge: explicit and tacit at individual and collective levels. They consider how knowing bridges the knowledge types. The knowing process is described as a "generative dance" in which different knowledge types are used. According to this metaphor, knowledge creation does not simply rely on an inventory of knowledge elements (possession), but on the utilisation of them as tools (action).

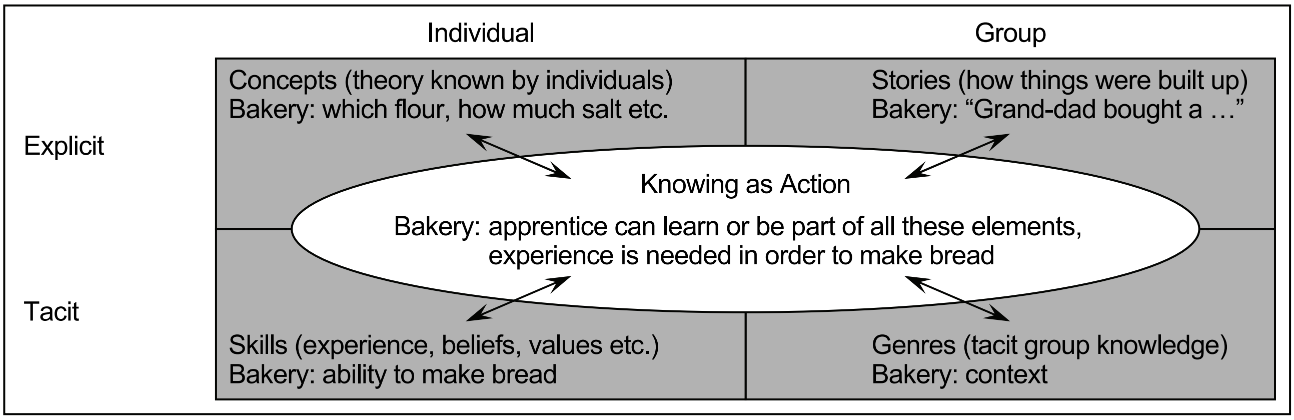
[143] Cook and Brown: Bridging Epistemologies: The Generative Dance between Organizational Knowledge and Organizational Knowing (1999)
Organization Science, Vol. 10, No. 4, pp. 381-400

Cook and Brown argue that knowledge is treated like something which people possess. Yet, this vision cannot account for all the knowing which is found in individual and group practice. Knowing as action should be explained with an "epistemology of practice." Moreover, the epistemology of possession tends to privilege explicit over tacit knowledge. It also tends to emphasise individual knowledge over group knowledge. Current organisational studies are limited by this privileging, and scant attention is paid to knowing.

Cook and Brown claim that organisations are better understood if explicit, tacit, individual and group knowledge are treated as four distinct and coequal forms of knowledge, each operating and benefiting in ways the others cannot. Knowledge and knowing should be seen as co-operating, not competing. Actions by groups cannot be reduced to the actions of individuals within them.

Cook and Brown continue that knowledge is a tool of knowing. Knowing itself is an aspect of our interaction with the social and physical world. Utterly, the interplay of knowledge and knowing can generate new knowledge and new ways of knowing. Their model strengthens links between product and product development work. In their view, product development reflects ways of "knowing" in the interaction of the workers with each other and their objects of work.

Figure 21. Bridging Epistemologies –Model



Cook and Brown: Bridging Epistemologies: The Generative…, Organization Science 10:4 (1999), p. 393 (adapted)

Knowledge Management in Project Environments

The nature of project organisations implies limited time and resources, multi-disciplinary processes and changing teams[144]. It causes specific problems for knowledge management and knowledge transfer. KM[145] in project environments involves the creation (collection, combination and refinement), administration (storage, organisation and retrieval), dissemination within and outside the project, and use of knowledge (integration into products and decisions, and application in other projects). It is challenged by the documentation and administration, as well as the distribution and sharing of newly generated knowledge.

There are various special features in knowledge management in project environments[146]. The need to share tacit knowledge and disseminate best practices represents the aim to leverage the organisational knowledge produced by project employees. KM encourages continuous

[144] Pretorius and Steyn: Knowledge management in project environments (2005) South African Journal of Business Management, Vol. 36 Issue 3, p. 41

[145] Kasvi, Vartiainen and Hailikari: Managing knowledge and knowledge competences in projects and project organisations (2003) International Journal of Project Management, Vol. 21, No. 8, pp. 571-572

[146] Carrillo, Robinson, Al-Ghassani and Anumba: Knowledge Management in UK Construction: Strategies, Resources and Barriers (2004) Project Management Journal, Vol. 35, No. 1, pp. 46-56

improvement in project environments. The lessons learned during the project life cycle may prevent the repetition of errors in the same project or another, similar project, reducing the costs and time for rework. The ideas generated in a project should be transferred to future projects. Kasvi et al. state that people involved in projects are not only organisationally but also often geographically dispersed. Project workers have diverse backgrounds and may speak several languages. When the project ends, the people involved and the lessons learned are scattered. It will, in turn, very likely result in fragmentation and loss of organisational knowledge and learning.

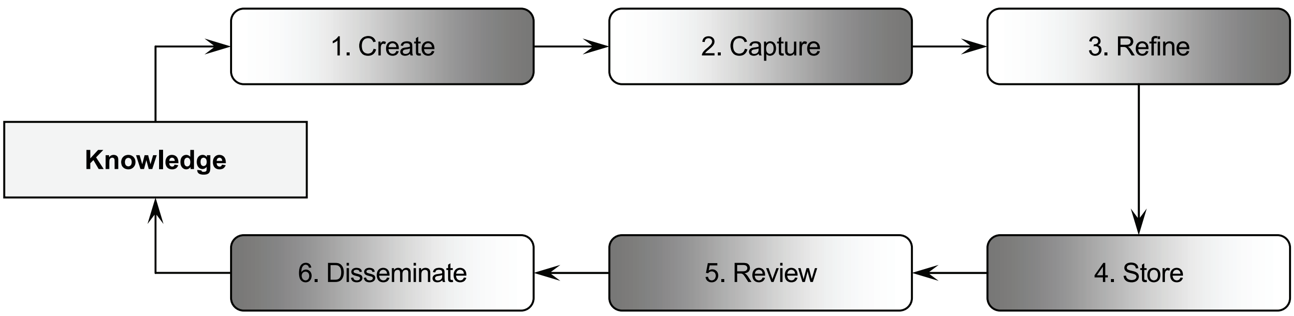
Knowledge is a vital resource in project-based industries[147]. If managed effectively, knowledge can be utilised to reduce project time, improve quality and customer satisfaction. This management of knowledge, be it explicit or tacit, is a necessary prerequisite for project success in today's dynamic and changing environment. However, the management of intellectual assets is a new and challenging process for companies in the project business. Schindler and Eppler[148] have identified four key reasons for project amnesia, i.e. not eliciting and documenting lessons learned. The specific individual reasons of the project amnesia are all related to time, motivation, discipline and skills.

3.1.3. KNOWLEDGE MANAGEMENT PROCESS

The knowledge management process comprises six steps in a cycle[149], illustrated in Figure 22. The cycle works in the following manner: (1) knowledge is created, which takes place when people determine new ways of doing things or develop know-how, (2) knowledge is captured and it must be identified valuable and represented in a reasonable way, (3) knowledge is refined and it is placed in a context so that it is actionable, (4) useful knowledge is stored in a reasonable format in a knowledge repository for others to access and use, (5) knowledge has to be reviewed periodically, i.e. knowledge has to be kept valid, relevant and accurate, and (6) knowledge is disseminated and made available in a useful format to anyone who needs it.

As knowledge is disseminated, individuals develop, create, and identify new knowledge or update old knowledge, which they replenish into the system. The knowledge management cycle is repeated continuously in refining information. Fernie[150] et al. have demonstrated the crucial role of re-contextualisation, social interaction and dialectic debate in understanding knowledge sharing.

Figure 22. Knowledge Management Process



Turban et al.: Information Technology for Management: Trans… (2002), p. 395 (adapted)

[147] Love, Edum-Fotwe and Irani: Management of knowledge in project environments (2003) International Journal of Project Management, Vol. 21, No. 3, pp. 155

[148] Schindler and Eppler: Harvesting project knowledge: a review of project learning methods and success factors (2003) International Journal of Project Management, Vol. 21, No. 3, pp. 219–228

[149] Aronson: Knowledge Management (2002) In Turban , McLean and Wetherbe (eds.): Information Technology for Management: Transforming Business in the Digital Economy, p. 394-396

[150] Fernie, Green, Weller and Newcombe: Knowledge sharing: context, confusion and controversy (2003) International Journal of Project Management, Vol. 21, No. 3, pp. 177-187

Turner and Makhija[151] put emphasis on targeting and controlling the knowledge management process. They state that the knowledge management process includes (1) knowledge creation and acquisition, (2) the transfer of knowledge to other individuals or organisational units, (3) the interpretation of knowledge in a manner conducive to the objectives of the organisation, and finally (4) the application of the knowledge toward organisational goals. KM covers the competencies, culture and connections that enable and foster an organisation's innovation, agility, awareness, adaptation and survival. It is critical to any company whose success depends on the ability to create and expand existing knowledge in its field. In principle, KM takes care of the intellectual capital of an organisation.

Turner and Makhija propose a model demonstrating the role of organisational control mechanisms (outcome, process and clan) in managing organisational knowledge. They suggest ways of how particular mechanisms differ in affecting the ability of the company to acquire, transfer, interpret, and finally use knowledge. They argue that the use of different control mechanisms creates distinguishably different knowledge management processes within the company.

Process controls clearly specify the appropriate behaviour and processes in which employees must engage. Such controls consider individuals to be accountable for explicitly delineated processes rather than the outcomes of these processes. The process controls include formalised standard operating procedures and rules, clearly established routines, specialized job descriptions, hierarchical supervisor-subordinate relationships, and highly structured groupings and settings. They are most adept at using highly specialised knowledge and the individuals' jobs are reduced into clearly specified and specialised tasks.

Outcome controls focus on the outcomes or the specific outputs desired by the organisation. The most distinctive feature of outcome controls is that they specify the explicit outcomes of the employees' work. The outcome controls excel in the development of new knowledge.

Clan controls are described as informal socialisation mechanisms that take place in an organisation and facilitate shared values, beliefs and understanding among the members of the organisation. Examples include rituals, ceremonies and other socialisation processes. The clan controls are utilised in knowledge transfer, meetings, teams and task forces. The clan controls require a high amount of interaction and communication. They are superior in transferring tacit knowledge (sticky knowledge) across the members of the organisation.

3.1.4. KNOWLEDGE TRANSFER

Knowledge transfer, especially in the form of best practice transfer, has raised conflicting views. Some regard best practices transfer as the most beneficial way to manage knowledge, while others do not support even the existence of best practices and propose to call this beneficial knowledge transfer good or useful practice transfers. It is quite common that knowledge management aims to transfer internal best practices[152, 153, 154]. The aim is justified by the assumption that organisations tend to have an underutilised treasure of knowledge, know-how and best practices. This information could generate millions to the bottom line and yield huge gains in speed, customer satisfaction and

151 Turner and Makhija: The Role of Organizational Controls in Managing Knowledge (2006)
Academy of Management Review, Vol. 31, No. 1, pp. 197–217

152 Alavi and Leidner: Review: Knowledge Management and Knowledge Management Systems: Conceptual Foundations and Research Issues (2001)
MIS Quarterly, Vol. 25, No. 1, pp. 107-136

153 Jarrar and Zairi: Best Practice Transfer for Future Competitiveness: A Study of Best Practices (2000)
Total Quality Management, Vol. 11, No. 4/5/6, p. S734

154 O'Dell and Grayson: If Only We Knew What We Know: Identification and Transfer of Internal Best Practices
California Management Review, Vol. 40, No. 3, p. 154

organisational competence. The best practice approach is increasingly recognized as a powerful performance improvement effort for processes, business units, and for entire corporations. The most advocated statement supporting best practice transfers claims that

> “The fastest, most effective and powerful way to manage knowledge assets is through the systematic transfer of best practices.”[155]

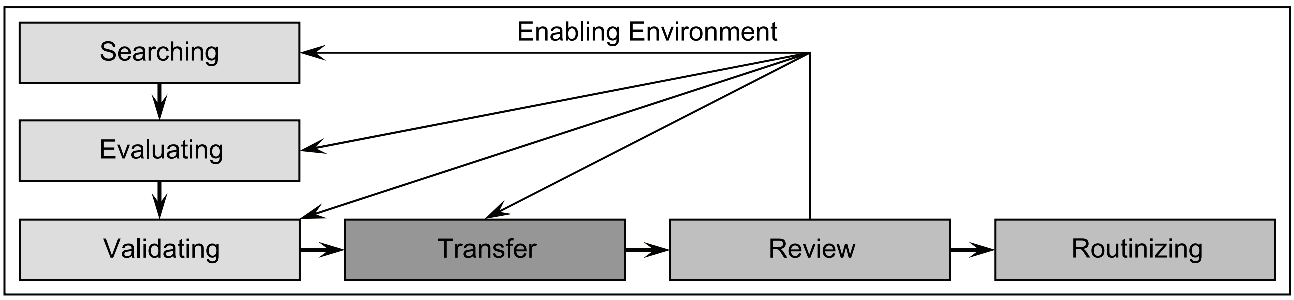
Transfer of Best Practices

O’Dell and Grayson[156] state that the most effective transfer processes are those that are demand-driven. They consider a transfer situation ideal, where the pull to learn exists and change comes from the person or unit that has a problem or need. O’Dell and Grayson have specified a set of advice to embark on best-practice transfer. They recommend use benchmarking to create a sense of urgency or find a compelling reason to change. They advice to focus initial efforts on critical business issues aligned with organisational values and strategy. Additionally, the initial efforts should have high payoff, because real learning and transfer is time- and talent-consuming. They also remind that resources have to be reserved for the transfer. Organisations have a tendency to forget that they can only invest in and support a finite amount of changes at a time.

O’Dell and Grayson emphasise that benchmarking has to focus on the real underlying process differences, not to stray to measure different processes of the corresponding functions. They also propose that the reward system has to encourage knowledge sharing and support best practice transfers. Moreover, they encourage use technology as a catalyst to the internal search for best practices, but they warn not to rely solely on IT to provide a solution. Last, leaders will need to consistently and constantly spread the message of sharing knowledge for the greater good.

Jarrar and Zairi[157] describe the transfer process of best practices as a six-phase-process, which takes place in a supportive environment, as illustrated in Figure 23. Jarrar and Zairi claim that the development of IT is expected to result in more transfer of best practices. Many organisations have already their own Intranets, e-mail and other applications supporting knowledge management. With the increasing importance of best practice management, it is crucial that organisations have a “process” for collecting, assessing, validating, transferring and applying best practices, because best practice transfer has massive potential to benefits.

Figure 23. Transfer Process of Best Practices



Jarrar and Zairi: Best Practice Transfer for..., Total Quality Management, 11:4/5/6, (2000) p. S736

[155] Aronson: Knowledge Management (2002)
In Turban , McLean and Wetherbe (eds.): Information Technology for Management: Transforming Business in the Digital Economy, p. 425

[156] O'Dell and Grayson: If Only We Knew What We Know: Identification and Transfer of Internal Best Practices
California Management Review, Vol. 40, No. 3, pp. 171-172

[157] Jarrar and Zairi: Best Practice Transfer for Future Competitiveness: A Study of Best Practices (2000)
Total Quality Management, Vol. 11, No. 4/5/6, pp. S736-S740

Turner and Makhija[158] discuss the impact of organisational controls in knowledge transfer. They claim that the use of different controls creates distinguishably different knowledge transfer processes. Their conclusions are summarised in Table 8.

Table 8. Impact of Organisational Controls in Knowledge Transfer

	Process-Related Knowledge	Outcome-Related Knowledge
Outcome Control	Negligible	Significant
Process Control	Low	Negligible
Clan Control	Significant	Significant

Turner and Makhija: The Role of Organizational Controls in Managing Knowledge (2006), p. 205 (adapted)

First, the use of outcome controls on explicit, complete and non-diverse knowledge allows outcome-related knowledge to be easily transmitted to other parts of the organisation. It is not only the explicitness of knowledge that promotes transferability, but also the straight-forwardness of the underlying knowledge eases understanding. Second, process controls are appropriate for transferring process-related knowledge across the organisation. Standard operating procedures, job descriptions and rules are highly codified. Therefore, they are easily transmitted from one organisational unit to another. However, the specialised nature of process-related knowledge normally limits the transfer of process knowledge to other individuals or organisational units. Third, clan controls are particularly appropriate for the internal transfer of tacit and diverse knowledge, because of their emphasis on socialisation and communication.

Transfer of Useful Practices

Orlikowski[159] claims that “best practices” cannot be transferred, because (according to her) knowing is inseparable from its constituting practice. She claims that knowledge or “best practices” are not discrete objects or stable processes to be packaged and transported to other places, because practices are generated through people’s everyday actions. Thus, Orlikowski concludes that only data or information can be transferred, but the transfer necessarily entails innovation and disagreement. Instead of transferring ”best practices”, she proposes distributing ”useful practices” in organisations.

Orlikowski suggests that knowing is not a static embedded capability or stable disposition of actors, but rather an ongoing social accomplishment, constituted and reconstituted as actors participate in the situation at hand. She claims that the competence to do global product development is both collective and distributed, grounded in the everyday practices of organisational members. She also suggests that tacit knowledge is a form of “knowing” and thus inseparable from action because it is constituted through such action. She continues claiming that knowledge and best practices are non-transferable, because they are based on inseparable tacit and explicit elements.

Orlikowski has identified a set of practices used to disseminate knowledge and to build competence: sharing identity, interacting face to face, aligning effort, learning by doing and supporting participation. She states that the list is not exclusive or exhaustive. On the contrary, the practices should be understood as interdependent; they overlap and intersect through the activities of the individuals. The first two of these practices (sharing identity and interacting face to face) constitute

[158] Turner and Makhija: The Role of Organizational Controls in Managing Knowledge (2006)
Academy of Management Review, Vol. 31, No. 1, pp. 205-207, 209

[159] Orlikowski: Knowing in Practice: Enacting a Collective Capability in Distributed Organizing (2002)
Organisation Science, Vol. 13, No. 3, pp. 249-273

the knowing of the organisation and the players in it. They generate the knowing of how to be coherent, committed, and co-operative across a variety of spatial, temporal and political boundaries. The remaining three practices (aligning effort, learning by doing and supporting participation) concentrate on how to co-ordinate on complex projects, to develop capabilities for product development, and to innovate within global operations. The practices are summarised in Table 9.

Table 9. Repertoire of Practices, Activities and Knowing

Practice	**Activities Comprising the Practice**	**Knowing in the Practice**
Sharing identity	• Engaging in common training and socialisation • Using common orientation to do development work • Identifying with the organization	Knowing the organisation
Interacting face to face	• Gaining trust, respect, credibility and commitment • Sharing information • Building and sustaining social networks	Knowing the players in the game
Aligning effort	• Using common model, method and metrics • Contracting for expertise annually • Using standard metrics	Knowing how to co-ordinate across time and space
Learning by doing	• Investing in individual development • Mentoring employees in their careers • Rewarding not punishing effort	Knowing how to develop capabilities
Supporting participation	• Globally distributing product development work • Involving participants in project decisions • Initiating and supporting overseas assignments	Knowing how to innovate

Orlikowski: Knowing in Practice: Enacting…, Organization Science 13:3 (2002), p. 257 (adapted)

3.1.5. KNOWLEDGE MANAGEMENT SYSTEMS

Managing the existing knowledge is a hard task anywhere. Knowledge is created, modified and even sometimes deleted or discarded. Knowledge changes its form, content, location and validity. The dual nature of knowledge causes understandable difficulties in planning, implementing and using knowledge management systems (KMS). Nevertheless, KMS[160] benefit organisations. They have the potential to increase organisational productivity manyfold, especially in geographically dispersed organisations and organisations using new work arrangements, such as virtual teams and telecommuting. Coupled with the ever-increasing rate of change in the environment, the organisation's knowledge assets have become a critical determinant of organisational success.

Knowledge, competence and the related intangibles have been recognised to form competitive advantage in companies, not because of the importance of knowledge itself, but because of the expansion markets, leaving intangible assets as the main basis of competitive differentiation in many business branches. Knowledge management systems provide ways to use and increase these intellectual assets[161].

Alavi and Leidner's[162] literature review of organisational knowledge management initiatives reveals three common application areas: (1) the coding and sharing of best practices, (2) the creation of

[160] Bowman: Building Knowledge Management Systems (2002)
Information Systems Management, Vol. 19, No. 3, p. 40

[161] Teece: Capturing Value from Knowledge Assets: The New Economy, Markets for Know-How, and Intangible Assets (1998)
California Management Review, Vol. 40, No. 3, pp. 55-79

[162] Alavi and Leidner: Review: Knowledge Management and Knowledge Management Systems: Conceptual Foundations and Research Issues (2001)
MIS Quarterly, Vol. 25, No. 1, p. 114

corporate knowledge directories, and (3) the creation of knowledge networks. Particularly internal benchmarking aimed at transferring internal best practices seem in their study to be a common application of knowledge management.

According to Alavi and Leidner, knowledge management systems refer to information systems applied to managing organisational knowledge. They are IT systems developed to support and enhance the organisational processes of knowledge creation, storage, retrieval, transfer and use. While IT does not apply to all of the issues, it can support knowledge management significantly. Examples include database searches, sharing knowledge and working together in virtual teams, access to information of past projects and analysing customer needs from recorded transactions. KMS can leverage the knowledge assets of the organisation.

Technologies of Knowledge Management Systems

There are a number of technologies with suitable functionality to knowledge management systems[163]. Because KM has received increased attention, the distinction between some of these technologies has blurred. For example, traditional document flow management focuses on the creation and maintenance of document, and version control has been incorporated into groupware and collaboration applications. Table 10 represents the technologies and their use in KM.

Table 10. Technologies of Knowledge Management Systems

Technology	Use
Intranets	Corporate intranets may be considered to be early forms of repository KMS. They utilized WWW standards to simplify the tasks of storing and distributing a wide range of materials in different file formats.
Web authoring tools	HTML editors, graphic design tools, proprietary animation packages, and streaming video/audio tools that have emerged since the advent of the WWW. They provide useful technologies for creating intranets, offering a rich variety of text and multimedia content.
Document/content management systems	These tools were initially developed to assist in the creation, version control, storage and retrieval of complex sets of word processing documents. They have expanded to handle additional file formats and provide knowledge maps to categorise the stored materials.
Search engines	Search engines were developed by the library science community to enable bibliographic search and retrieval. They were quickly adapted for the WWW. Search engines provide the ability to index any type of file by keyword for subsequent search and retrieval.
Office suites	The traditional office automation suites have added features that support Web publishing and collaboration features, such as discussion threads and change tracking. They can integrate with browsers to provide automatic notification of document changes and Web file management capabilities similar to those for local file systems.
Collaboration software	Collaboration tools enable employees to share documents in multiple formats, both synchronously and asynchronously. These tools are not directed at storing, retrieving, or otherwise managing a repository. Rather, collaboration tools assist in the creation, modification and refinement of materials that have been retrieved from the repository.
Enterprise information portals	This software is designed to create and manage knowledge repositories. Access is via the familiar browser interface. EIP products have a broad range of useful features, including search engines, knowledge mapping, repository personalization, standing queries, affinity group filtering and simple collaboration.

Bowman: Building Knowledge Management Systems, Information Systems Management (2002), p. 36

[163] Bowman: Building Knowledge Management Systems (2002) Information Systems Management, Vol. 19, No. 3, pp. 32-40

Resistance towards Knowledge Management Systems

The resistance to applying knowledge management systems originates the very same organisation that is supposed to use the system. There is a reluctance to share knowledge, because employees feel that their exclusive control over knowledge gives them power. Even the basics of microeconomics state that a restriction in the quantity of supply (a good or skill) will result in a higher price (or wage) for the good (assuming competitive markets and no change in quantity demanded). From an individual's point of view, it makes no sense to share his unique knowledge and skills with others in a competitive situation. It is easily understood that if he is the only person in the organisation who knows how to do a task, he is more valuable to the company. He is less likely to get fired, and he is more likely to get a salary rise.

The other problems arise with integration with other KMS. Particularly older legacy systems could be difficult to integrate with a knowledge management system. The immaturity of information technology in knowledge management also causes difficulties. Professionals are still rare and some of them are inexperienced.

3.2. BEST PRACTICES APPROACH

Best practices[164] may be described as optimum ways of performing work processes to achieve high performance. The Best practice approach is a widely used corporate solution of knowledge management. The effectiveness (doing the right things) and efficiency (doing the things right) of business processes determines the sustainability and profitability of a company. In the ever-lasting search for success and excellence, companies have used various methods to find out the best practices of the right processes.

The modern form of best practices[165] is seen to have been launched in the General Electric Company (GE). The historical success of GE had led to a degree of complacency in the company. To improve the situation, Jack Welch (Chairman of GE at the time), started a radical campaign to modify the company culture at GE. As a part of the campaign, he instituted a program of effectively benchmarking GE against carefully selected companies (seven major US corporations and two leading Japanese multinational companies), which were seen as excellent in terms of management practices. The main findings of the program were that these highly productive business entities shared the following characteristics:

- They managed processes rather than people.
- They used documentation, process mapping, and benchmarking to find opportunities for improvement. It involved every single step, no matter how small, of a particular task.
- They emphasised continuous improvement process and praised incremental gains.
- They relied on customer satisfaction as the main measure of performance. They had also overcome the tendency to focus on internal goals at the customer’s expense.
- They stimulated productivity by introducing a constant stream of new, high-quality products for efficient manufacturing.
- They treated their suppliers as partners.

[164] Loo: Working towards Best Practices in Project Management (1994)
International Journal of Project Management, Vol. 20, No. 2, p. 93

[165] Channon: Best Practices (1998)
In Cooper and Argyris (eds.): The Concise Blackwell Encyclopedia of Management, pp. 43-44

Later, best practices were popularised in the late 1980s in professional and business management books. The idea has gained support and it has remained as a catch phrase among managers. The management movement of best practices might imply that many, if not most situations, are repeatable. If we can sufficiently gather experience and distil knowledge, we can foresee most of the possible scenarios, figure out the way to best handle them, and prepare ourselves beforehand for necessary actions. Basically, the idea of best practices results to a kind of self-steering system.

Peters and Waterman[166] wrote their book *In Search of Excellence* to support the best practice approach. The book focuses on solving business problems with as little business process overhead as possible. The writers suggest devolving power to the lowest person possible in an organisation to empower them to solve the most problems possible. According to them, the previous outlook of a centralised authoritative structure of business organisations was imperfect because it required business leaders to know too much and overburdened them with needless trivia. The other main points of the book include allowing employees to fail occasionally, on the premise that doing nothing is usually much more expensive than doing the wrong thing in the business environment. Since it is very difficult to predict which things are right and wrong, the business decision-maker should just try their best guess and try in order to save time and effort.

Best Practice Levels

Best practices are hard to define. Not only is "best" an ever moving target, but it is highly situation-specific. One way to cope with these problems is to define levels for the best practice approach[167]. For example, Chevron has defined best practices as any practice, knowledge, know-how, or experience that has proven to be valuable or effective within one organisation and that may have applicability to other organisations. Based on the definition of best practices, Chevron recognises four levels of best practices: good idea, good practice, local best practice and industry best practice.

A good idea is unproved, not yet substantiated by data but makes a lot of sense intuitively. It could have a positive impact on business performance, but requires further review or analysis. If substantiated by data, it can be a candidate for implementation in one or more locations.

A good practice is defined as a technique, methodology, procedure, or process that has been implemented and has improved business results for an organisation (satisfying some element of customers' and key stakeholders' needs). Good practice is substantiated by data collected at the location, and a limited amount of comparative data from other organisations exists. It has potential to diffuse to other locations within an operating company.

A local best practice is defined to be a good practice that has been determined to be the best approach for all or a large part of an organisation. The analysis of the best practice is based on process performance and competitive intelligence, which has revealed similar practices outside the company. This practice is applicable at most or all locations within the operating company and may be applicable to other locations.

An industry best practice comprises practices that have been determined to be the best approach for all or large parts of an organisation. The status of the practice is based on both internal and external benchmarking work, including performance analysis. External benchmarking is not confined to the industry branch of the company.

[166] Peters and Waterman: In Search of Excellence: lessons from America's best-run companies (1982), 360 p.
[167] O'Dell and Grayson: If Only We Knew What We Know: Identification and Transfer of Internal Best Practices California Management Review, Vol. 40, No. 3, p. 167

Tacit Assumptions behind the Best Practices Approach

According to Wareham and Gerrits[168], there are some common tacit assumptions behind the best practice approach. They have classified these assumptions into five groups: homogeneity of organisations, universal yardstick, transferability, “alienability” and “stickiness”, and validation. Wareham and Gerrits question whether any universal yardstick exists. This implies that they are only interested in industry best practices, leaving the levels out of their presentation.

Homogeneity of organisations, at least to some degree, is needed in applying the knowledge of one organisation in another organisation. The organisations should resemble each other in order to allow the transfer of best practice. The issue of homogeneity is barely addressed in the current best practice approach, although it is clearly assumed. In best business practice transfer, attention should be paid to the homogeneity of organisations. The questions to be answered include:

- What aspects of the organisations (source and recipient) need to resemble each other: the process, the technology, the environment, etc.?
- How can resemblance be identified and measured?
- What degree of resemblance is necessary to ensure successful transfer of best practices?

A universal yardstick is a basic assumption in the best practices approach. It supposes that it is possible to define what is universally best (at least to some degree). Consulting companies with their best practice databases imply that there is such a universal yardstick. It indicates that it is possible to measure which practice has superior performance. Wareham and Gerrits question whether such a universal yardstick exists. They state that organisations strive after the fulfilment of their strategies, which implies that the scales for measuring performance should be different. For example, a bank pursuing a low cost strategy might consider the cost of ‘selling a loan’ an important yardstick. This measure will not be applicable for a bank of high quality services for affluent clients.

Transferability of best practices is the third fundamental assumption of best practices. The best practice approach implicitly assumes, in varying degrees, that a practice from one organisation can be applied in another organisation and it will provide similar results. However, real world cases prove that the adaptation of a best practice without any shaping of it to the receiving organisation is a unique curiosity. Some revisions are needed to comply with the specific characteristics of the receiving party. Only on rare occasions can best practices be transplanted in another organisation with minimal modification. In most cases, adaptations of the best practice are needed.

”**Alienability**” **and** ”**stickiness**” describe the possibility of separating knowledge from its owner. In many instances, even if the source and recipient are alike, enabling the best practice transfer, it may be hampered by transfer difficulties. “Alienability” refers to the question of whether knowledge can be alienated, i.e. extracted from its context. It is critical in the best practice transfer including tacit knowledge. If a best practice applies tacit knowledge, the practice will be difficult to dissect from the organisational context. Another perspective on the problem is to declare that the best practice cannot be transferred independently without moving human resources. “Stickiness” is a concept describing the willingness (co-operation) of the source and the absorptive capacity (will or capacity to assimilate the new practice) of the recipient.

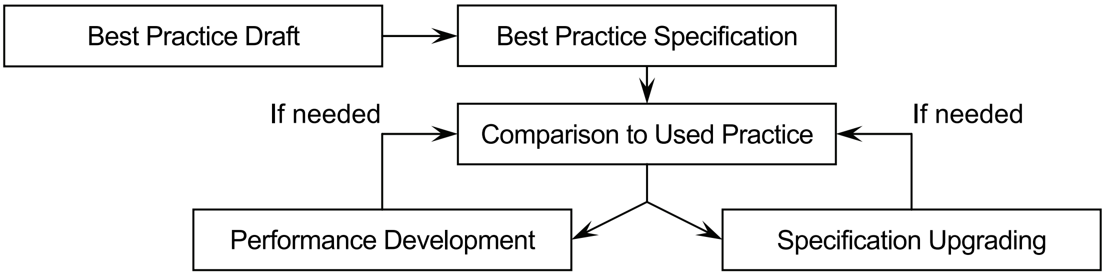
Validation is based on the practical beliefs that the “best in class” organisations use practices which are excellent and produce the best performance. In fact, best practices are rarely rigorously validated or benchmarked.

[168] Wareham and Gerrits: De-Contextualising Competence: Can Business Best Practice be Bundled and Sold ? (1999) European Management Journal, Vol. 17, No. 42, pp. 39-49

Best Practice Process

The aim of best practices is to create a specification of what the best methodology is in any given situation. The best practices document the knowledge to achieve consistently maximal (or optimised) results. The best practice specification is expected to be compared towards current performance. Finally, it is determined whether the performance has been somehow lacking or the specification for best practices needs updating to include the practice and its performance being graded. The best practice process is presented in Figure 24.

Figure 24. Best Practice Process



In the beginning, the critical processes and the profitability, quality, safety etc. factors are determined. Next, a draft of a best practice is prepared for the processes by the stakeholders and/or process experts. It generally requires collaboration of the employees and management to prepare a best practice specification. The drafts undergo peer review. The reviewed drafts are accepted and published as best practice specifications, which are benchmarked. The idea behind best practices can be considered as a development process[169].

Benchmarking

Some form of benchmarking is necessary to compare practices. Benchmarking can be classified into four genres: (1) competitive benchmarking, (2) internal benchmarking, (3) process benchmarking, and (4) generic benchmarking[170]. Wareham and Gerrits base their presentation on *Benchmarking for Competitive Advantage* written by Bendell, Boulter and Kelly[171].

Competitive benchmarking is used when operations are compared towards the best performer in the business. The benchmarking is geared towards recognising and understanding the causes of the competitor's superior performance. If many product and competitive environment variables of the source and recipient organisations are similar, the transferability of the best practices is relatively high. Sometimes this kind of benchmarking is difficult to do for competitive reasons. The situation could be alleviated, if, for example, the companies operate in different geographical markets.

Internal benchmarking is used if an organisation with multiple units performing the same kind of tasks is benchmarked. Afterwards, the organisation is prepared to transfer the best practices between business units or departments. For example, a multinational company having national sales offices might consider finding out the reasons why certain sales offices perform better than others. If the reasons for the better performance are not external, but results of the work methods of the sales office, it might be profitable to study the operations and transfer that knowledge to other sales offices.

[169] Signal: Best Practice Makes Perfect (2006)
Dairy Industries International, Vol. 71, No. 2, pp. 32-35

[170] Wareham and Gerrits: De-Contextualising Competence: Can Business Best Practice be Bundled and Sold ? (1999)
European Management Journal, Vol. 17, No. 42, pp. 39-49

[171] Bendell, Boulter and Kelly: Benchmarking for Competitive Advantage (1993), 266 p.

Process benchmarking assumes that practices can be studied at the level of business processes. Different organisations delivering different products in different markets can learn by studying the same type of processes. For example, an airline may study the catering process in a hospital to improve its own catering operations.

Generic benchmarking focuses on the technological aspects of the process. The best practice constitutes the optimal employment of technology. Benchmarking in this case is used to progress along the learning curve of a new technology implementation.

Roles of the Best Practice Approach

Wareham and Gerrits see that it is valuable to explicitly define the roles of best practices in order to maximise benefits. For example, if the best practice is to support creative insight, there is minimal need for resemblance between the source and recipient organisations. If best practices are utilised to move up the learning curve of a new technology, the same technology should be used in both organisations. The best practice approach is not simply a matter of imitating excellent performers, but involves a number of other perspectives. Wareham and Gerrits distinguish three best practice roles: (1) moving up the learning curve, (2) supporting creative insight, and (3) supporting change.

Organisations have to learn how to best exploit new technologies and work methods. Therefore, best practices could be utilised from a learning perspective. The focus is here on the implementation and increased exploitation of new technology. Best practices will be described and analysed in its context with regard to new technology. The potential recipients of the best practice use the same technology, but have not yet achieved full implementation or benefits of the technology.

The best practices can be viewed as a means to support creativity. From this perspective, the best practices are not targeted for immediate implementation, but rather serve as a catalyst of creativity. Generic benchmarking will in many cases fuel creativity in contrast to a direct copy transfer. Last, best practices can be considered as a roadmap for change. Many companies are aware of best practices, but for some reasons they have not been able to implement them. Many studies discuss the tactics for the change process, thus enabling organisations to implement the best practice.

3.3. BUSINESS PROCESS DEVELOPMENT IN PÖYRY

Project management and procurement are important business processes in industrial plant projects. They are the key products in project service assortment of Pöyry Oyj. They support the implementation of engineering products, and they provide vital information for future projects. Pöyry Oyj had faced the hard international competition and had prospered. In the late 1980s and in the early 1990s, the recession pointed out that these processes were not cost-competitive globally.

In the beginning, the project manuals were seen to be outdated and needing revising. More generally, it was noticed that Pöyry Oyj would need knowledge management to support its engineering and project management business. Business process development was initiated to improve the company's competitiveness through specifying and disseminating best practices in project management. The most experienced personnel were appointed to the task. Juhani Silvasti, a member of business development projects, summed up the problem aptly:

> "Pöyry has hired very prominent professionals able to do nearly anything. They know everything in the forest business. On the other hand, the organisation knows nothing."[172]

[172] Silvasti, Pöyry Oyj: Discussions of project professionals and knowledge (1991)

Pöyry Oyj had truly succeeded in hiring many prominent talents of the forest business, but this did not save the company during the economic depression in the early 1990s. In the turmoil of the period, Pöyry Oyj did not manage remarkably better than the rival companies. It was suggested that economical problems were caused by the organisation, which was not able to enrich and deliver the knowledge of these professionals to everyone everywhere in the company.

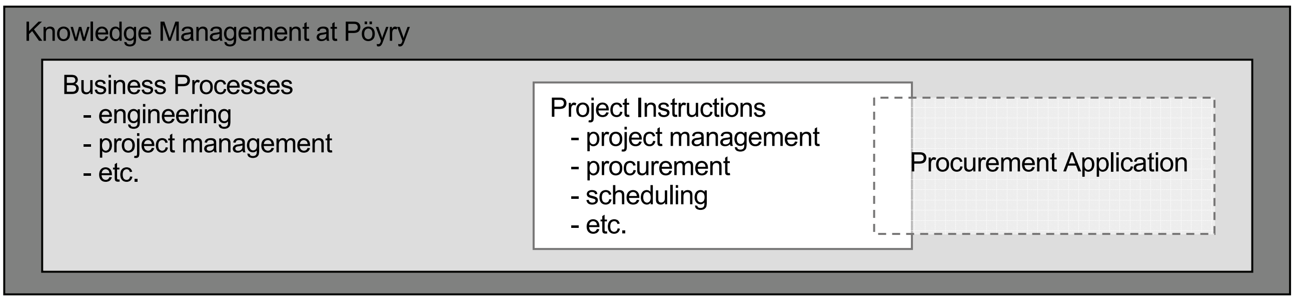
3.3.1. KNOWLEDGE MANAGEMENT AT PÖYRY

The need of knowledge management emerged immediately when Pöyry Oyj started operating; suitable ways to manage engineering and projects were sought after. An engineering company does not survive in the long run, if it does not take care of its most important asset, knowledge. Success in knowledge management is not guaranteed. Oshri et al.[173] have made a case study of a company introducing new practices to promote knowledge transfer between projects. Their study explores the trade-offs and tensions between knowledge management initiatives and expertise development practices. Their findings include that knowledge transfer initiatives might upset the harmonic supportive co-existence between expertise development and knowledge management practices.

In the late 1980s and in the beginning of the 1990s, it was decided to develop business processes through improved knowledge management. Several attempts were made to improve knowledge utilisation in the company. First, the project instructions were rewritten, project standards were created, and models were provided to support the project work. These efforts were targeted at capturing and refining the company knowledge. Second, knowledge transfer between projects was seen profitable, and knowledge transfer was decided to be improved and reorganised. Last, it was decided to program procurement software in order to rationalise the procurement tasks.

From a scientific point of view, the knowledge management part of the research was carried out as a single-case study in one engineering company. Informal interviews, or rather discussions, were performed to gather information about the successful projects. The material of these conversations was used to reformulate the best practices in project management. Normally, a single-case study does not provide strong proof for any theory. In this case, the regular use of the rewritten project instructions in hundreds of industrial plant projects with dozens of international customers vindicate that the instructions support project implementation and contain valid project management knowledge. The areas of knowledge management at Pöyry Oyj are illustrated in Figure 25.

Figure 25. Knowledge Management at Pöyry



[173] Oshri, Pan and Newell: Managing trade-offs and tensions between knowledge management initiatives and expertise development practices (2006)
Management Learning Vol. 37, No. 1, pp. 63-82.

Transfers of Data, Information and Knowledge

Organising and improving transfers of data, information and knowledge were regarded as major knowledge management tasks at Pöyry Oyj. According to Aronson's framework[174], information transfer is transfer of processed or organised data, and knowledge transfer is transfer of contextual, relevant and actionable information. For the decades, there had been several serious attempts to manage internal data, information and knowledge including the transfers of them within and between the projects managed by Pöyry Oyj.

Pöyry Oyj has organised and managed data and information transfer from the very beginning of the company. Due to the vast volume of data and information in large industrial plant projects, the efficiency of transfers of data and information is important. Pöyry Oyj continuously seeks improvements. In the early days of the company, transfers of data and information took place mostly in paper format. Later, microfilms and computer files partly replaced paper documents, but the change was targeted at condensing the presentation, not changing the content or the structure. The advance of information technology changed the situation. The use of databases, the Internet, and particularly e-mail has introduced more efficient and influential ways to transfer data and information. I consider the procurement software with its database as one step in improving transfers of data and information in large industrial plant projects.

Knowledge transfer was seen to have an organisational, documentation and software solution. In the beginning, knowledge transfer occurred naturally through project personnel allocations, in which the same field personnel handled the project implementations. The organisational solution to support knowledge transfer was to encourage project professionals to work in different offices, both in Finland and abroad. The documentation solution comprised the rewriting of project manuals and the efforts to keep the project manuals up-to-date. The project manuals were previously the best application of knowledge management, which made the knowledge transfer more or less translation and teaching tasks. The software solution is based on the embedded procurement knowledge of the procurement software. The software guides less-experienced project professionals to follow the recommended procurement practices.

While the organisational solution is capable to transfer both tacit and explicit knowledge, the documentation solution (project instructions) and the software solution (procurement software) were considered to transfer only explicit knowledge. It was pointed out that the knowledge transfer has to result in better performance in the recipient units than before. This implies that the transferred practices have to be better than corresponding and competing practices in the recipient units. My goal was that the projects would be managed better after the introduction of the project instructions and the procurement software.

The organisational, documentation and software solutions in transferring knowledge match the findings of Turner and Makhija[175]. First, they propose the use of outcome controls on explicit, complete and non-diverse knowledge. In the case of Pöyry Oyj, it means the well-defined standard documents used to carry out procurement tasks, i.e. documentation solution. Second, Turner and Makhija state that the process controls are appropriate for transferring process-related knowledge across the organisation. Standard operating procedures, job descriptions and rules are highly codified, and therefore, easily transmitted from one organisational unit to another. However, the

[174] Aronson: Knowledge Management (2002)
In Turban, McLean and Wetherbe (eds.): Information Technology for Management: Transforming Business in the Digital Economy, p. 388

[175] Turner and Makhija: The Role of Organizational Controls in Managing Knowledge (2006)
Academy of Management Review, Vol. 31, No. 1, pp. 205-207, 209

specialised nature of process-related knowledge normally limits the transfer of process knowledge to other individuals or organisational units. In the Pöyry environment, this comprises the recommended workflows carried out to perform the procurement tasks both described in the *Procurement Manual* and programmed in the procurement software, i.e. documentation and software solution together. Third, the organisational solution matches the clan controls.

Project Manuals

The project manuals, *Project Management Manual* and *Procurement Manual*, are traditional applications of knowledge management. They make the knowledge available in written format. They harness the existing knowledge of best practices in the business. They carry out knowledge management tasks: they gather, enrich and disseminate information. The main advantage of the project manuals lies in capturing, documenting and presenting the company knowledge of project management.

The *Project Management Manual* describes the general project management approaches and the general features of the main project management functions. The *Procurement Manual* gives a clear picture of how generic engineering standards evolve from the conceptual engineering phase through basic engineering and detail engineering phases to detailed specifications used in the construction phase. The project management instructions are presented in Section 4.3. and the procurement instructions are discussed in Section 5.3. Although the rewriting of the project manuals took place quite a while ago (in the late 1980s and in the beginning of the 1990s), Pöyry Oyj affirms that the manuals were rewritten and best project practices were severely attempted to be disseminated through the company[176].

The project manuals were, indeed, a very important step in harnessing the explicit knowledge of the company. The manuals deliver the most competent employees' knowledge to general use. The instructions were written to support project implementation. Newly hired employees could use the project manuals as handbooks. They contained widely accepted example materials to provide a safe start to projects. The manuals also simplified the decision-making. Recommendations and a limited set of rational choices were produced to help the project personnel's work.

Even the customers expect Pöyry Oyj to follow these project instructions, which describe favourable project principles, guidelines, work methods and even sample documents. The well-established work processes are considered as a guarantee of the quality in implementing demanding industrial plant projects. Projects following the instructions closely are considered to be more likely successful.

Procurement Application

Business process development initiated the development of the procurement software. The software was designed to be a procurement tool in industrial plant projects. It was designed according to the company knowledge of procurement function in industrial plant projects. The application was expected to carry out procurement tasks efficiently, to produce the necessary documents, and to estimate procurement status from actual transactions without any follow-up calculations.

Besides being an efficient tool for purchasing, the procurement application would gather, enrich, and disseminate procurement information, i.e. it would transfer data, information and explicit

[176] Halmepuro, Pöyry Oyj: Interview about rewriting the project manuals (28.04.2006)

knowledge within and between the projects. It would take care of data warehousing and accumulation of project data, and provide background information for future projects.

The procurement application was seen to provide and support more efficient ways to process and organise project information. The software would support the company practices and force project professionals to follow them.

3.3.2. BEST PRACTICES APPROACH AT PÖYRY

Pöyry Oyj sought best practices in project management. To find them, Pöyry Oyj used internal benchmarking. The company had completed numerous projects in a wide range of industries during the decades. Among the projects, there were successes and less successful projects. It was a realistic assumption that successful projects conducted their work better than other projects, especially if there was no other reason to explain the outcome.

The best practices approach was used in the restructuring of the project instructions. The development of the instructions included the search of best practices, standardisation of project management and procurement tasks, and organising knowledge management for the procurement function. In order to find out the best practices, several projects were studied and their practices were evaluated. Based on the evaluation, the most promising work methods were selected to be used as a base of project instructions.

The first step was to get the experienced project professionals together and sample their views on managing projects. Several ways to manage projects were found. The most successful projects were studied and the experiences were gathered. The processes were described and investigated for common features. Similarities in the successful projects were sought and they were pointed out. The project features were compared to a detail and they were classified by the project management approach. In each approach, the most useful practices were considered to form the best practices in that situation.

The search of best practices pointed out that there is seldom only one right answer. The project implementation method and the project environment had a heavy impact on the best practices. The specific needs set by local practice or different conditions may require adjustments, but the recognised principles formed the basis for the project management and procurement. The agreed best practices were formulated and documented in the project manuals. The aim of the documentation was to establish the principles and present guiding rules of project management. The documentation would facilitate the knowledge transfer, training and resource utilisation within the company. The material would be also used in introduction courses of project management. New employees would use the documentation as handbooks of project management and procurement. The principles presented in the documentation were expected to be valid everywhere.

The project instructions were written, standards were created, and sample documents were provided to support the project management. The renewed *Project Management Manual* and *Procurement Manual* were regarded as significant results of the business development process. It was evident that these project manuals were necessary, but not sufficient to carry out modern project management. The idea of the procurement software according to the project instructions was introduced and accepted. Procurement would be performed with computer software. The rewritten project manuals were considered as application requirements, because they described the procurement functions and operation environment.

3.4. REVIEW

There is controversy among scholars of the definition or even the existence of the best practices, knowledge transfer and best practice transfer. However, there are the studies of the best practices giving guidance for management. For example, Wareham and Gerrits[177] have argued that best practices and the transfer of best practices lack sound theoretical foundation despite the growth of the best practice approach. They have argued that the best practice approach suffers from epistemological challenges, as well as lack of a solid foundation of economic and organisational theory. They have also suggested that there are limited methods for identifying best practices. Despite the shortcomings of the literature of best practices, Wareham and Gerrits make a respectable effort to provide a solid foundation for best practice studies.

It is easy to understand the appeal of the best practice approach in business, where improvements are compared to costs. This makes copied (or adapted) solutions attractive, because they are truly economical. It is easy to support knowledge transfer, when it results in improvements. Particularly, it is an attractive situation in which both the source and the recipient organisation benefit of the knowledge transfer. I endorse knowledge transfers, when they help people to carry out their everyday work. The transferred knowledge, regardless of how it is called (“company practices”, “useful practices”, “good practices”, “best practices” etc.), should bring forth improvement at least in the recipient organisation and result in income increase and/or cost savings. This explains the popularity of internal knowledge transfer, as the company as a whole benefits, if one part of the company gains something in the transfer.

It was seen at Pöyry Oyj that organising knowledge management and knowledge transfer is a lengthy process. There were severe attempts to distil and share experience across the organisation. It was necessary to find the best methods to manage different situations and document them. Internal benchmarking was used in determining the best practices. The most successful projects were studied and their practices were compared to find out the best practices. The recognised best practices were documented in project manuals. Last, the gained knowledge presented in project manuals must be maintained and upgraded from time to time.

The business goal was to spread project implementation skills and capacity all over the company to every project. The ultimate target of the described business process development was to gain knowledge and define best workflows for project management. The project instructions and the procurement software were designed to transfer the explicit knowledge of the procurement function to project sites. It was pointed out that the transferred practices had to be better than the competing practices. I am a pragmatist and I was satisfied, if the situation after the introduction of the project instructions and the procurement software was better than before it. Later, the workflow definitions were used as requirements for a procurement application.

Last, I see that knowledge transfer is advantageous at least to the receiver of the knowledge. This explains why organisations attempt and support knowledge transfer between their units. If one business unit benefits of the knowledge transfer, the transfer benefits the whole organisation. Furthermore, I regard the transfer of best practices possible, at least in sense that best practices present the best available way to handle a certain task in a specific situation. I agree that the recipient and its environment have a critical effect on the success of the transfer. The transfer situation might even affect the definition of the best practices in the company.

[177] Wareham and Gerrits: De-Contextualising Competence: Can Business Best Practice be Bundled and Sold ? (1999) European Management Journal, Vol. 17, No. 42, pp. 39-49

4. PROJECT MANAGEMENT

This chapter concerns project management in industrial plant projects from the point of view of an engineering and consultancy company. The chapter focuses on the rewritten project management instructions, *Project Management Manual*. The manual is one of the most significant intermediate results of the business development process. My target is to describe Pöyry project methodologies, show their prowess in their domain, and relate them to general project management knowledge.

The rewriting of the *Project Management Manual* was carried out to support evolutionary development in the key project management processes. In principle, the rewriting of the project management instructions was carried out as a multi-case study using the gathered material and experience of dozens of industrial plant projects. Internal benchmarking was used to figure out the best project practices. After the benchmarking, the best project management practices were expected to be transferred to the subsidiaries of Pöyry Oyj and project sites.

The chapter comprises an overview of project management, the PMBOK approach of project management, and the project management methodologies of Pöyry Oyj. The overview section represents general project management knowledge. The PMBOK section gives an overall presentation of best practices in project management. The Pöyry section comprises the abridged sections of the rewritten *Project Management Manual*. The manual illustrates the environment (requirements and restrictions) for the procurement application.

4.1. PROJECT MANAGEMENT OVERVIEW

A project[178] is a temporary, but not necessarily short-timed, endeavour undertaken to create a unique product, service or result. All projects have three general features: (1) specific outcomes, i.e. products or results, (2) definite start and end dates determining when the project work begins and when it ends, i.e. schedule, and (3) allocated resources, i.e. people, funds, equipment, facilities and intellectual capital (data, information and knowledge) allocated to the project. It is a project management task to balance the tension among the specific outcomes, schedules and available resources. This being the case, project management continues through the entire project.

Project management[179] is the application of knowledge, skills, tools and techniques to a broad range of project activities in order to meet or exceed stakeholders' needs and expectations from a project. It is accomplished through the use of processes, such as initiating, planning, executing, controlling and closing. It involves balancing of competing elements of the project implementation, i.e. scope, time, cost, risk and quality. Particularly, quality[180], however it might be understood in project environments, affects significantly to other elements of the project

Moreover, project management[181] is regarded as an ensemble of activities concerned with successfully achieving a set of goals in a project environment. These activities include planning, organising, monitoring, controlling and reporting of all project aspects and motivating involved persons to strive for project goals. It has been stated and widely accepted that the companies using knowledge management principles achieve consistency and success both across project teams and projects.

[178] Keane, MELE Associates, Inc.: Introduction to Project Management
The Performance Institute > Project Management > Introduction to Project Management
http://www.performanceweb.org/CENTERS/PM/media/JKeane_Project_Management.ppt (03.04.2006)

[179] PMI: A Guide to the Project Management Body of Knowledge (PMBOK Guide) (2000)
pp. 6-7

[180] Reeves and Bednar: Defining quality: Alternatives and implications (1994)
Academy of Management Review, Vol. 19, No. 3, pp. 419-445

[181] ISO 10006:2003 Quality management systems. Guidelines for quality management in projects (2003)

Finally, project management can be considered as an art and science of managing projects under varying conditions. Reduced to its simplest form, project management is the discipline of maintaining the risk of failure as low as possible over the lifetime of the project. The risk of failure arises primarily from uncertainty at all stages of a project, which is often the area and responsibility of an individual project manager who seldom participates directly in the activities producing the end result. He rather strives to maintain the progress and productivity of the project. Engwall[182] even suggests that competent project management has to extend over projects temporal and organisational scope.

Project Business

Projects can be classified according to their type. Pelin[183] classifies business projects to (1) R&D projects, (2) research projects, (3) business development projects, (4) delivery projects, and (5) investment projects. He continues that a project organisation can be useful also outside business life, for example in arranging large conferences or other events.

Artto and Wikström[184] have made a bibliometric study to find out the features of project business. They noted that projecting is common in development, strategic sight and maintaining company competitiveness. This implies that projects belong to general business manners. The study indicates that several scientific and managerial aspects should be covered in the understanding and defining of project business. Both organisational and management considerations are linked to the company, its business and environment. Adaptiveness in processes and actions is needed in the project business, which leads to a general need for cross-disciplinary and in-depth understanding of the business area. It has also an impact on practical capability requirements among the projects' key stakeholders. Artto and Wikström affirm that discussions and theoretical views on projects as manufacturing devices are scarce in the most cited academic articles. They propose that the management of delivery projects is not an extensive application area in business.

Artto and Wikström's study contains seven key findings: (1) dominant role of projects in R&D, (2) no operation management context in projecting, (3) scarce project representation in strategy research, (4) environment-dependent approaches in projecting, (5) need for several theoretical foundations in projecting, (6) company presentations from organisation theory viewpoint, and (7) inter-organisational collaboration in projects. Finally, they define project business in the following way:

> "Project business is the part of business that relates directly or indirectly to projects, with a purpose to achieve objectives of a firm or several firms."[185]

Project Life Cycle

The project life cycle[186] defines the beginning and the end of a project. Morris[187, 188] advocates the idea that the life cycle is the only thing uniquely distinguishing projects from non-projects.

182 Engwall: No project is an island: linking projects to history and context (2003) Research Policy, Vol. 32, No. 5, pp. 789-808

183 Pelin: Projektihallinnan käsikirja (2002) pp.38-41

184 Artto and Wikström: What is project business? (2005) International Journal of Project Management, Vol. 23, No. 5, pp. 343-353

185 Artto and Wikström: What is project business? (2005) International Journal of Project Management, Vol. 23, No. 5, p. 351

186 PMI: A Guide to the Project Management Body of Knowledge (PMBOK Guide) (2000) p. 12

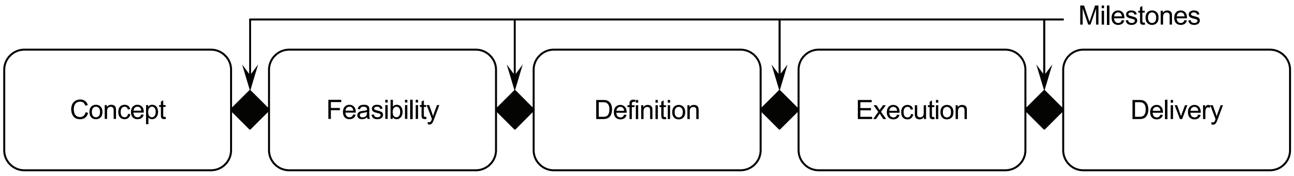
187 Morris: Science, objective knowledge, and the theory of project management (2001) http://www.bartlett.ucl.ac.uk/research/management/ICE_paper.pdf (19.09.2006)

188 Morris: The irrelevance of project management as a professional discipline (2003) http://www.bartlett.ucl.ac.uk/research/management/Moscow2003.doc.pdf (18.09.2006), seminar paper in Moscow 2003

Therefore, it is valuable to examine only the role of the project life cycle in studying project management. The rest would be common with one or more other management topics.

According to Morris, the project life cycle is the sequence of phases through which the project will evolve. The basic life cycle follows a common generic staging: concept, design, development, build and hand-over. The exact wording varies between industries and organisations. The management of projects takes place in completing these phases. Evaluation and approval points (often called milestones, stage gates or review points) are placed between the phases to control the progress of the project. The structure of the project affects the projects life cycle significantly. Several project life cycle models exist; one of a generic project life cycle is represented in Figure 26.

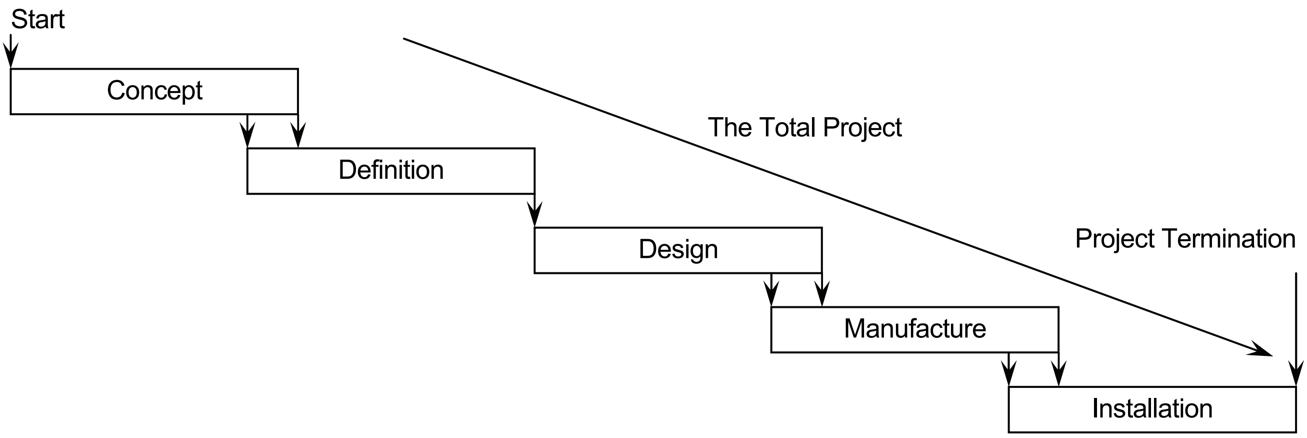
Figure 26. Generic Project Life Cycle



Morris: The irrelevance of project management as a professional discipline (2003), p. 3 (adapted)

Archibald[189] has stated that the project life cycle has identifiable start and end points, which can be associated with a time scale. The project life span includes all phases from the point of inception to the final termination of the project. The interfaces between the phases are rarely clearly separated, except in cases where formal authorisation to proceed separates two phases. A project passes several distinct phases as it matures and the project character changes in each phase. Archibald states that the generic project life span consists of concept, definition, execution and closeout phases, as illustrated in Figure 27. He reminds that the phases described in this way are so generic that the value of documentation is diminished.

Figure 27. Archibald's Project Life Cycle



Archibald: Managing High-Technology Programs and Projects (1976), p. 22

Archibald emphasises the importance of designing and documenting project life-cycle processes. This will ensure that all those concerned with creating, planning and executing projects understand the processes. Documenting facilitates capturing the best experience within the organisation so that the life-cycle process can be improved continually and duplicated on future projects. Designing and

[189] Archibald: Managing High-Technology Programs and Projects (1976) pp. 18-25

documenting project life-cycle processes enable all project roles and responsibilities. Furthermore, it ensures that the methods and tools for projects (planning, estimating, scheduling, monitoring and controlling) are appropriately related to the overall project management.

Different intermediate products (results) are created in each succeeding project phase. The product of the previous phase forms a major input to the next phase. The expenditure rate of resources changes; usually resource expenditure increases with succeeding phases, a fast decrease at completion. The people, skills, organisations and other resources change in each life cycle phase. A major review of the entire project occurs at the end of each phase. The review results in authorisation to proceed to the next phase, cancellation of the project, or repetition of a previous phase.

Generic Project Methodologies

Although a lot of project management is structured and documented common sense, there can be seen at least three generic project methodologies: 1) project life cycle, 2) project process, and 3) step-by-step methodologies[190].

1) Project life cycle methodologies

    PRINCE2[191] (Projects IN Controlled Environments) is a clear example of project life cycle-based project management. Six major processes form the project life cycle: (1) starting up a project, (2) initiating a project, (3) controlling a stage, (4) managing project delivery, (5) managing stage boundaries, and (6) closing a project. PRINCE2 is a widely recognised de facto standard in the UK. It describes a structured method for effective project management for all project types, not only for information systems.

    PRINCE2 has been developed and is maintained under the Office of Government Commerce (OGC) and it is a registered trademark of OGC. However, the method is in the public domain, offering non-proprietary best-practice guidance on project management.

2) Project process methodologies

    For example, Project Management Body of Knowledge[192] (PMBOK), is a process-oriented presentation of project management. It does not intend to tell people how to do any of the techniques or use any of the tools described in it. It only lays out the processes, how they link with each other and the possibly invoked tools and techniques.

    The *PMBOK Guide*, published by Project Management Institute, Inc. (PMI), describes the sum of knowledge within project management. This full body of knowledge includes knowledge of proven, traditional and widely applied practices. It also comprises knowledge of innovative and advanced practices, which may have more limited use.

3) Step-by-step methodologies

    Step-by-step methodologies are based on task lists, starting with the basic tasks. For example, TenStep[193] is a flexible and scalable methodology for managing work as a project. It is designed to provide the information necessary to manage projects of all kinds. Tom Mochal is the creator and the primary author of all TenStep products. Today, Tenstep Inc. develops these business methodologies and consults and trains in the use.

    The TenStep Project Management Process is divided into ten steps: two for definition and planning, and eight for managing and controlling the work. The planning steps are (1) define work and (2) workplan/budget. The managing steps comprise (3) workplan/budget, (4) issues, (5) scope, (6) communication, (7) risk, (8) documents, (9) quality, and (10) metrics.

[190] Wideman: Max's Project Management Wisdom > Paper/Books > Project Management Methodologies > The Importance of the Right Methodology
http://www.maxwideman.com/papers/pm-methodologies/importance.htm (17.10.2005)

[191] Prince2 > Prince2 > What is PRINCE2? (Multilingual) > What is PRINCE2?
http://www.prince2.com/whatisp2.html#process (17.10.2005)

[192] PMI > Professional Practices > Standards > Third Edition Excerpts
http://www.pmi.org/info/pp_pmbok2000welcome.asp (17.10.2005)

[193] Tenstep Inc. > Tenstep Project Management Process > Download the TenStep Executive Summary > Project Management Process Executive Summary
http://www.tenstep.com/open/miscdocs/200TenStepExecutiveSummary.pdf (17.10.2005)

Solution-based project management methodologies can be seen as forming an additional generic project management approach. It is a truly miscellaneous group, which consists of project methodologies based on specific features of a certain solution (IT system, calculation method, management principle etc.). In general, they have to follow and fulfil the needs of the solution.

Besides generic project methodologies, there are also business branch dependent approaches. Especially the IT sector has developed many widely used approaches to support information system development. For instance, the system development life cycle and waterfall model can be understood as project approaches.

Prevailing Trends in Project Management

The project management approach and project management methods[194] have become more attractive in management for various reasons. The modern economical environment with low inflation makes it mandatory that corporate profitability becomes less from raising prices and more from streamlining operations more efficiently.

The influx of global markets makes the competition more demanding. New global markets raise new global challenges, for example in entering markets first with the superior product. Shortened project life cycles mean that products become obsolete increasingly fast, requiring companies to invest ever higher amounts in R&D and product development. The increasingly complex and technical products make R&D increasingly difficult. Technologies diffuse and the technical complexity of products grows. Narrow product launch windows of the new products causes that a small delay can cost to a company its competitive advantage.

The reasons above create business environments where the project management approach is successful. The success has encouraged more and more companies to study and attempt the approach. In turn, it has led to a wider adopting the project management principles, particularly with new project management advancements. The most notable advancements include:

1) Risk management

   Risk management represents a new approach for many project-driven organisations. It has developed more sophisticated up-front methodologies to assess risks better prior to any significant commitment to the project. Risk management consists of risk identification, quantification, response development and risk control.

2) Organisation structure

   Project organisations have adopted two new ways of organising work: heavyweight project organisations and project management offices (PMO). Heavyweight project organisations represent the shift towards a true matrix organisation with an external, customer focus. The introduction of PMOs origins from the desire of companies to create a central administrative function to co-ordinate and manage their project portfolios.

3) Project team co-ordination

   Cross-functional co-operation and the punctuated equilibrium model have been applied in project management. Cross-functional co-operation positively affects both task and psychosocial outcomes, suggesting that co-operation promotes better task performance as well as general positive feelings. Punctuated equilibrium proposes that real changes become through long steady periods triggered by a catalytic event. The event propels upward, to evolutionary adjustments. It suggests that initial impressions are often lasting. Early behaviour and norms quickly solidify and become the controlling force behind the project team's behaviour.

[194] Pinto: Project Management (2002)
Research Technology Management, Vol. 45, No. 2, pp. 22-37

4) Scheduling

Critical chain project management (CCPM)[195] is the major improvement in scheduling for since the introductions of PERT and CPM. CCPM has several alterations compared to traditional PERT scheduling.

First, all individual slack, "buffer", becomes project buffer. Each activity is estimated without any safety padding (basically it leads that only a half of the activities will meet the deadline). All activities of the critical path and feeder paths are linked with minimal safety padding. The project padding is aggregated and some of the saved time is added to the project time span. CCPM saves time, because project professionals need to be less concerned with activity padding and more concerned with task completion. Even if they miss the delivery date, the overall effect on project schedule is minimised because of the downstream project buffer.

With the PERT approach, the project buffer is a function of overall completed tasks. It means that the project buffer is a product of the task dependencies. In CCPM, the project buffer is placed independently beforehand, based on the reasoned cut in each activity.

5) Control

Earned value analysis (EVA) has become increasingly popular in project management. EVA is used to track project costs relative to project performance. EVA enhances the traditional project control, linking project performance to date with more traditional metrics of time and expenses.

Without a clear estimate of actual work performed in relation to the budget and schedule, the traditional S-curve presenting the progress can be highly misleading. EVA brings some new concepts to overcome the difficulties. Budgeted cost of the work scheduled (BCWS) refers to the cost estimate of the resources scheduled on the cumulative baseline, i.e. planned value. The budgeted cost of the work performed (BCWP) identifies the actual value of the performed work to date, meaning earned value. The actual cost of work performed (ACWP) is the sum of the costs incurred in completing the work, i.e. the actual cost.

Variances are calculated using the previously defined figures. Schedule variance is the difference between BCWP and BCWS (Schedule variance = BCWP – BCWS). Cost variance is the deviation between BCWP and ACWP (Cost variance = BCWP – ACWP).

6) Impact of new technologies

Internet and web technologies provide an opportunity of virtual project teams working within and between geographically dispersed organisations. Project professionals may never actually meet, but they can work in close collaboration for project success.

4.2. PROJECT MANAGEMENT BY PMBOK

I have used PMBOK as the general project management standard. PMBOK is an overall presentation of project processes, tools and techniques. Project Management Institute (PMI) publishes and maintains this body of knowledge. It is a general, industry-independent presentation of project management. My presentation is based on the year 2000 edition of the *PMBOK Guide*, which is organised into nine knowledge areas and five project management processes.

> "**Project**
>
> A project is a temporary endeavor undertaken to achieve a particular aim and to which project management can be applied, regardless of the project's size, budget, or timeline."[196]

In the definition of the project, temporary means that every project has a definite beginning and end; unique means that the product or the service of the project is different in some distinguishing

[195] Goldratt: Critical Chain (1997), 246 p.

[196] PMI > Professional Practices > About the Profession > The Evolution of an Idea > What is a Project? http://www.pmi.org/info/PP_WhatIsAProject.asp (08.02.2005)

way from all other products or services. For many organisations, projects provide means to respond to those requests that cannot be addressed within the normal operational limits.

> "**Project Management**
>
> Project management is the application of knowledge, skills, tools, and techniques to a broad range of activities in order to meet the requirements of a particular project. Project management is comprised of five Project Management Process Groups – Initiating Processes, Planning Processes, Executing Processes, Monitoring and Controlling Processes, and Closing Processes – as well as nine Knowledge Areas. These nine Knowledge Areas center on management expertise in Project Integration Management, Project Scope Management, Project Time Management, Project Cost Management, Project Quality Management, Project Human Resources Management, Project Communications Management, Project Risk Management and Project Procurement Management."[197]

In project management, the project team manages work typically involving competing demands for scope, time, cost, risk and quality. Also, project stakeholders may have different needs and expectations for the project. It is important to note that many project management processes are iterative by nature. This is partly due to the necessity of progressive elaboration throughout the project life cycle; the more you know about your project, the better you are able to manage it.

PMBOK is founded on the principle of "plan before doing". The section "Project Management Integration" describes planning a project, which has dictated the order of knowledge areas[198]. The author of the section, Max Wideman, describes the planning logic in the following manner:

1) What needs to be done? - Scope
2) Produced to what standards? - Quality
3) What is the sequential order and pace of the tasks involved? - Time
4) How much will the tasks and resources cost? - Cost
5) What is the degree of uncertainty associated with work? - Risk
6) What people are required, with what skills? - Human Resources
7) What must be procured, or what resources contracted? - Procurement
8) What information must be delivered to make it all happen? - Communications

Wideman has described the reasoning behind the order. If the costs of a project are all-important, you can not determine them (cost) until you know all the activities involved and their degree of urgency (time). The duration of these activities can not be determined until you also know the required grade of quality, since a higher quality usually requires more time (quality). Last, of course, you can not know what you are doing until you know what is to be produced in the first place (scope). Therefore, if you follow this logic, the progressive sequence is: scope, quality, time and cost.

Managing the execution of a project, the tendency is to move sequentially upward in the general planning order. First, communication must be effectively established with people to get them to do something and refer to the contract or other form of commitment for the agreed details. Then the project team should consider the opportunities and risks involved within the constraints imposed, so that they are then in a position to focus on precisely what is to be delivered.

197 PMI > Professional Practices > About the Profession http://www.pmi.org/info/PP_AboutProfessionOverview.asp?nav=0501 (08.02.2005)

198 Wideman: Max's Project Management Wisdom > Max's Musings > Project Management, PMBOK and Order http://www.maxwideman.com/musings/order.htm (17.10.2005)

Knowledge Areas

The *PMBOK Guide* states project management[199] to consist of nine knowledge areas and the respective component processes of each area. The illustration below, Figure 28, gives an overall view of project management.

Figure 28. Knowledge Areas and Component Processes

Project Management		
Integration Management - Project Plan Development - Project Plan Execution - Integrated Change Control	Scope Management - Initiation - Scope Planning - Scope Definition - Scope verification - Scope Change Control	Time Management - Activity Definition - Activity Sequencing - Activity Duration Estimating - Schedule Development - Schedule Control
Cost Management - Resource Planning - Cost Estimating - Cost Budgeting - Cost Control	Quality Management - Quality Planning - Quality Assurance - Quality Control	Human Resource Management - Organisational Planning - Staff Acquisition - Team Development
Communications Management - Communication Planning - Information Distribution - Performance Reporting - Administration Closure	Risk Management - Risk Management Planning - Risk Identification - Qualitative Risk Analysis - Quantitative Risk Analysis - Risk Response Planning - Risk Monitoring and Control	Procurement Management - Procurement Planning - Solicitation Planning - Solicitation - Source Selection - Contract Administration - Contract Closeout

PMBOK 2000, p. 8

Integration management consists of the processes required to ensure that the various elements of the project are properly co-ordinated. Project plan development, project plan execution, and integrated change control belong to integration management. **Scope management** comprises the processes required to ensure that the project includes all the work required and only the work required to complete the project successfully. The scope management processes are initiation and scope planning, definition, verification, and change control.

Time management processes ensure timely completion of the project. It consists of activity definition, activity sequencing, activity duration estimating, scheduling and schedule control. **Cost management** is required to ensure that the project is completed within the approved budget. Cost management comprises resource planning, cost estimating, cost budgeting and cost control. **Quality management** contains the processes required to ensure that the project will satisfy the needs for which it was undertaken. The parts of quality management are quality planning, quality assurance and quality control.

Human resource management processes are required to make the most effective use of the people involved with the project. Human resource management consists of organisational planning, staff acquisition and team development. **Communications management** consists of the processes ensuring timely and appropriate generation, collection, dissemination, storage, and ultimate disposition of project information. The processes are communications planning, information distribution, performance reporting and administrative closure.

[199] PMI: A Guide to the Project Management Body of Knowledge (PMBOK Guide) (2000) pp. 7-8

Risk management processes are concerned with identifying, analysing and responding to project risks. The component processes are risk management planning, risk identification, qualitative risk analysis, quantitative risk analysis, risk response planning, and risk monitoring and control. **Procurement management** processes are needed to acquire goods and services from outside the performing organisation. Procurement management consists of procurement planning, solicitation planning, solicitation, source selection, contract administration and contract closeout.

Project Management Processes

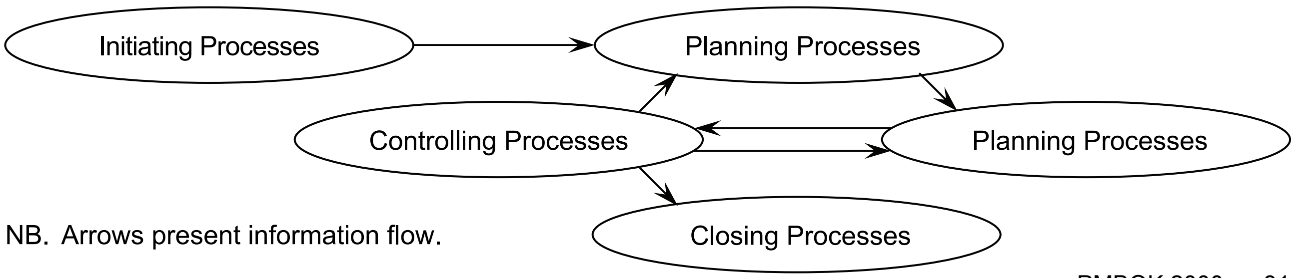
The PMBOK organises project management processes[200] into five groups: initiating, planning, executing, controlling and closing processes. The process groups are connected by the results they produce. The result or outcome of one often becomes an input to another. The links can be also iterative: planning provides a documented plan for execution, and then provides documented updates to the plan as the project progresses. The connections are illustrated in Figure 29.

Initiating processes authorise a project or a project phase. They are an integral part of scope management. **Planning processes** define and refine objectives. They are also performed to select the best of the alternative action courses to attain the project objectives. Planning is of major importance because the project involves doing something that has not been done before. However, it does not mean that project management is primarily planning – the amount of planning performed should be commensurate with the scope of the project and the usefulness of the information developed. Planning should be considered as an ongoing effort throughout the life of the project.

Executing processes co-ordinate people and other resources to carry out the plan. They include core processes and facilitating processes. Core execution processes and facilitating processes carry out the project plan by performing the activities included therein. **Controlling processes** ensure that project objectives are met, by monitoring and measuring progress regularly. They are performed to identify departures from plan so that corrective action can be taken when necessary and appropriate project planning processes adjust the plan. For example, a missed finish date may require adjustments to the current staffing plan, reliance on overtime, or trade-offs between budget and schedule objectives. Controlling also includes preventive actions in anticipation of possible problems.

Closing processes formalise the acceptance of the project or phase and bring them to an orderly end. Contract closing carries out the completion and settlement of the contract, including resolution of any open items. The administrative closing of a project or a project phase generates, gathers, and disseminates information in order to formalise phase or project completion. It includes evaluating the project and compiling lessons learned for use in planning future projects or phases.

Figure 29. Connections between Process Groups



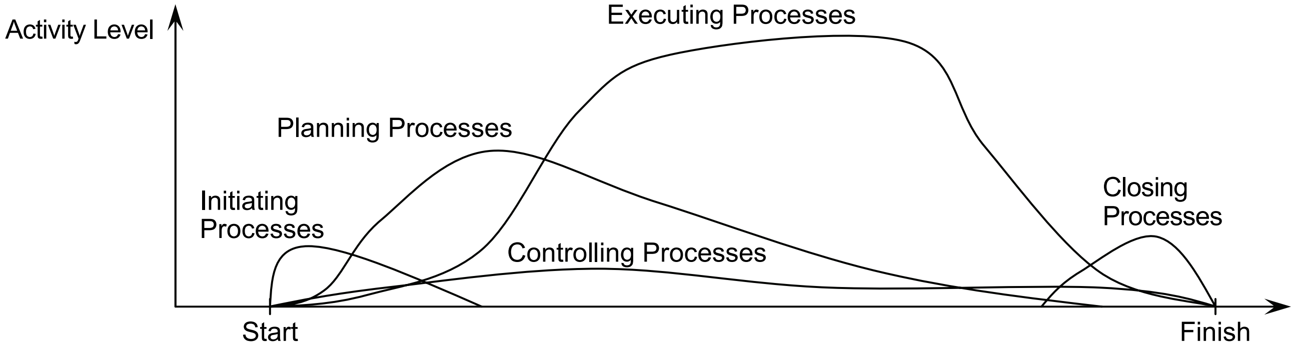
NB. Arrows present information flow.

PMBOK 2000, p. 31

[200] PMI: A Guide to the Project Management Body of Knowledge (PMBOK Guide) (2000) pp. 30-37

The project management processes are not discrete, one-time events; they are overlapping activities that occur at varying intensities throughout each stage of the project. Figure 30 presents the overlapping of the process groups and the varying activity levels within a phase.

Figure 30. Overlapping of Process Groups



PMBOK 2000, p. 31

4.3. PROJECT MANAGEMENT BY PÖYRY

Pöyry Oyj has developed internationally accepted methods to carry out project management in industrial projects. The first descriptions of the recommended work methods at Pöyry Oyj date in the late 1950s and in the early 1960s. I would particularly like to mention Paul Talvio who developed a new set of project manuals in the 1970s. His versions of project manuals continued and strengthened the use of best practices in project management.

This section is heavily based on the rewritten *Project Management Manual*[201] which is widely considered to describe industry level best practices in project implementation. The most significant improvement in the rewritten manual is the introduction a new project management method: the lead consultant method. There are lots of minor adjustments to the earlier manuals, especially in describing project management tools reflecting that computers had made their way to project sites.

Pöyry Oyj has always described the nature of project management[202] as a balancing or optimising task between the key project elements. The company states regularly that balancing of the elements is necessary to ensure smooth project implementation. A shortage, or a failure, in any aspect can limit, or even prevent successful project implementation. The models illustrating the nature of project management have evolved during the years. In the beginning, project management was seen as a combination of basic project management functions, namely scheduling, cost control and performance technology. It means that project management performed the balancing of time, cost and scope. This definition of project management can be traced back to Kerzner's basic triangle of project management[203]. Next, the model developed towards a constraint balancing task (following the ideas of PMBOK, see Section 4.2) which involved the balancing of time, cost, scope and quality. Risks were cast aside due to marketing reasons.

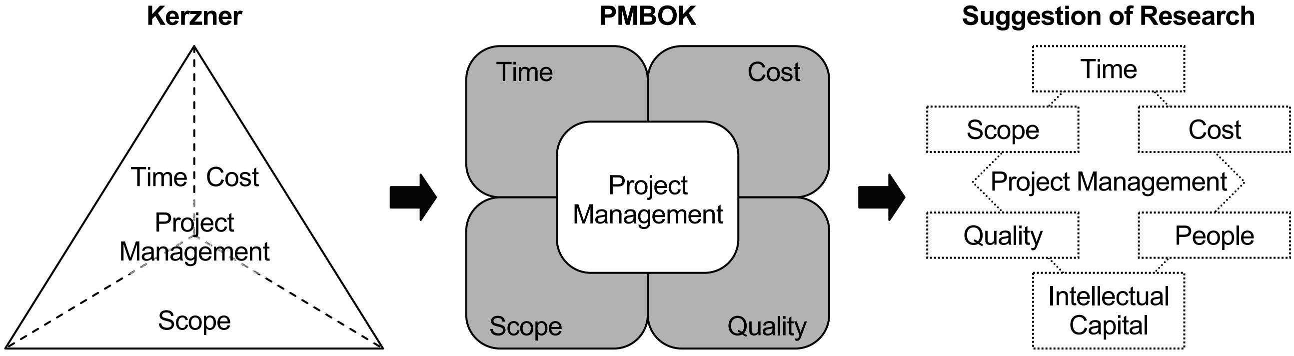
I assume that the next step would be towards resource balancing involving time (working hours), cost (money), scope (technology), quality (technology), people (human resources) and intellectual capital (data, information and knowledge resources). Figure 31 on the next page illustrates the development in presenting the nature of project management.

201 Pöyry Oyj: Project Management Manual (1989)

202 Pöyry Oyj: Jaakko Pöyry Project Management Services (1991) Presales material

203 Kerzner: Project management : a systems approach to planning, scheduling, and controlling (1995) p. 5

Figure 31. Nature of Project Management



This section describes project management from four different angles: life cycle, implementation method, scheduling and cost management. The "traditional" project life cycle identifies a sequence of steps to be completed in industrial plant projects. The subsection of project implementation methods concentrates on project implementation issues. Project scheduling introduces project timing. Finally, project cost management covers the main economical aspects of industrial plant projects.

4.3.1. PROJECT TARGETS

There are different opinions on how to estimate the success of a project. However, the ultimate criteria for project success must include the idea of **serving best the owner's business objectives.** It requires that setting of project targets must go through a serious thinking process. The following intermediate project objectives must be included:

1) Identifying the best feasible project for the owner's business
2) Selecting the most appropriate technology
3) Maximising the performance/cost ratio of implementation and production (i.e. the best return for the money)
4) Designing the details for a cost-effective construction resulting in the most functional mill
5) Executing the construction on time, within budget and maintaining a high quality of work
6) Securing smooth transition from construction to production

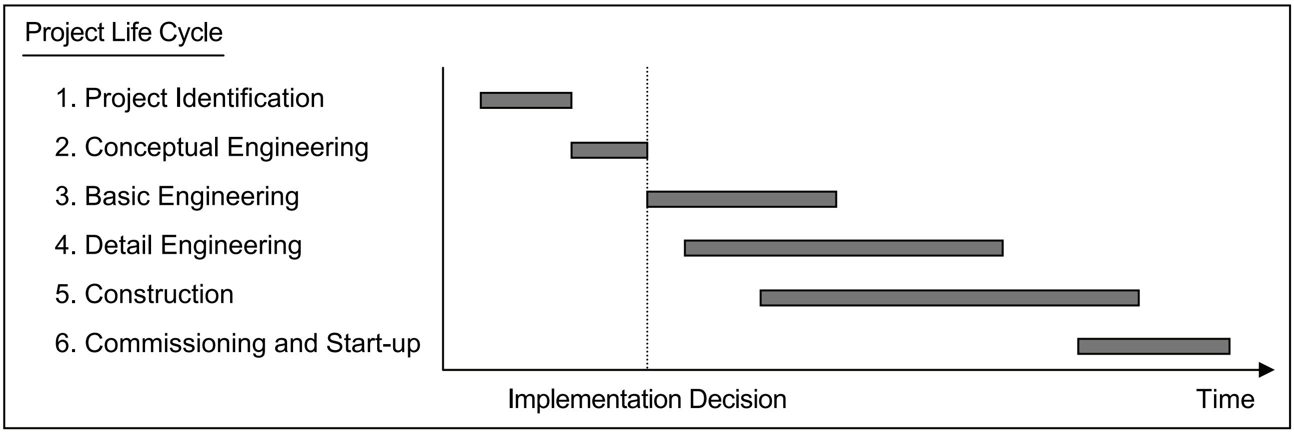
These targets are not dependent on the project implementation method. They must be considered with each method in every project. They are not separate and they can seldom be achieved by clear-cut tasks chained to each other. The tasks overlap in order to minimise the implementation time. The targets are, however, clearly defined topics, always to be kept in mind when investing money in an industrial project. The project implementing crew has to be aware that the achieved targets measure also the quality of the project management.

4.3.2. PROJECT LIFE CYCLE

Every project should go through the stages, regardless of the project implementation approach. The first three stages are especially important. Right choices made during these stages lay the ground for the success of the project. The later stages can not totally compensate for wrong early decisions. The most fatal error is that result of the project identification stage is faulty, there are for example no markets for the product or the price is much lower than expected.

A project can be phased to stages in many ways. Project stages groups similar tasks together. Normally, there is a "Go-NoGo" -decision between the most critical stages. At a "Go-NoGo" -decision point the project can be either terminated, halted, or it can continue to the next stage. Together, the project stages together form the project life cycle, illustrated in Figure 32.

Figure 32. Project Life Cycle



Jaakko Pöyry: Procurement Procedures, Appendix II/1 (adapted)

Project Identification

This stage is also known as a prefeasibility study or feasibility study. The focus of the stage is to find out possible profitable projects. As a result, the project providing the best profitability and long-term competitiveness will be recommended and selected.

A complete feasibility study comprises the following parts: market study, competitiveness study, raw material inventory, site selection study, environmental impact study, human resource evaluation, evaluation of financing options, investment and production cost estimates, profitability analysis, and risk analysis.

Conceptual Engineering

This stage lays the foundation for the whole project. It is the most creative part of the engineering. The time required can vary from one month to several months, depending on the number of options to be studied. It is an evolutionary process where many alternatives are studied, and the technical and financial aspects are compared. The conceptual engineering before the final implementation decision establishes the technology of the mill to the extent that the critical decisions can be made.

The two most significant critical decisions comprise:

1) Selection of the most appropriate area-specific process equipment from the domestic or international market
2) Developing engineering standards for general-purpose standard equipment and construction materials to secure high reliability and low maintenance costs.

The purchase negotiations in this stage are conditional, because the implementation decision has not been made yet. Negotiations on area-specific process equipment, or a subset of them, are carried out separately in order to obtain the best possible solution. The judgments are based on the proposed technology, the guaranteed technical performance, quality and price. The conceptual design stage determines the process concept and the generic engineering standards.

The process concept covers the whole plant. The concept consists of production technology, simple process diagrams, overall balances, performance specifications for major equipment, mill site layout, preliminary plot plans, production control system, manpower plan, master schedule, preliminary project budget, profitability calculations and financing options.

The generic engineering standards are prepared for each engineering discipline separately. The standards include component data sheets, repetitive design documents, selection guides for materials and components, design and calculation rules, document hierarchy system, and sample documents. The conceptual design stage also defines the rules of choosing the ancillary equipment and materials (especially wetted parts) and engineering documents supporting a cost-effective construction. It also provides documents for troubleshooting and maintenance after the start-up.

The end of the conceptual engineering stage is a natural point to halt non-profitable projects. It can be done without losing much money. The accuracy of investment and production costs is reasonably high and the results of the stage are reliable.

Basic Engineering

The basic engineering stage determines most of the investment costs. The money committed for the major equipment is typically only 30 % of the total investment. However, the final flow sheets and layouts determine the quantities of ancillary equipment and materials as well. After selecting the suppliers for these parts, the construction work is the only major cost to be estimated.

The basic engineering stage is decisive as regards the operating costs. The selected machinery and process configurations determine the consumption figures, operating manpower, maintenance requirements and the achievable running time of the plant. In other words: the basic engineering stage determines how wisely the money will be spent. Therefore the future owner of the plant should always use the best brains he can find for this phase of the work.

The basic engineering stage is divided into two parts: 1) mill configuration and 2) selection of ancillary equipment and material suppliers. Mill configuration establishes the technology of the plant to such an extent that all major items go right down the line for the rest of the project. The supplier selections for ancillary equipment (pumps, motors, motor control centres (MCCs), instruments, valves, etc.) and materials (building parts, piping parts, cables, etc.) are based on unit prices.

1) The most important outcomes of mill configuration are:
   - inquiry specifications for the main equipment
   - process equipment bid evaluation and main equipment purchasing contracts
   - final flow sheets with process data and final equipment lists with performance data
   - production and process control system description
   - final site layout and process area plot plans
   - connection diagrams between mill process areas
   - site preparation plan
2) The selection process stages of ancillary equipment and materials supplier selection comprise:
   - selection stage 1: inquiry documents with generic specifications and estimated quantities
   - selection stage 2: unit price proposals from suppliers
   - selection stage 3: bid evaluations
   - selection stage 4: blanket and bulk order awards
   - selection stage 5: confirmed engineering data from suppliers
   - selection stage 6: exchange of generic data with manufacturer-specific data

As the result of the basic engineering stage, the generic engineering standards are replaced by project-specific engineering standards.

Detail Engineering

If the groundwork described so far has been properly done, detail engineering becomes routine work. The basic engineering stage ensures that no major point goes wrong, and the engineering standards ensure that all minor choices are correctly made. It should be remembered that engineering standards do not only specify the components and materials but also the rules on how the components and materials are used in the detail engineering. CAD systems can be configured to apply them automatically, which ensures that the rules are followed.

Detail engineering also completes the final needs of ancillary equipment such as pumps, electrical motors, MCCs, instruments, valves, etc. The purchase requisitions are given to the suppliers according to the schedules agreed upon when the blanket orders were awarded.

Construction

During the early phase of detail engineering, unit price inquiries for mechanical, electrical and instrumentation constructions are prepared. Each construction discipline – equipment, instrumentation, electrical devices, piping, insulation, painting, HVAC (heating, ventilation, air-conditioning), etc. is divided into construction objects. A construction object can include both material and labour or labour only.

The estimated number of each construction object is given in the inquiry. The contractors give their construction object prices per unit. This way, the total contract value comes from the sum of the construction object values. This total contract value is the only compensation to the contractor. Consequently he must distribute all his costs to the unit prices (e.g. salaries, fringe benefits, home office overhead, site overhead, profit, etc.).

The unit-pricing in contracting encourages the contractor to improve his productivity. He also usually pays per piece to his suppliers, subcontractors and employees. On the other hand, the contractor's risk is smaller because the client always pays for what he really gets – what has been put in place.

Construction schedules are very tightly connected to engineering schedules. The other reason for using unit price contracts is to obtain maximum overlapping. This means that engineering must follow the delivery times of documents and purchase requisitions to the contractors and suppliers exactly. There is very little lead-time included in the implementation schedule.

Commissioning and Start-Up

The commissioning and start-up of the mill is the most intense phase of the project. In a comparably short time span all departments of the mill are checked and tested by numerous people. One cannot overemphasise the importance of well-planned and efficiently performed commissioning for a smooth start-up and for a steep production curve[204].

Detailed planning of the commissioning and start-up is very important and must be made in connection with detailed construction planning. These activities need very detailed advance planning to succeed, and must be updated almost daily to keep track with the changing developments on the mill floor. Detailed day-by-day schedule is followed and results of tests are recorded on forms prepared beforehand.

[204] Pöyry Oyj: Jaakko Pöyry Construction Management Services (1990) Presales material, pp. 13-14

Long before the beginning of the commissioning and start-up stage, the start-up dates are set. The first conceptual schedule puts the target date for the start of the production. The start-up of the mill takes normally place in several steps. All the process areas (departments) do not start on the very same day. The start-up sequence determines the order of the last construction and commissioning tasks.

Logistics planning of the whole of the commissioning and start-up sequence is absolutely necessary for a successful start-up of the mill. The completion of MEI (mechanical, electrical and instrumentation) erections and their check-outs are divided into clear phases. The planning starts with the definition of test loops, which are scheduled item by item so that they are ready for start-up performance. Usually, the tests are divided to check-out, commissioning and start-up tests.

Check-Out is the last stage of erection work. It starts commissioning and includes all measures for checking that the physical erection has been completed. This is done using so called "punch lists" where all missing items and outstanding works are listed and classified as to their urgency. A dry test is performed to ensure that single pieces of equipment work.

Commissioning comprises functional tests which are performed for complete equipment loops, including control systems. Running water is normally used as a medium and this test sequence is called the "wet test". Gradually the loops will be integrated together, involving larger systems and putting higher loads on electrical supplies as well. Before running the loop the necessary pressure and tightness tests are performed with water.

Start-Up takes place when process media are introduced into the test runs and the start-up sequence has commenced. It continues into production tests as specified in the suppliers' contracts. After final adjustments and their performance evaluations the plant will be ready for taking over by the client for continuous commercial operation. The availability of raw materials and chemicals for start-up must also be planned and taken care of in good time before the start-up.

The training of the personnel is another important part of the start-up. The necessary operating instructions are prepared during the detail engineering stage. The instructions describe the process and used equipment. They give step-by-step instructions for the start-up, monitoring the process, managing disturbances, regular shutdowns and for emergency shutdowns. They comprise flow diagrams, control system screens, interlocking diagrams, group start diagrams and alarm explanations. In short: the operating instruction books are meant for operator training as well as operating handbooks.

A hand-over procedure is carried out to finish the industrial plant process. At the end of the successful production tests an official "Taking over Certificate" will be issued. The client will then be responsible for the running of the mill. The guarantee test runs must prove that the long-term production rate and the quality targets would be reached. The final "Acceptance of the Plant" follows at the end of the guarantee period pending successful performance test runs.

Project Road Map

When project stages are presented with corresponding intermediate project targets, we have a project road map. Each stage is targeted primarily to achieve one of the previously mentioned intermediate project targets. The transition from project implementation to production has been smooth in the projects, where the owner's project organisation has continued operating the mill. The complete road map of industrial plant projects is illustrated in Figure 33 on the next page.

Figure 33. Project Road Map

1. Project Identification
 - the best project for the owner's business

* markets
* products
* raw material base
* financing options
* community restraints
* environmental restraints
* profitability
* risks

2. Conceptual Engineering
 - the most appropriate technology

A) Process Concept

* low consumption figures
* easy operation
* low maintenance costs
* environmental compatibility
* competitiveness

B) Generic Engineering Standards (specifying generic components)

* high reliability
* high uptime
* optimum economic life
* uniform documentation

3. Basic Engineering
 - maximum overall performance/cost ratio

A) Mill Configuration
 - selection for major process equipment

* final flow sheets
* mill site and process area layouts
* production and process control system

B) Material and Ancillary Equipment Database

* exact specs and types for generic components and materials through awarding blanket and bulk orders

4. Detail Engineering
 - the most functional mill with cost effective construction

* constructability of design
* documents serving construction as well as mill operation
* material requisitions for economical procurement
* work package requisitions for on-time construction

5. Construction
 - high quality work, on time, within budget

* precise planning
* functional contract forms
* reliable progress follow-up
* effective quality assurance

6. Commissioning and Start-Up
 - smooth transition from construction to production

* well-thought test loop forming
* precise scheduling
* well-documented operating instructions
* early operator participation
* responsibilities of participants well-defined

Pöyry Oyj: Project Management Manual, Basic Method, Appendix I

4.3.3. PROJECT IMPLEMENTATION APPROACHES

There are several competing approaches to implement industrial plant projects. Any implementation method can be applied successfully, if skilled people with right tools are involved. The approaches differ from each other by the carrier of the engineering and management responsibilities and the division of the project tasks. The main distinguishing factor between the project implementation methods is the procurement policy, or vice versa. The project implementation method has a definite and substantial impact on the success of the project. The main implementation methods are following:

1) Construction Manager Method
   An owner/engineer-driven project applying piecewise procurement of equipment, materials and services.
2) Supplier Package Method
   An owner/engineer-driven project applying piecewise purchase in the first place, but by grouping the pieces into commercial or functional packages supplied by one supplier, provided that it makes sense from the economical point of view.
3) Turnkey Method
   The owner buys the mill from a turnkey contractor. The main terms of the turnkey contract are limits and guarantees for price, start-up date, product quality, production start-up curve and production costs
4) Lead Consultant Method
   The owner hires a renown engineering company to be his partner in the project. The partner company assists the owner in project management, conceptual and basic engineering and in supervising detail engineering.

If the owner has as his partner an experienced consultant with reliable cost files, the consultant can make alternative cost estimates based on the different project implementation approaches. This gives the owner a basis to evaluate the amount of needed own work and the costs in each approach. When considering the different project implementation approaches and procurement methods one should remember the golden rule of purchasing; **buy from each supplier or contractor only what he knows well**. Adding on things outside somebody's normal business is calling for trouble.

Construction Manager Method

The construction manager method is the original Pöyry project method. It was even earlier called the Pöyry basic method. It gives the owner and the engineer plenty of different opportunities to pursue success in project implementation. The construction manager method integrates the engineering, procurement, construction and start-up of a plant. Engineering is seen to provide proper information to procurement, construction and start-up activities. Engineering guides procurement and construction throughout the project to achieve maximum task overlapping and minimum project time period. Systematic and disciplined working methods are required to ensure that the large number of vital decisions is correct.

The construction manager method is analoguous to the case where person wants a made-to-measure suit rather than shop for ready-made clothes. The owner must make a great number of choices and decisions. The owner’s main business is producing and selling goods, and therefore he needs professional help in implementing an investment project. The construction manager method places hard requirements for the engineering company. The engineering company should have efficient project management tools, strong technical background in the industry, cost effective engineering methods, and highly skilled people available at the right time. In order to arrive to the right decisions an extensive amount of preparatory work is needed.

In the construction manager method, the most appealing opportunities include applying the best ideas in order to create easy-to-operate and cost effective processes, selecting the most appropriate equipment from the international market and combining the production and process control systems from the best combination of hardware, software and application know-how. The final cost is known early, because the only cost variable is the quantity after the procurement of mill equipment and awarding the unit price contracts.

Furthermore, the construction manager method gives possibilities to develop mill site layouts and plot plans, which are the most appropriate for operation and future needs. It ensures through generic engineering standards that the ancillary equipment and construction materials provide high reliability and long lifetime at low maintenance costs. The construction manager method helps to obtain the best price; purchasing takes place with very clear specifications directly from each supplier his own products and services only. This is seen to ensure the availability of engineering data at the right time through unit price contracts in order to avoid costly delays and engineering errors.

The construction manager method emphasises that the major equipment is purchased with technical supervision of erection and commissioning at a fixed price in order to make the vendor responsible up to the point when the production targets have been reached. The construction work is bought in several unit price packages without waiting for engineering documents for lump sum bids in order to start each phase of construction at the earliest possible point in time. Unit price construction contracts are used to decrease the construction costs, because the contractors must compete with productivity instead of hourly rates. The unit price construction contracts also minimise claims, because the owner pays only for what can be clearly verified, i.e. for what has put in place.

The construction manager method directs the engineering so that the resulting documents and computer data files are uniform throughout the mill and they are most practical for troubleshooting and maintenance. The method helps in preparing high-class operating instructions for the mill as a complete dynamic production system. The method also uses input from the production people, engineering company and equipment vendors to produce operating instructions.

The construction manager method emphasises that incoming operators participate in the construction supervision and commissioning to the maximum extent possible for learning purposes. Last, the method makes it easier to plan and execute the commissioning so carefully that the start-up is smooth, and the production curve rises steeply.

Supplier Package Method

The supplier package method means an owner or engineer-driven project, which groups the pieces into commercial or functional packages and each package is supplied by one supplier. Packaging is applied as far as it makes sense from economical point of view. The precondition for a successful project implementation through the supplier package approach is a well-done conceptual and basic engineering by the owner/consultant.

Before inquiries for any kind of packages can be prepared, the owner must specify them technically as well as commercially. Therefore, conceptual engineering must be carried out. It is, however, advisable not to go directly to package inquiries after the conceptual phase, because the scope of packages would depend on the capabilities of the selected supplier. The forming of packages is recommended to bee done in two steps. The first step is soliciting of fixed price proposals for major equipment and unit price proposals for ancillary equipment. The second step comprises the forming of packages through negotiations with major equipment suppliers.

Good supplier package forming demands that the mill configuration is clear and project standards are made for materials and ancillary equipment. The multi-package approach will require significant managerial and technical input from the owner. There are three main types of supplier packages: (1) commercial packages, (2) system packages, and (3) mechanical packages.

Commercial packages can be divided to fixed price and handling fee parts. Fixed prices are normally applied to the supplier's own products and services. Additional purchases are specified and negotiated by the owner, but the supplier places the order as an agent for the owner. The handling fee is agreed upon in the original purchase contract. The handling fee of a commercial package is a kind of an allowance in the purchase contract. It is placed on top of the fixed price part for additional purchases. The purpose of the commercial package is to use the supplier's ability to arrange the needed equipment and services to the project. This applies especially in the purchases from the supplier's home country. Commercial packages are mainly used, when the owner needs financing from the package suppliers.

System packages include everything except buildings. The supplier is committed to follow the owner's engineering standards. The purpose is to put the system responsibility rather than the normal component responsibility on the supplier. For this reason, the supplier is responsible for engineering the system, specifying and supplying the components, and for erecting or at least supervising the erection work. System packages are recommended, when the suppliers have most of the engineering.

Mechanical packages consist of process equipment and piping. System packages cause problems in maintaining the project standards in general, but especially in the electrical and process control standards. Therefore, the supplier's supply is limited to the mechanical process equipment and piping. Mechanical packages typically comprise hardware and services. The hardware includes area-specific process equipment, service-specific process equipment (pumps, agitators, heat exchangers, etc.), and process piping, including manual valves following the owner's standards. Services contain process engineering, layout engineering, piping engineering, and control system descriptions (logical diagrams, alarms, etc.), including approvals of electrical and instrumentation functional diagrams with control panel layouts and screen displays. The erection of the supplier’s hardware is normally placed in the service section of the contract. Last, services define the training, commissioning and start-up assistance of the mechanical package contract. Mechanical packages can be used, if the supplier is a renowned process developer and the process equipment for the area is concerned.

The scope of the packages can be formed in many different ways. Before the scope for the package can be outlined, the package must be defined in the total mill configuration. The mill is not a sum of clear-cut processes, islands with clear coastlines. The most cost-effective way concerning the investment and operating costs is to integrate the different processes into one production system. The production system is supervised from one or two control rooms.

There are cost saving principles to be followed in defining the scope of packages. The processes of different production areas should fit together in an optimal way. The overall heat, power and water consumption has to be minimised. The mill layout minimises the building costs, pipeline and cable lengths, and gives the optimal locations of control and electrical rooms. The building design is uniform from architectural and structural points of view. Mill components (pumps, valves, motors, instruments, HVAC equipment etc.) and the control system are of the same make throughout the mill and backed up by local service. Additional savings are achieved when the integration of control systems of different process areas (i.e. different packages) is properly made in each control room and across the mill. Each package cannot have a separate control room, or not even its own independent console in the common control room, when today's modern systems are used.

Costs will be decreased also by making the construction manageable. The construction should not happen in irrational overlapping and redundancy of functions at site. The construction costs cannot be the lowest possible, if each package supplier sets up his own concrete mixing station, welding shop, temporary store for commodities, transportation fleet, heavy construction equipment etc. In the end, the owner pays for all this after all.

The type of equipment or service is also used as a package-forming factor. The suppliers can offer to the project only certain type equipment or services, where they have the best expertise. Common general expertise packages are site preparation, underground connections, piling, cast-in-situ concrete (at least up to ground level and for all other heavy structures), power distribution, electrical equipment, field instruments, control systems, pumps and valves.

Also the engineering must be "standardised" in packages. The advantages of standardised engineering comprise that the same standards and codes are followed, and the same material selection rules are followed (especially important for wetted parts). It is also beneficial that uniform numbering and marking systems are used, identical documents are prepared for electrical and process control systems (trouble shooting), and instruction manuals are prepared in good time in the owner's language for operator training.

The most common way to organise purchase packages is that the owner separately buys mechanical packages and general expertise packages (component packages). Figure 34 gives an example of such a situation: mechanical packages are drawn vertically and general expertise packages horizontally. Some of the mechanical packages can be replaced by system packages, which include everything except the building. The owner usually demands the supplier to use owner-selected subcontractors for civil and structural parts. In a way, the addition of the buildings with civil and structural parts makes the system package a complete turnkey system. If some parts of the mill are not suitable for package purchase, the owner or the consultant should do the detail engineering for it. He should also buy the goods piecewise and organise construction for the part of the mill.

Figure 34. Pulp Mill Example of Packaging

<table>
<tr><td colspan="6">Owner/Consultant: Project Management
Conceptual Engineering
Basic Engineering
Construction Management</td></tr>
<tr><td>Woodhandling</td><td>Cooking
Washing
Screening</td><td>Bleaching</td><td>Bleaching
Chemicals
Preparation</td><td>Evaporation
Recovery Boiler
Feedwater System
Air Compressor</td><td>Causticising
Lime Kiln</td></tr>
<tr><td colspan="6">Electrical</td></tr>
<tr><td colspan="6">Instrumentation and Control</td></tr>
<tr><td colspan="6">Pipe Bridges and Other Interconnections</td></tr>
<tr><td colspan="6">Civil Construction</td></tr>
</table>

Pöyry Oyj: Project Management Manual, Vendor Package Method, Appendix III

The contracts must define the delivery limits for the goods and services precisely. In engineering, the limits are often difficult to find. In a mechanical package case, the architectural, civil, structural, electrical, process control, HVAC and service systems engineering are not included in the package. Therefore, the supplier's process, mechanical and piping engineering must be tightly integrated to the owner/consultant's engineering activities. Most suppliers do not have their own people for detail engineering, but they hire outside professionals for the work. The owner or the consultant must set precise engineering standards (including sample documents) and carefully follow the progress of the supplier's engineering, because the hired professionals might not have systematic working procedures or international level of documentation.

The owner and the consultant must provide an overall construction management team. The supplier constructs its own part only. For example, if the packages cover the mechanical part only, the owner must provide the construction of civil, structural, electrical and instrumentation parts. This can be done through unit price contracts, just as in the construction manager approach. The owner must provide site services (construction power, water, first aid, guarding, canteen, telecommunication lines, etc.) in any case.

It is important that the package suppliers prepare operating instructions for training in good time. The suppliers have the instruction books ready for their equipment, but not for the plant as a whole. Suppliers also tend to underestimate the work needed for operation instructions. The owner may find it easier to let the consultant prepare the operation instructions.

The owner must require a commissioning plan from the package suppliers well in advance. The test loop forming and testing schedule must be carefully documented. The owner/consultant should participate in the testing. The contracts define guarantee conditions and guarantee run procedures. The contracts also specify the owner’s obligations for guarantee runs. Such obligations are providing adequate supply and quality of raw materials, power, water, chemicals, skilled people, etc. The owner should demand that the obligations are met before starting the guarantee runs.

Turnkey Method

In turnkey method, the owner buys a complete mill from a turnkey contractor, setting only some economical and technical conditions to the mill. There are several reasons, why the method is seen to be attractive. The owner might not have the industry know-how or skilled people available, he may not be willing to carry the cost and scheduling responsibility, the plant environment is strange to the owner, or the mill will be a replica of an existing mill successfully implemented by the contractor.

The turnkey method works best, if the owner has made a well-documented mill concept and generic engineering standards before asking for bids. The owner should take care that the terms in the turnkey contract allow him to monitor the engineering, subcontractors and construction contractors. Close project follow-up is needed to ensure good construction and proper documentation.

The turnkey method easily takes most of the control out of the owner's hands. The owner should, however, maintain his power to influence the crucial choices. The right choices of processes and components should be ensured before the turnkey contract is awarded. It should include a state-of-the-art process concept, the best combination of key process equipment, and the best process control hardware. The functional layout of the mill should be developed for production, maintenance, housekeeping and future investments. High-class components and materials complying with mill standards have to be selected and the availability of local services has to be ensured.

There is an opportunity to place the production and maintenance people in construction and commissioning for learning their work environment thoroughly before the start-up. This gives also additional project control and has an influence on the quality of the construction. Well-organised engineering and manufacturer documentation should be available for easy troubleshooting and maintenance. The training material has to cover the whole plant, not only single machines.

This approach may make sense for the same mill areas where system packages are applied. The system package procedures must be followed in turnkey implementation. It must, however, be remembered that the skills needed for manufacturing and erecting one's own products are not the same as those needed for running the construction from earth-moving to the start-up of the mill.

Lead Consultant Method

The lead consultant method is used when there is a general type of engineering capacity available in the owner's country at a favourable price, but little or no experience in the pulp and paper industry. The owner can demand to use local suppliers and contractors to the maximum extent and is not willing to apply big foreign packages. The lead consultant and a local detail engineering company together are supposed to form a strong enough engineering force to implement the project with the construction manager method. Another possible approach is dividing plant areas to construction manager method areas and supplier package areas.

The lead consultant method might require more co-ordination in project implementation than the ordinary owner - single consultant method, because there are three parties, i.e. the owner, the lead consultant and the detail engineering company involved in the project. The most difficult aspect in the lead consultant method is to make all three parties to understand their tasks and responsibilities in the same way. Project management and engineering tasks are very intangible and difficult to understand by those who do not deal with them continuously. Such terms as overall project co-ordination, basic engineering and detail engineering are difficult to explain precisely. The lead consultant method is considered risky concerning the quality, completion time and construction claims. The low cost of the local engineering hours might, however, compensate for the increased amount of man-hours. It is an advantage to all parties if these matters are defined as clearly as possible in the contract forming phase. Good documentation would serve as a base for smooth co-operation.

An overall organisation diagram of the project is needed, showing the command and communication lines between the parties. Descriptions of the most important jobs in the project organisation should be included in the documentation. Special attention should be paid to the construction management tasks. The decision-making procedure should be clear, determining especially the authorities to release documents for material supply and construction. Rules for changing orders resulting from scope changes or shifts of responsibilities must be defined between the parties.

The documentation should include the complete scope description of the whole project (especially important for rebuilds). It should divide of the whole project scope into clearly limited areas. There must be clear division of work between the owner, the lead consultant, the detail engineering company and the suppliers including the responsibility for expediting. The documentation should define the interface between the lead consultant and the detail engineering company and the outcomes of the detail engineering with document samples. Last, reporting procedures should be defined with report samples showing the typical contents of different reports.

4.3.4. PROJECT SCHEDULING

The aim of project scheduling is to co-ordinate the various stages of projects. The numerous functions of each stage should be organised to form a logical and smooth base for the whole project. The result should be an optimum solution between three limiting factors, i.e. time, resources and costs. Project scheduling must be carried out in co-operation with the project management, engineering groups, construction contractors, suppliers and client representatives.

Schedules are intended to direct and influence the performance of the activities they describe. It is necessary to create schedules detailed enough for each purpose, but free from non-related input. Modern scheduling programs make it easy to keep all relevant connections valid, but they only present what is necessary.

The scheduling starts with general schedules covering the whole project. Gradually they become more precise and detailed along the progress of the project. The scheduling progresses along the progress of project implementation. It begins with schedules for preliminary engineering, showing the activities of a feasibility study and the timing of the activities. The schedules for preliminary engineering prepare a program for the study project. Target schedules cover the whole of the project and indicate the total time required for the projects. They also comprise the most important intermediate targets. Preliminary schedules are studies of different subjects of the project, such as procurement, civil construction and start-up. The studies reveal the limitations of the project.

Condensed schedules (combined target schedules) include a separate target schedule for each area. In condensed schedules, the target schedules for each area are tied together in order to show the interconnections between them. The condensed schedules specify the final framework of a project, i.e. the framework for engineering, procurement, construction and erection. The client should approve the framework and after the approval the framework is considered as a master plan on which all the area master schedules are based on.

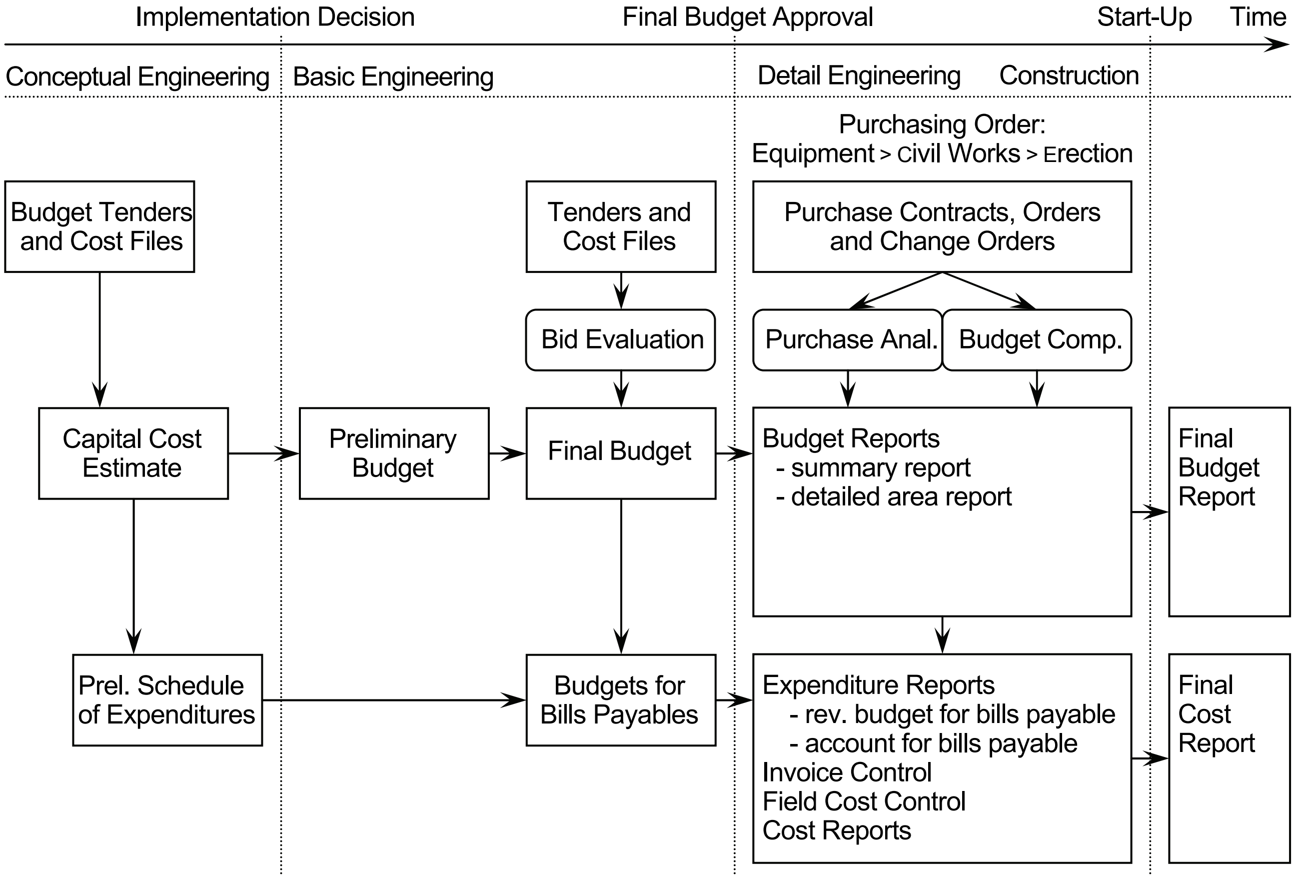
Area schedules are prepared for specific areas, which can be considered to be subprojects. Therefore, area schedules can also be seen as a subproject schedules. They show important activities of procurement, engineering, deliveries, civil construction, erection, commissioning and start-up. The activities should be presented in detail, but the schedule should be kept simple enough to give an overall picture at a glance.

4.3.5. PROJECT COST ADMINISTRATION

Project cost administration is established to keep the total project expenditure within the approved capital cost limit. Cost administration consists of observation and registration, value and timing judgments and recommendations for corrective actions to improve the financial situation.

The capital cost estimate and preliminary schedule of expenditures are made to provide a basis for the client's approval of the project. If the client decides to proceed, a preliminary project budget is issued. Tenders are obtained and tender evaluations are made. Based on the tender information, the final budget is established and submitted to the client. It is normally recommended that purchase orders are placed only after the approval of the final budget. As the procurement progresses, commitments are quantified and compared with the final budget, enabling the prediction of the final project cost. Cashflow and expenditure estimates are prepared, based initially on the final budget and updated from the procurement information. These estimates enable the control of project expenditure. Figure 35 on the next page summarises the way how Pöyry Oyj administers the costs in industrial plant projects.

Figure 35. Budgeting and Cost Control



Pöyry Oyj: Project Management Manual, Investment Cost Estimating and Control, p.2

Project Estimates

Project estimates are developed to establish the size of the project. They are used as the basis of the project budget. They also serve as a control device for the cost and manpower control of the project. The development of the project estimate is started as early as possible within the time scale that is compatible with the available process and engineering data. Therefore, the project estimates develop progressively and evolve as further information is within reach. They are, or should be, reflections of the design concepts and construction planning expressed in terms of costs. Basically three estimate types can be used: conceptual, preliminary and final estimate.

The conceptual estimate is usually used in the early project stages before the implementation decision. It is intended only to indicate the magnitude of the capital costs. Conceptual estimates can be used to rank competitive project concepts by costs.

The preliminary estimate is developed during the conceptual stage of the project. The process and engineering design have to be advanced to a level that allows the formulation for the project. Facilities and services are sized and placed on the mill layout. Budget tenders, cost files from previous projects, estimated working hours for engineering and project management are used to create a cost estimate the project. A preliminary estimate is expected to have 10-15 % accuracy.

The final estimate is created along the same lines as the preliminary estimate. It is more refined by additional details provided by the advanced engineering work. The final estimate should obtain an accuracy of between 5-10 %.

Budgeting

The preliminary budget is prepared at the time of the implementation decision. It is based on the capital cost estimate from the budget tenders and cost files. The aim of the preliminary budget is to provide a basis for the finance and expenditure planning, but it can not be used for cost control purposes.

When the client approves the final estimate, it becomes the original budget. It is used for project cost control and it is the base of cost administration. The budget is not changed, except to incorporate changes required and approved by the client. Therefore, it is vital that the structure of the estimate coincides as far as possible with the form in which the costs will be committed and collected.

The final budget forms the initial basis for the commitment and expenditure reporting. The expenditure reporting is derived from the final budget. Also the expenditure reporting is refined progressively to reflect the progress of the procurement.

Cost Control

The primary goal of project cost control is to analyse, report and control project costs. Controlling the costs means that the costs are intentionally directed and minimised consistently with the established design of the mill. Cost control involves far more than sincere attempt to keep within an established budget. It can only result from concerned and continuous efforts to find optimum cost solutions to engineering, procurement and construction. To a great extent, cost control must be designed and built into a project.

Cost control is used to contribute cost efficiency. It encourages and promotes cost consciousness in all phases of the project work. It provides accurate data on cost status and outlook. It highlights any unfavourable cost conditions and trends, prompting for corrective action. Finally, cost control supplies positive feedback of cost statistics for continuous evaluation.

4.3.6. PROJECT MANAGEMENT CONCLUSIONS

An industrial plant project can be successfully implemented by using any of the mentioned project management approaches. Understanding the right road map of implementation helps to avoid pitfalls in the different methods. Reading the descriptions of the project road map and the different project implementation approaches does not make a master of anybody, but it helps in understanding project management in varying conditions.

There are thousands of decisions to be made in a large project. A great number of approvals and decisions must take place at the right time. The most critical decisions concern purchasing and scheduling. Organising a project means finding answers to four repeatedly asked questions:

1 – What should be done?
2 – When should it be done?
3 – How should it be done?
4 – Who does it?

Projects should employ people who can answer all these questions. The game plan to carry out an industrial project should be discussed in joint meetings in order to get the message through and create a feeling of joint commitment to the project. Commitment and co-operation between all parties secures success.

4.4. REVIEW

General knowledge of project management gives a good starting-point of understanding the project methods of Pöyry Oyj. For example, Archibald's project methodology has heavily influenced the project models. Artto and Wikström's study affirms that projects are not extensively studied from this point. Their study and my own literature survey (see Section 1.2.) confirm my surprise that there are only scarce academic articles describing large industrial plant projects. On the other hand, there are some generic business-oriented presentations of project management, such as PMBOK, PRINCE 2 and TenStep. In my research, I have presented in more detail PMBOK, the project management methodology developed in the Project Management Institute. PMBOK is a well known and widely accepted general project management methodology. It is approved and honoured also in Pöyry Oyj. More important, PMBOK gives a suitable process view for procurement application development.

The Pöyry project methods apply project life cycle in large industrial plant projects. These project methods have been vigorously tested in hundreds of industrial projects. The methods emphasise, for understandable reasons, the management of engineering and project implementation. They describe the project implementation methods in the outcome controlled way. They discuss how to divide the project tasks and responsibilities between the future owner of the plant, the main engineer (or consultant) and the suppliers of equipment.

The rewritten *Project Management Manual* peaks the evolutionary business process development at Pöyry Oyj. The manual culminates the project management knowledge accumulated in the company during the decades. The rewritten project instructions are based on the experience gathered from hundreds of industrial projects. I was appointed to the rewriting of project manuals as a secretary; my work focused mostly on restructuring and illustrating the procurement instructions. My contribution to project management was nearly insignificant, except in the area of procurement follow-up. The automated workload-based procurement follow-up seems to be a novelty in industrial plant projects, described in Subsection 8.3.2.

Pöyry Oyj (the client from my view) dictated the application features. The views and needs of Pöyry Oyj overrode the general project management knowledge. From the point of view of application development, general project management knowledge is not needed. The Pöyry project methods overrun and placed general requirements for the procurement software. However, I have to remind that project management aspects do not have strong effect on the procurement application. The rewritten *Project Management Manual* describes the business framework for the research and project management is only the framework for the procurement software. The implementation approaches represented in the manual only affect the ways of using the procurement software. All the differences between the implementation approaches are handled by using the procurement application according to the implementation approach.

In 2006, the *Project Management Manual* has been in use for ca. 15 years. The manual has helped and supported project management in numerous projects and sustained the competitive advantage of Pöyry Oyj. Even the customers expect Pöyry Oyj to follow the project manual, which describes favourable project principles, guidelines and work methods. The well-established project processes are regarded as guarantee of quality.

5. PROCUREMENT IN PROJECT ENVIRONMENTS

The focus of this chapter is in the rewritten Pöyry procurement instructions, the *Procurement Manual*. It is an equally significant result of the business development as the *Project Management Manual*. This chapter describes Pöyry procurement methodologies, show their prowess in their domain and relate them to general procurement knowledge. Originally, the rewritten manual represented a document-based view on the procurement function in project implementation. Despite it makes sense from the learning point of view, I have rewritten and restructured the instructions to present procurement from the process view. The restructured instructions are presented in Section 5.3.

The procurement function is presented in the context of large-scale industrial plant projects. The environment sets some particular requirements for procurement; procurement is forced to operate under the uncertainty with changing (gradually more defining) item specifications. The uncertainty origins from the overlapping activities, usually called fast tracking of projects. The methods to overcome these uncertainties in procurement are discussed in detail in Section 5.3. The procurement instructions presented functional requirements for the procurement software. In the beginning, the manual was used as metadefinitions in software development. Later, after the re-engineering of the procurement process, the manual provided definitions for procurement tasks, printouts and reports.

Similarly to the rewriting of the project management instructions, the *Procurement Manual* is a part of evolutionary development in the procurement function in industrial plant projects. In principle, the rewriting of the procurement instructions was carried out as a multi-case study using the gathered material and experience of dozens of industrial projects. Internal benchmarking was used to judge the best procurement practices. After the benchmarking, the best procurement practices were expected to be transferred to the subsidiaries of Pöyry Oyj and to project sites.

The chapter comprises the overview of procurement in project environments, the PMBOK approach to procurement, and restructured procurement methodologies of Pöyry Oyj. In the overview section, I describe generic value configuration models (of which the value shop model illustrates most the business of Pöyry Oyj) and procurement process models (all applicable, though the fast tracking model explains best special features of procurement in project environments). The PMBOK section describes the procurement process in industrial projects. The Pöyry section deals with the best procurement practices in industrial plant projects.

5.1. OVERVIEW OF PROCUREMENT IN PROJECT ENVIRONMENTS

The procurement function can be seen from various angles in project environments. Procurement traditionally encompasses the process of buying[205]. It involves determining the need, selecting the supplier, arriving at a proper price, specifying terms and conditions, issuing the contract or order, and follow-up to ensure proper delivery. In practice many terms and concepts are used to describe procurement. However, no agreement exists about the definition of these terms. Terms like procurement, purchasing and buying are often used interchangeably.

Purchasing as a business function is concerned with obtaining the goods necessary for running, maintaining and managing the organisation. There is such a rich variety of purchasing requirements that it makes it difficult to define the field of the purchasing function in practice. Procurement may concern a large variety of items. In general, purchased materials and services can be grouped into raw materials, supplementary materials, semi-manufactured products, components, services, finished products, investment goods, and maintenance, repair and operating materials (MRO items).

[205] Van Weele: Purchasing and Supply Chain Management (2002) pp. 14-15, 22-23

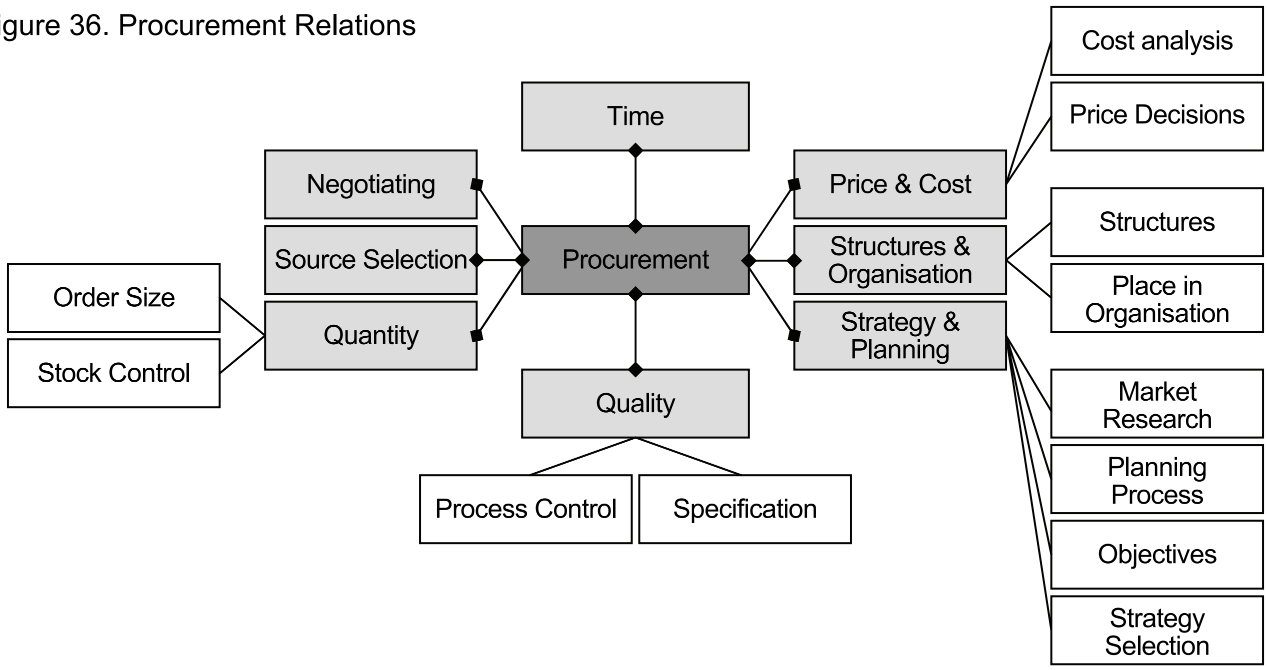
Esswein[206] gives general advice to manage projects by better procurement. The advice is provided for construction projects, but the recommendations apply also in other project types. First of all, all the actions in a project should be in line; they should be aimed at reaching the target of the project. The better and more purposefully you control the project demands, specifications, budget and schedule, the smoother things will go once the project begins. It will also help prospective contractors to make more realistic estimates of their costs and time. It is recommended to stay in a plan, if the last minute changes do not provide significant improvements.

In selecting appropriate suppliers, the project management should concentrate on picking up partners, not the lowest bidders. The traditional method is to solicit three bids from suitable contractors and to select the lowest one. However, money is not everything. It is advisable to find first several contractors who offer prices within a comfortable range, interview them and pick the one who best understands the project needs and communicates well.

The decisions and selections must be made in time, well in advance of construction. It is reasonable to procure the equipment with the longest lead time. The selection process might prove out much harder than expected. The selection process might yield much more passable solutions than anticipated. In project environments surprises are nearly inevitable. It is wise to expect them to realise and be prepared for them. The plans should have some built-in flexibility. Especially schedules tend to be exceeded, because of unanticipated problems. Last, it is reasonable to use contract models which include final payment after all the major phases have been completed and paid for. The final payment gives some leverage towards the supplier to ensure completion of the project satisfactorily.

Farmer[207] has used the mind map technique to show the multiplicity of procurement functions, as illustrated in Figure 36. He asks us to rethink the role of procurement. He explains that while the mind map seems to suggest that each stem with its various nodes is separate from the others, they should be seen as being part of the whole. Each may be related to, influence and be influenced by the other stems and nodes included in the map.

Figure 36. Procurement Relations



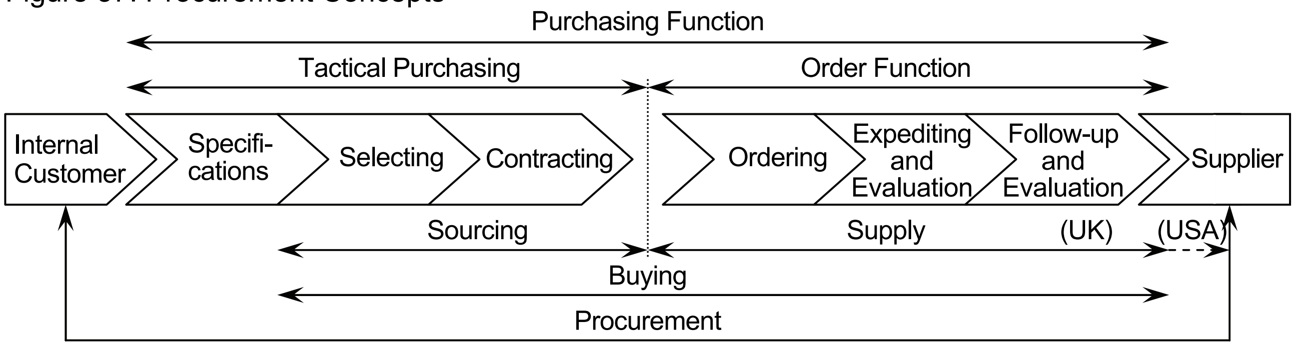
Farmer: Purchasing Myopia Revisited, European Journal of Purchasing & Supply Management 3:1 (1997), p. 7 (adapted)

[206] Esswein: What it takes to get done on time and ON BUDGET (2005) Kiplinger's Personal Finance, Vol. 59, No. 11, p. 32

[207] Farmer: Purchasing Myopia Revisited (1997) European Journal of Purchasing & Supply Management, Vol. 3, No. 1, pp. 1-8

Van Weele[208] has developed a purchasing process model which illustrates schematically the interrelated main activities within procurement (Figure 37). The model does not include the responsibility for materials requirement planning, materials scheduling, inventory management, incoming inspection and quality control. However, in order to be effective, purchasing operations should be closely linked and interrelated to the logistics.

Figure 37. Procurement Concepts



Van Weele: Purchasing and Supply Chain Management, p. 15

It is noteworthy that the definition of procurement in this research differs from Van Weele's presentation. This research uses the definition of the *Procurement Manual*, in which procurement covers only the tactical purchasing of Van Weele's presentation, i.e. from specifications to contract signing. The definition of procurement is founded on the scope of the service contracts between Pöyry Oyj and its clients. At the contract-signing point, procurement tasks are transferred from Pöyry's project professionals to the client's personnel and their ERP software.

This subsection begins with presenting three generic value configuration models: value chain, value shop and value network. Next, the subsection continues to describe procurement process models and ends by describing the importance of procurement in project environments, cost reduction possibilities and general procurement trends.

5.1.1. VALUE CONFIGURATION MODELS

Stabell and Fjeldstad[209] suggest that there are three generic value configuration models: the value chain, value shop and value network. Stabell and Fjeldstad have defined value configuration analysis as an approach to analyse company-level competitive advantage. They state that alternative forms of value creation are a prerequisite for expressing and exploring the differences in the competitive advantage of companies. Their suggestion is based on Thompson's typology of long-linked, intensive and mediating technologies[210], and Porter's value chain framework[211] is used as the key reference and the base line model for these value configuration models.

Stabell and Fjedstad's suggestion is based on the value creation for different company types. The value chain describes the activities of long-linked technology, delivering value by transforming inputs into products. The value shop illustrates companies where value is created by mobilising resources and activities to resolve a particular customer problem. The value network presents companies that create value by facilitating a network relationship between their customers.

[208] Van Weele: Purchasing and Supply Chain Management (2002) pp. 14-15

[209] Stabell and Fjeldstad: Configuring value for competitive advantage: On chains, shops, and networks (1998) Strategic Management Journal, Vol. 19, No. 5, pp. 413-437

[210] Thompson: Organizations in action: social science bases of administrative theory (1967), 192 p.

[211] Porter: Competitive Advantage: Creating and Sustaining Superior Performance (1985), 557 p.

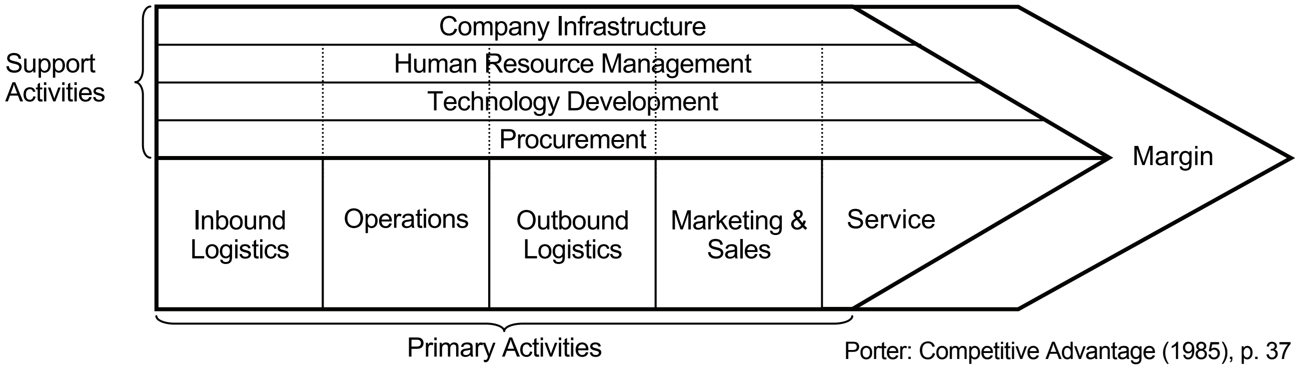
Value Chain

Porter's value chain framework[212] has made its way to the forefront of management thinking. Porter states that every company is a collection of activities that are performed to design, produce, sell, deliver and support its products. The activities can be presented using a value chain, as illustrated in Figure 38. The relevant level for constructing a value chain is a performer of activities (an organisation) in a particular industry. The value chain operates by classifying the generic value-adding activities of an organisation. The ultimate goal is to maximise value creation while minimising costs.

Value is the amount a buyer is willing to pay for what a company provides him. Value is measured by total revenue, a reflection of the price a company's product commands and the units it is able to sell. Creating value for buyers that exceeds the cost of doing so is the goal of any generic strategy. Value, instead of cost should be used in analysing competitive position, since companies often deliberately raise their cost to command a premium price through product differentiation.

The value chain displays the total value, consisting of value activities and a margin. Value activities are the physically and technologically distinct activities that a company performs. They are the building blocks used in creating a product valuable for its buyers. The margin is the difference between the total value and collective cost of performing these value activities. Every value activity employs purchased inputs, human resources and some form of technology to perform its functions. They use and create information, performance parameters and statistics. Value activities may create also financial assets (inventory, accounts receivable) or liabilities (accounts payable).

Figure 38. Generic Value Chain



Porter: Competitive Advantage (1985), p. 37

Porter classifies the value activities to primary and support activities. Primary activities are directed at physical transformation and handling of final products, which the company delivers to its customers. The primary activities comprise: (1) inbound logistics, (2) operations, (3) outbound logistics, (4) marketing and sales, and (5) service. Support activities enable and support the primary activities, and they might support the whole company as well. The support activities are grouped into: (1) procurement, (2) technology development, (3) human resources management, and (4) company infrastructure. Porter regards procurement as a support activity, because it obtains inputs for both the primary and support activities. He uses the term "procurement" rather than "purchasing" because (according to him) the usual connotation of purchasing is too narrow among managers.

> "The dispersion of the procurement function often obscures the magnitude of total purchases and means that many purchases receive little scrutiny."[213]

[212] Porter: Competitive Advantage: Creating and Sustaining Superior Performance (1985) pp. 36-43

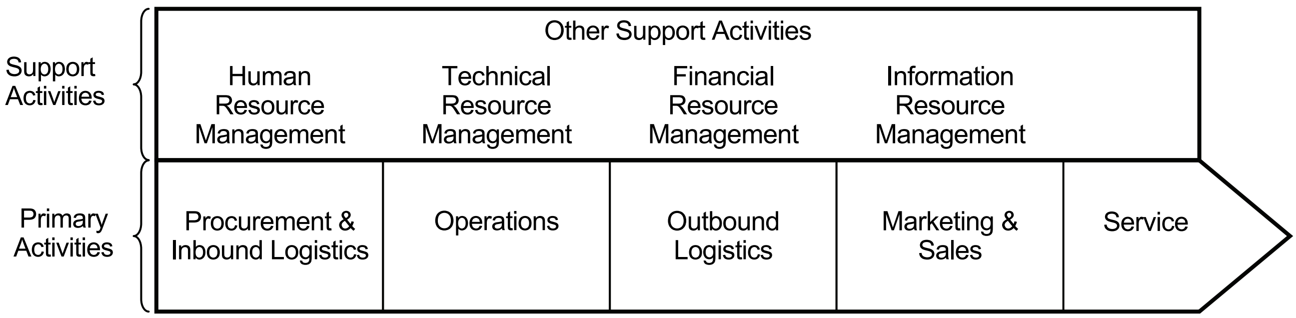
[213] Porter: Competitive Advantage: Creating and Sustaining Superior Performance (1985) p. 41

Procurement[214] supports primary activities, if the procurement function is able to meet the material requirements related to inbound and outbound logistics, and, normally more important, related to operations. Operations, consisting of production and production related activities, have different characteristics in different companies. Usually production operations can be classified to: (1) make to stock (MTS), (2) make to order (MTO), and (3) engineer to order (ETO).

Procurement may be also related to supplying products and services for the other support functions. These purchases may vary a lot. The examples cover laboratory equipment, lease-cars for the sales force, computers for the administrative personnel, food and beverages, cleaning materials for housekeeping, etc. Some of the purchases to be made are routine, for example MRO -supplies. They may be repetitive and low in value. Other purchases may have some “project character”, if they are unique and of high value such as investment goods, capital equipment and buildings.

Järvinen[215] suggests a new way to present Porter's value chain, as illustrated in Figure 39. He partitions supporting functions according to various resource types and he combines procurement with primary activities, because it acquires the raw material from which the products are produced. Also, referring to the special emphasis needed for information and financial resources, he separates them from "Company Infrastructure" to be independent supporting functions. Furthermore, he combines procurement with inbound logistics and leaves some minor functions (if there are any) to the remainder class "Other Supporting Activities". Järvinen claims that the resulting illustration has not lost anything from Porter's model (Figure 38), but presents the value chain in a new way.

Figure 39. Järvinen’s Proposal for the Presentation of the Value Chain



Computers and networks in the age of globalization (1998), p. 297

Value Shop

Stabell and Fjeldstad[216] call the value configuration of an intensive technology as a “value shop”. The primary value creation takes place in solving a customer’s or a client’s problems. The selection, combination, and usage order of resources and activities vary according to the requirements of the problem at hand. Thus, while the value chain performs a fixed set of activities to produce a standard product in large numbers, the value shop schedules activities and applies resources dimensioned and appropriate to the needs of the client’s problem. The client’s problem determines the ‘intensity’ of the shop’s activities.

The label “shop” means that a company is directed at a unique and delineated class of problems, similar way to a repair car shop. The shop metaphor denotes that the assembly and matching of problems and problem-solving resources are important for the organisation and the management

[214] Van Weele: Purchasing and Supply Chain Management (2002)
pp. 12-13

[215] Järvinen: Improving quality of drawings (1998)
In Munari, Krarup and Rasmussen (eds.): Computers and networks in the age of globalization, pp. 293-306

[216] Stabell and Fjeldstad: Configuring value for competitive advantage: On chains, shops, and networks (1998)
Strategic Management Journal, Vol. 19, No. 5, pp. 420-427

of the value shop. Problem-solving, and thus value creation in value shops, comprises the change from an existing to a more desired state. Problem situations involve cases requiring corrective actions and cases where there are improvement opportunities. The intensive technology is directed to bring desired changes to the client or the customer in some specific case.

There are five generic primary activity categories in value shops: (1) problem-finding and acquisition, (2) problem-solving, (3) choice, (4) execution, and (5) control and evaluation. The problem-finding and acquisition activities are associated with recording, reviewing and formulating the problem to be solved and choosing the overall approach to solve the problem. Problem-solving is associated with generating, applying and evaluating alternative solutions. Choice comprises the activities associated with selecting among alternative solutions. Execution activities are associated with communicating, organising and implementing the solution. Finally, control and evaluation control and evaluation activities are associated with measuring and evaluating the results; to what extent the implementation has solved the initial problem statement. Each category is divisible into a number of distinct activities that depend on the particular industry and company strategy.

Many of the support activities, such as human resource management, are co-performed with the primary activities. This might lead to the conclusion that they should be removed from the value shop diagram. Although these functions are not distinct, they are crucial to competitive advantage.

Value Network

Stabell and Fjeldstad[217] state that value networks link clients or customers who are or wish to be interdependent. The mediating technologies facilitate relationships among customers distributed in space and time. A company cannot form a value network, but the company might provide a networking service, as for example telephone companies, retail banks, insurance companies and postal services. The term “value network” underlines that a critical determinant of value to any particular customer is the set, or the network, of connected customers. Stated in communication terms, the value of a communication service depends on its capacity to enable the customers to communicate within the network.

The mediation object distinguishes the mediators. There are, however, strong similarities between the activities of various value networks even if the nomenclature differs from industry to industry. The primary activity description is inspired by the telecommunication industry, because telecommunication is a rather generic form of mediation. Also, explicit activity decomposition models are well established in telecommunication both at the micro level of peer-to-peer communication and at the industry level in delineating industry actors.

The primary activities of the value network comprise: (1) network promotion and contract management, (2) service provisioning, and (3) network infrastructure operation. Network promotion and contract management consist of activities associated with inviting potential customers to the network, selecting customers allowed to join, and the initialisation, management and termination of contracts governing service provisioning and charging. Service provisioning includes activities associated with establishing, maintaining and terminating links between customers, and billing for the value received. The links can be synchronous (telephone service), or asynchronous (electronic mail service, banking). Billing requires measuring customers’ use of the network capacity. The network infrastructure operation consists of activities associated with maintaining and running a physical and information infrastructure.

[217] Stabell and Fjeldstad: Configuring value for competitive advantage: On chains, shops, and networks (1998) Strategic Management Journal, Vol. 19, No. 5, pp. 427-433

Among the support activities of the value network, there are two distinct but related technology development activities: network infrastructure development (including design, development and implementation of the network infrastructure) and service development, which comprises everything from the modification of contract terms to the development of brand new services, e.g. voice mail services in a telephone company. It also includes modifications to the company-customer interface. Procurement, often specialised, is heavily linked to the network infrastructure and service development. Similarly, infrastructure and service development often have specialised human resource management functions. Company infrastructure, i.e. general management, financing and management information systems, should not be confused with the value network infrastructure. The former facilitates operating the company, while the latter focuses on creating value for customers.

Comparison of Value Configuration Models

Introducing three distinct value configurations helps to clarify the critical value analysis assumptions[218]. Table 11 summarises the main differences of the three value configurations. Distinctive value creation technologies are the critical reference point between the configurations.

Table 11. Comparison of Value Configuration Models

	Value Chain	**Value Shop**	**Value Network**
Value creation logic	Transformation of inputs into products	(Re)solving customer problems	Linking customers
Primary technology	Long-linked	Intensive	Mediating
Primary activity categories	• Inbound logistics • Operations • Outbound logistics • Marketing • Service	• Problem-finding and acquisition • Problem-solving • Choice • Execution • Control/evaluation	• Network promotion and contract management • Service provisioning • Infrastructure operation
Main interactivity relationship logic	Sequential	Cyclical, spiralling	Simultaneous, parallel
Primary activity interdependence	• Pooled • Sequential	• Pooled • Sequential • Reciprocal	• Pooled • Reciprocal
Key cost drivers	• Scale • Capacity utilisation		• Scale • Capacity utilisation
Key value drivers		• Reputation	• Scale • Capacity utilisation
Business value system structure	• Interlinked chains	• Referred shops	• Layered and interconnected networks

Stabell and Fjeldstad: Configuring value for competitive adv…, Strategic Management Journal 19:5 (1998), p. 415

5.1.2. PROCUREMENT PROCESS MODELS

The procurement process[219] can be described as a sequence of individual activities, culminating in the purchase of the item fulfilling the requirements. I present three procurement process models: the supplier-oriented, item-oriented and fast tracking model. The supplier-oriented and item-oriented procurement models are considered as general procurement models, also very applicable in project

218 Stabell and Fjeldstad: Configuring value for competitive advantage: On chains, shops, and networks (1998) Strategic Management Journal, Vol. 19, No. 5, pp. 414-415

219 Parkinson and Baker: Organizational Buying Behaviour (1986) p. 79

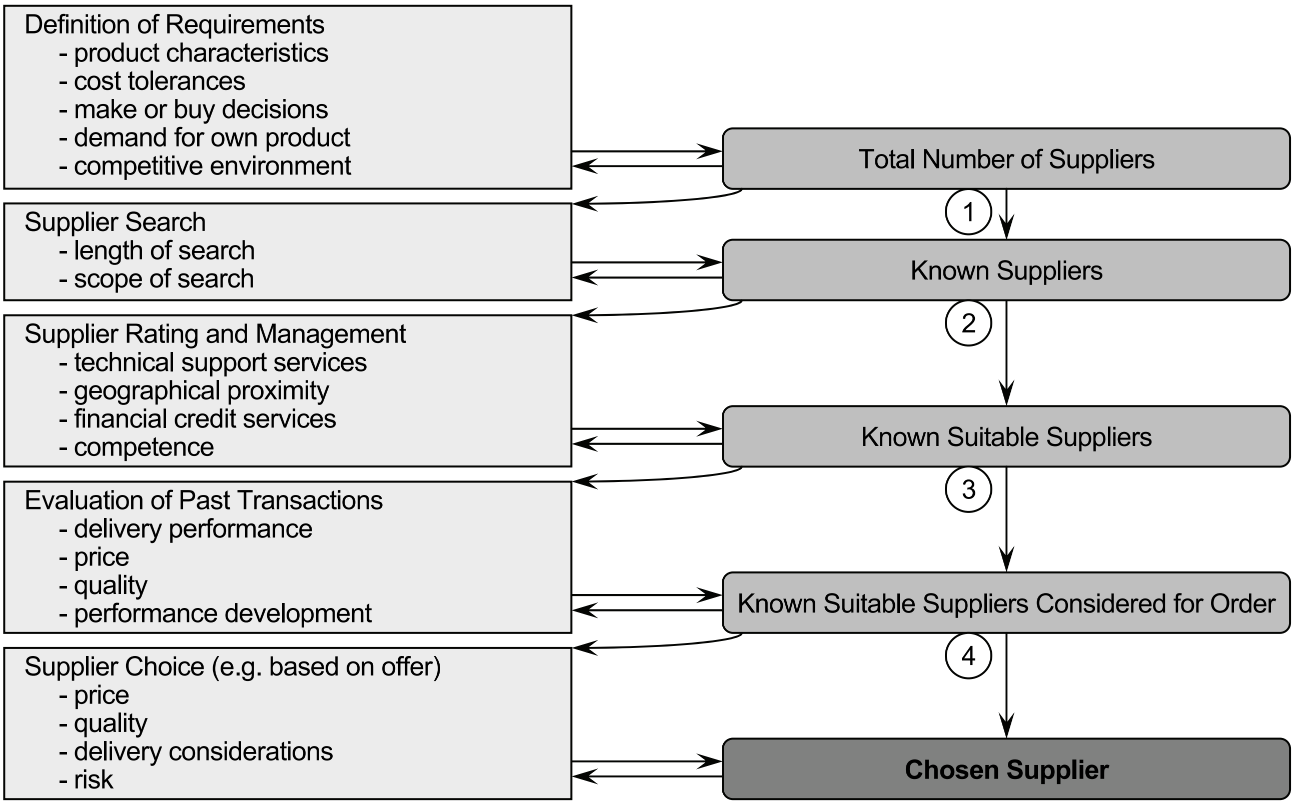
environments. The fast tracking procurement model illustrates special features of procurement in project environments. Fast tracking is based on a concurrent engineering model; the activities of engineering, procurement and implementation are overlapping.

The practice can, of course, be very different from these theoretical illustrations. However, the representations are useful for descriptive purposes. They support various practical observations, intuitive conclusions and guide purchasing tasks. However, they should not be taken literally as a managerial model since they lack any predictive power or causative explanation of buying decisions.

Supplier-Oriented Model

Parkinson and Baker's organisational buying decision model[220] represents a supplier-oriented procurement approach. The model describes the supplier selection, starting from all the possible suppliers of the required item, and ending in finding the actual supplier for the goods, as illustrated in Figure 40. It is an eliminating process carried out in order to find the proper supplier. The model gives a simplified view of the purchasing process and omits recycling in the framework. In reality, some stages can be omitted and there is likely to be a considerable amount of iteration within the process.

Figure 40. Organisational Buying Decision Model



Parkinson and Baker: Organizational Buying Behaviour (1986), p.79 (adapted)

The organisational buying decision model begins with the definition of the requirement. The supplier search identifies suppliers who appear to be able to satisfy the requirements. Usually not all the potential suppliers are found – the number of the recognised potential suppliers depends on the thoroughness of the search. In the supplier rating and management process the buyer reduces the number of candidates to the suppliers deemed suitable for the needs of the company.

220 Parkinson and Baker: Organizational Buying Behaviour (1986) pp. 78-82

The selection of the supplier candidates for an order depends greatly on the purchasing situation, i.e. straight rebuy, modified rebuy or new buy. Past relations with individual suppliers are likely to influence the selection of suppliers to whom the inquiries are sent. The supplier status in terms of its capacity, order load and delivery capability might also affect the candidate selection. Finally, at the supplier choice stage the buyer will compare individual offers and make the decision to order the goods. The buyer might also split the order between most promising suppliers. Sometimes the buyer refrains from buying. He might try to find a better product, supplier or contract terms.

Item-Oriented Model

Wilson has presented an extended purchasing process model[221], which illustrates a classical item-oriented procurement process. It puts the emphasis on the items to be bought. The process comprises twelve discernible procurement stages, which may overlap or be omitted, depending on circumstances. Wilson's extended purchasing process is summarised in Table 12 below.

Table 12. Extended Purchasing Process

Stage	**Description**
1. Requirements	A need is recognised.
2. Analysis and assessment	Analysis and assessment of provisional specifications, probable order sizes and frequencies, possible costs, make/buy decision, and profiles of potential suppliers.
3. Criteria setting	Identifying and ranking the most important purchasing conditions.
4. Negotiation	Quotation requests, prototyping, pilot studies, trials, visits to suppliers' premises and reference sites, pursuit of references, capacity, and liquidity assessment.
5. Value engineering	Systematic evaluation of shortlisted suppliers. Searches the most able supplier to fulfil the needs at the lowest net cost, all relevant aspects considered.
6. Decision	In the broader context, decision is the outcome of the previous stages. The final negotiations may be conducted at senior levels to adjust any residual uncertainties until agreement is struck with one favoured supplier.
7. Delivery and receipt	Delivery terms have been agreed on in the contract but receiving procedures are often overlooked. However, they can vary considerably and can cause administrative confusion, frustrating delays, deterioration of goods, and problems of disputed payment.
8. Inspection	Carried out on arrival and before receipt. It may not be practical because of the weather, the nature of packaging, the type of good/service, or congestion in the receiving area.
9. Storage	Storing of the goods is preferably only brief, but this will vary according to contract terms, storage life, cost of storage, safety stocks, and so on.
10. Payment	The key stage in purchasing. Legitimises the ownership of the goods.
11. Review	Reviews of procurement should take account of the views of production and financing; including scrap and obsolescence rates, delivery performance, quality control, and the compatibility of the goods with proposed changes to product design or production systems.
12. Reassessment	This stage takes place in anticipation of major changes in design, suppliers or technology.

Fast Tracking Model

The fast tracking model is widely used in project environments in which engineering, procurement and implementation overlap. The approach has tremendous potential in addressing the three key issues of quality, cost and time. The approach is a three-way winner by increasing quality, reducing

[221] Wilson: Purchasing Process (1998)
In Cooper and Argyris (eds.): The Concise Blackwell Encyclopedia of Management, pp. 537-538

cost and reducing cycle time. The fast tracking model in procurement is based on concurrent engineering[222, 223, 224], which emphasises the overlapping of project phases supported with early purchasing and supplier involvement. All this results in greater customer value, leading to customer satisfaction and long-term loyalty of valued customers.

Effective concurrent engineering requires early, and sustained, involvement by key suppliers. They have a major role in determining each of the three critical aspects of the project: quality, cost and time. The procurement function must be involved in identifying, evaluating and selecting the suppliers. The selection decision is conditioned by the influence that the supplier's product has on the desired quality attributes, coupled with its total cost, lead time requirements and performance reliability. Once the suppliers (or supplying partners) are selected, the organisations work to design and develop the optimal product, focused on the external customer's quality requirements. This up-front participation by suppliers is commonly called early supplier involvement.

O'Neal[220] states that the concurrent engineering approach is customer-focused to product and process design. The traditional sequential approach incorporates some downstream customer requirements after the recognising them, through engineering changes. Concurrent engineering attempts to identify these requirements up front, and strives to accommodate them into the initial design. The two key features of concurrent engineering are (1) customer focus centering on doing the right things, and (2) cycle time reduction focusing on doing them right the first time.

Yeo and Ning[221] state that each engineering project is unique even if similar design is involved. This makes procurement planning unique for each project. For example, a new site condition, a new client in a different country or new suppliers can lead to new project requirements. The considerable overlapping of the engineering/design stage with the procurement stage increases uncertainties. The procurement decisions on long lead-time items are usually made soon after the preliminary designs and before the construction designs and drawings are completed. The uncertainty of procurement may affect the entire construction process and overall project schedule.

Yeo and Ning propose that the focus in a concurrent engineering, procurement and construction project (EPC project) should be placed on procurement covering bulk construction materials, major equipment and services. They underline the importance of procurement and logistics to meet on-site requirements as a major area of constraint and opportunity, which can be exploited to dramatically improve the overall performance of project delivery.

The critical importance of procurement is due to at least nine separate reasons: (1) the procurement function connects engineering and construction. Purchased materials are the foundation of constructed facilities, (2) material costs represent a major portion of total costs in any EPC projects, (3) procurement is highly dependent on external companies, who are suppliers and subcontractors, (4) procurement needs a lot of communication and negotiation with these external parties, (5) control is not as strong as in engineering and construction, especially in outsourcing and purchasing equipment with long lead-time, (6) unlike in the manufacturing industry, neither the major equipment suppliers nor the client keep a buffer inventory for the project, (7) the major equipment is costly and requires a long lead-time to manufacture, (8) suppliers and prime contractors separately use time buffers to protect themselves from uncertainty arising from unforeseen circumstances, and (9) successful procurement management can lead to superior performance in project cost and delivery.

[222] O'Neal: Concurrent Engineering with Early Supplier Involvement: A Cross-Functional Challenge (1993) International Journal of Purchasing and Materials Management, Vol. 29, No. 2, pp. 3-9

[223] Yeo and Ning: Integrating supply chain and critical chain concepts in engineer-procure-construct (EPC) projects (2002) International Journal of Project Management, Vol. 20, No. 4, pp. 253-262

[224] Caron and Marchet: Project logistics: integrating the procurement and construction processes (1998) International Journal of Project Management, Vol. 16, No. 5, pp. 311-319

Love, Gunasekaran and Li[225] claim that the procurement function has a fragmented approach towards the delivery of construction projects, which affects the project effectiveness. They claim that this is caused by current project practices which do not effectively encourage integration, co-ordination and communication between participants. They suggest that the concurrent engineering approach may significantly improve the way in which projects are procured.

There are also critical views towards concurrent engineering and fast tracking in project implementation. Tighe[226] claims that fast tracking has negative impacts on both the design and the construction of projects. He also claims that the benefits of fast tracking have been challenged. He sees fast tracking as a remedial step rather than a desirable alternative. Finally, he states that with proper planning, fast tracking would be unnecessary.

Comparison of the Procurement Process Models

I have introduced three distinct procurement process models: supplier-oriented, item-oriented and fast tracking models. Supplier-oriented and item-oriented models overlap significantly. The biggest distinction is the emphasis; how the procurement function divides the importance of the supplier and item in the procurement. Otherwise they are quite close to each other. The fast tracking model is very different. It tries to overcome the timing and specification uncertainties in project environments.

Procurement practices are highly situation sensitive, varying between people, organisations and industry branches. Therefore the comparison in Table 13 is useful only for descriptive purposes and is not meant to be exhaustive. The key idea is to show the differences between the models.

Table 13. Comparison of Procurement Process Models

	Supplier-Oriented	**Item-Oriented**	**Fast Tracking**
Applicability	General, supplier-oriented	General, item-oriented	Project environments
Key decision factors in purchasing (most cases)	Product quality, price, supplier reputation	Price, product quality, supplier reputation	Timing (available capacity), supplier reputation, product quality, price
Uncertainty in item specifications	Low	None	High
Supplier contribution	None to low	None to low	Low to high
Importance	Low to significant	Low to significant	Significant to crucial

5.1.3. ROLE OF PROCUREMENT IN PROJECT ENVIRONMENTS

The procurement function is concerned with obtaining all goods necessary for running, maintaining and managing the project; in principle this also includes contracting services. The importance of the procurement function can be deduced directly from the effect of (potential) savings on the capital to be invested. However, interesting indirect contributions can be achieved through innovations in items to be purchased and in the procurement process itself, reducing the total investment cost.

Last, the procurement function is under many changes. Tighter demands on quality, reduction of stocks and cutting down on lead times in logistics and project implementation cause tighter

[225] Love, Gunasekaran and Li: Concurrent engineering: a strategy for procuring construction projects (1998) International Journal of Project Management, Vol. 16, No. 6, pp. 375-383

[226] Tighe: Benefits of fast tracking are a myth (1991) International Journal of Project Management, Vol. 9, No. 1, pp. 49-51

demands on the suppliers. The procurement function is the logical body of project management in communicating these demands to the suppliers and to ensuring that they are met.

Direct Contributions of Procurement

The importance of procurement[227] for an organisation is primarily deduced from the effect of potential purchasing savings on the company profits. Every saved Euro will increase the profit with one Euro, if savings do not have any other influence on company operations. The importance of the procurement function can be explained by the financial impact of the procurement, which can be illustrated by return on net assets (RONA) calculations. A small saving in purchasing costs can lead to remarkable improvement in RONA, because purchasing savings improve RONA in two ways.

First, RONA is improved through reduction of all direct materials costs. This will immediately lead to an improvement of the company's sales margin, which in turn will increase RONA. A number of purchasing actions may lead to lower direct materials costs, such as introducing new suppliers, competitive tendering, looking for substitute materials, etc.

Second, RONA is increased through a reduction of the net capital employed by the company. This will affect the company's capital turnover ratio positively. There are many measures which will lead to a lower capital employed. Examples include longer payment terms, reduction of inventories (just-in-time agreements), supplier quality improvement (smaller buffer stocks required) and leasing instead of buying equipment.

Indirect Contributions of Procurement

Apart from immediate savings, the procurement can also improve the company's competitive position in a more indirect manner[228]. In practice, indirect contributions often turn out to be more substantial than direct savings in procurement (i.e. exclusively by purchasing). An indirect contribution can take place, for example as (1) product standardisation, (2) stock reduction, (3) product and process innovation, (4) reduction of quality costs (costs related to inspection, rejection and repairs), (5) increasing flexibility, and (6) fostering purchasing synergy.

Product standardisation is aimed at cost reduction through decreasing product variety. Another way to stock reductions includes imposing and enforcing a solid discipline on the suppliers to follow the scheduling of deliveries. Also special stock arrangements can be organised with suppliers, e.g. consigned stock agreements. The ultimate goal in stock reduction is to minimise the capital employed.

The procurement can minimise quality costs related to the materials purchased. When suppliers deliver products, many companies conduct both an incoming and a quality inspection. The costs of inspections can be reduced by selecting the suppliers wisely. The supplier should have their production well under control and have sound quality management procedures. However, quality improvement should be given first priority.

The procurement can also increase flexibility and foster purchasing synergy. Flexibility sets high requirements to the suppliers' performance. Particularly, flexible manufacturing systems with just-in-time scheduling demands steady deliveries from the suppliers. The procurement will impose these demands on the selected suppliers. In general, a procurement policy aiming at improving supplier

[227] Van Weele: Purchasing and Supply Chain Management (2002) pp. 17-22
[228] Van Weele: Purchasing and Supply Chain Management (2002) pp. 20-22

performance will definitely benefit the company's competitiveness. Purchasing synergy might evolve, if a company can co-ordinate contracting of common materials from a smaller supplier base.

Furthermore, Wynstra[229] shows in his doctoral dissertation that the purchasing function and suppliers can play an initiating role regarding innovation processes. Purchasing can actively contribute to a continuous innovation and improvement of products by supporting and enhancing communication between both parties. It has been demonstrated that successful industrial innovations can follow from an intensive interaction between suppliers and buyers[230].

Procurement Trends

Many companies are confronted with diminishing growth opportunities; a turnover can be increased only through the competition of the market shares. This leads to increased pressure on sales prices and consequently on margins and costs, which in turn causes two major development trends: (1) a power shift from seller's markets to buyer's markets, making the role of the buyer more dominant than earlier, and (2) increasing pressure on sales prices and margins, resulting in an increased pressure on direct material-related costs.

As a result of these development trends above, the procurement has undergone several major changes[231]. The following examples do not make an exhaustive list of the changes, but gives an idea of the current development in procurement. The major changes include: (1) increased co-ordination of purchasing requirements, (2) integration of purchasing in logistics, engineering and production planning, (3) growing use of the purchased components, subassemblies and services, (4) reciprocity agreements and compensation obligations, (5) total quality control and just-in-time production, (6) advance of modern information technology, and especially the Internet, challenging traditional purchasing strategies and solutions, and (7) environmental issues.

5.2. PROCUREMENT BY PMBOK

The *PMBOK Guide* provides an overall presentation of best practices, tools and techniques of procurement in project environments. The *PMBOK Guide* summarises procurement nicely as a part of project implementation. It says that procurement[232] comprises processes required to acquire goods and services to attain project scope from outside the performing organisation. Most of the discussion, however, is equally applicable to formal agreements between the units of the performing organisation. Procurement is discussed from the perspective of the buyer in the buyer-seller relationship. The buyer-seller relationship can exist at several levels of one project. Depending on the specific case, the seller may be called a subcontractor, a vendor, or a supplier.

Procurement[233] consists of (1) procurement planning, (2) inquiry planning, (3) inquiry processing, (4) source selection, (5) contract administration, and (6) contract closeout. These processes interact with each other and with other processes in other knowledge areas. Each phase is discussed in more detail in its dedicated subsection below. Although the processes are presented as discrete elements with well-defined interfaces, they may overlap and interact in ways not described here.

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[229] Wynstra: Purchasing involvement in product development (1998), 320 p.

[230] von Hippel: Successful Industrial Products from Customer Ideas (1978) Journal of Marketing, Vol. 42, No. 1, pp. 39-49

[231] Van Weele: Purchasing and Supply Chain Management (2002) pp. 23-25

[232] PMI: A Guide to the Project Management Body of Knowledge (PMBOK Guide) (2000) p. 191

[233] PMI: A Guide to the Project Management Body of Knowledge (PMBOK Guide) (2000) pp. 147-159

The seller typically manages his work as a project. This implies that the buyer eventually becomes the customer making the buyer a key stakeholder for the seller. The seller's management must be concerned with all the processes of project management, not only the procurement processes of the project. The contract becomes a key input to many of the seller's processes. For example, the contract contains information of major deliverables, key milestones and cost objectives. The contract may limit the project team's options (e.g. buyer approval of staffing decisions on design projects).

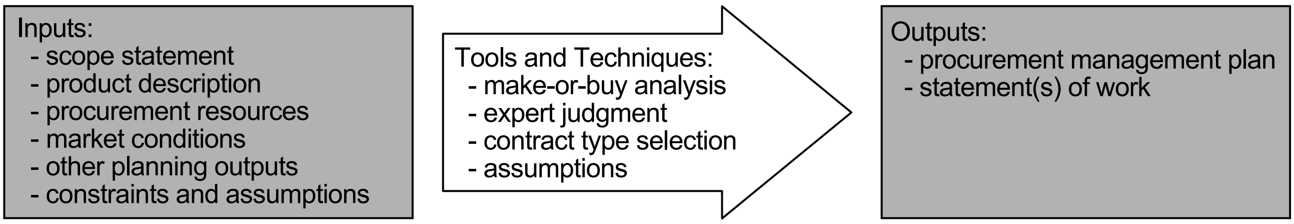
The procurement processes are described and illustrated with inputs, tools and techniques and output figures. Inputs are documents or documentable items that will be acted upon. Tools and techniques are mechanisms applied to the inputs in order to create the desired outputs. Outputs are documents or documentable items resulting from the process. The outputs of the previous process are usually the key input in the next procurement process.

Procurement Planning

Procurement begins with the procurement planning phase, illustrated in Figure 41, determining what to purchase and when. It identifies the needs which can be best met by procuring products or services from outside the project. Procurement planning is accomplished during the project scope definition phase, involving considerations and decisions of whether to procure, how to procure, what to procure, how much to procure, and when to procure. When the project obtains products and services, the processes from inquiry planning to contract closeout will be performed. The project management team may seek support from specialists in contracting and procurement. They may be involved as members of the project team.

Procurement planning should also include consideration of potential sellers. Particularly so, if the buyer wishes to exercise some degree of influence or control over the contracting decisions. When the project does not obtain products and services outside the performing organisation, the processes from inquiry planning to contract closeout will not be performed.

Figure 41. Procurement Planning



The procurement management plan describes how the procurement processes will be managed. The plan may be formal or informal, highly detailed or broadly framed, according to the needs of the project. It is a subsidiary element of the project plan. For example, the procurement management plan can address the following questions:

- What contract types will be used?
- Who will prepare independent estimates and when, if they are needed for evaluation?
- What actions can other teams take independently without the procurement personnel?
- Where are the standardised procurement documents placed?
- How will multiple suppliers be managed?
- How will procurement be co-ordinated with scheduling, performance reporting and other project aspects?

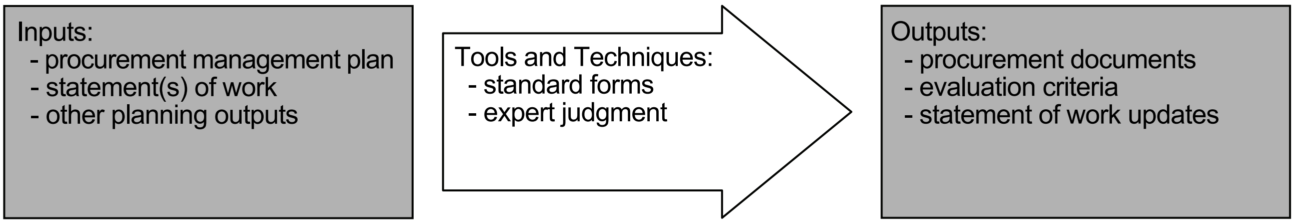
The statement of work describes the item. It is done in sufficient detail to enable prospective sellers to determine if they are capable of providing the item. The accuracy of the item description varies according to the nature of the item, the needs of the buyer, or the expected contract form.

Inquiry Planning

The inquiry planning phase, presented in Figure 42, consists of specifying product requirements and identifying potential suppliers. Inquiry planning involves preparing the documents needed in the inquiry processing. Procurement documents are used to invite proposals from prospective sellers.

The term "proposal" is generally used when other considerations, such as technical skills or technical approach, are paramount. The terms "bid" and "quotation" are normally used in buying commercial or standard items, when the selection will be mostly based on price. However, all the terms are often used interchangeably. One should be careful not to make unwarranted assumptions about the implications of the term used. Common names for different procurement documents types include: “Invitation for Bid”, “Request for Proposal”, “Request for Quotation”, “Invitation for Negotiation” and “Contractor Initial Response”.

Figure 42. Inquiry Planning



Procurement documents should be structured to aid and facilitate accurate and complete responses from prospective sellers. The procurement documents should be rigorous enough to ensure consistent, comparable responses, but flexible enough to allow seller suggestions for better ways to satisfy the requirements. They should always include the relevant statement of work, a description of the desired form of response and any required contractual provisions. In the public sector, some or all of the content and structure of procurement documents may be regulated by legislation.

Evaluation criteria are used to evaluate, rate or score proposals and the criteria are usually included in the documentation. The criteria may be objective (e.g. the capacity of a pump) or subjective (e.g. configuration of pump manuals). The criteria may be limited to purchase costs if the item is available from numerous sources. Purchase costs include both the price of the item and ancillary expenses, such as delivery. When cost is not the only decisive factor, the other criteria must be identified and documented to support the assessment; the purchasing decision might include evaluation of:

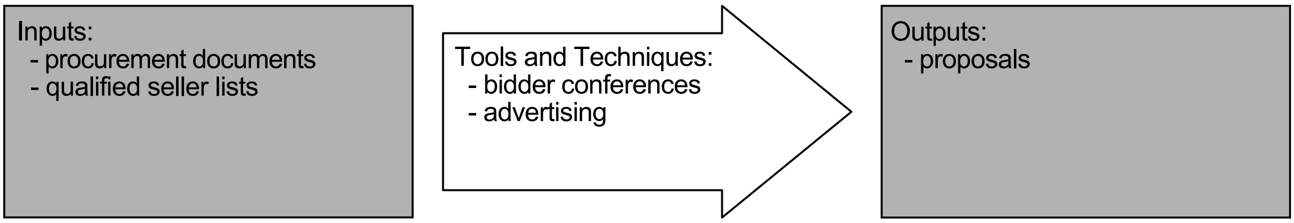
- Understanding the needs (the seller’s proposal should demonstrate the understanding)
- Overall or life-cycle costs (the seller should produce the lowest total cost, i.e. the lowest total of purchase cost and operating cost)
- Technical capability (the seller has needed technical skills and knowledge)
- Management approach (the seller has adequate management resources for the project)
- Financial capacity (the seller has the necessary financial resources)

The updated statement of work consists of modifications to one or more statements of work. They may be identified during inquiry planning.

Inquiry Processing

The Inquiry processing phase, illustrated in Figure 43, covers obtaining tenders, quotations, bids, offers, or proposals, as appropriate. It involves obtaining responses (bids and proposals) from prospective sellers on how the needs of the project can be met. Most of the actual work in the inquiry processing stage is expended by the prospective sellers, normally at no cost to the project.

Figure 43. Inquiry Processing



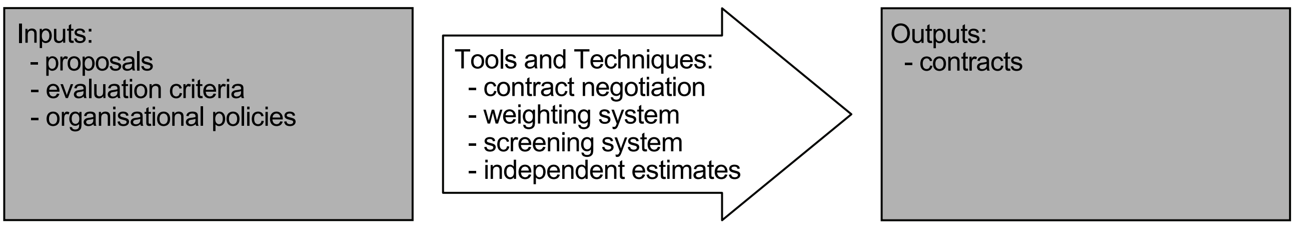
Proposals are seller-prepared documents that describe the seller's ability and willingness to provide the requested item. They are prepared in accordance with the requirements of the relevant procurement documents. The proposals may be delivered with a supplementary oral presentation.

Source Selection

Source selection (presented in Figure 44) means selection among the potential sellers of the product. Source selection involves receiving bids or proposals and applying evaluation criteria to select a supplier. Many factors aside from cost or price may need to be evaluated in decision-making. Price may be the primary determinant for an off-the-shelf item, but the lowest proposed price may not be the lowest cost. The seller might prove to be unable to deliver the product in a timely manner causing additional costs. Proposals are often separated into technical and commercial sections. The sections have to be evaluated separately. Later, the summary includes both sections.

On major procurement items, the source selection may be iterative. A short list of qualified sellers may be selected after preliminary proposals. Later, a detailed evaluation will be conducted based on a more detailed and comprehensive proposal. Finally, a contract is made to clarify the purchase.

Figure 44. Source Selection



A contract is a mutually binding agreement between a seller and a buyer. It obligates the seller to provide the specified product and the buyer to pay for it. A contract is a legal subject to remedy in a court of law, if necessary. The agreement may be very simple or truly complicated. A contract may be called with various names, such as an agreement, a subcontract, a purchase order, a call-off or a memorandum of understanding. Most organisations have documented policies and procedures defining who can make agreements on behalf of the organisation.

All project documents are subject to some form of review and approval, and contracts do not make an exception. The legally binding nature of the contract means that contracts will be subjected to a more extensive approval process. In all cases, the review and approval process focus on ensuring that the contract describes a product or service that will satisfy the identified need. In major projects undertaken by public agencies, the review process may even include public review of the agreement.

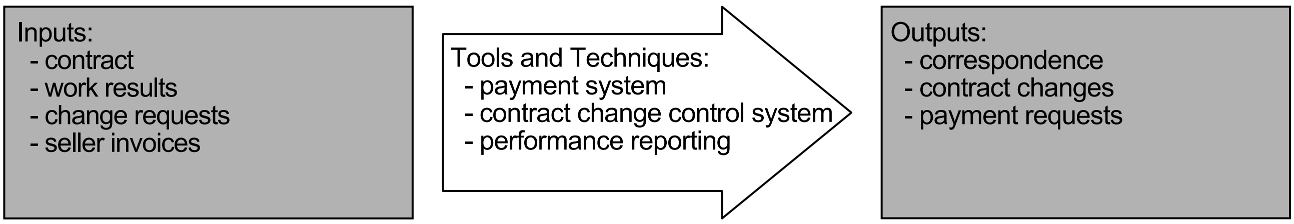
Contract Administration

The contract administration phase, illustrated in Figure 45, is carried out to manage the relationships with the seller. Contract administration aims at ensuring that the seller meets the contractual requirements. In larger projects, a key aspect of contract administration is managing the interfaces between the various providers. The legal nature of the contract relationship makes it imperative that the project team is aware of the legal implications of actions taken when administering the contract.

Contract administration includes application of the appropriate management processes to the contract relationship(s). It also consists of integration into the overall management of the project. This integration and co-ordination will often occur at multiple levels if there are multiple sellers and multiple products involved. The applied project management processes must include project plan execution (to authorise the contractor's work at the appropriate time), performance reporting (to monitor contractor cost, schedule and technical performance), quality control (to inspect and verify the adequacy of the contractor's product), and change control (to ensure that changes are properly approved and all the necessary parties are informed of the changes).

Contract administration also has a financial component. The payment terms should be defined in the contract and they must build a specific linkage between the seller's progress made and seller's compensation paid.

Figure 45. Contract Administration



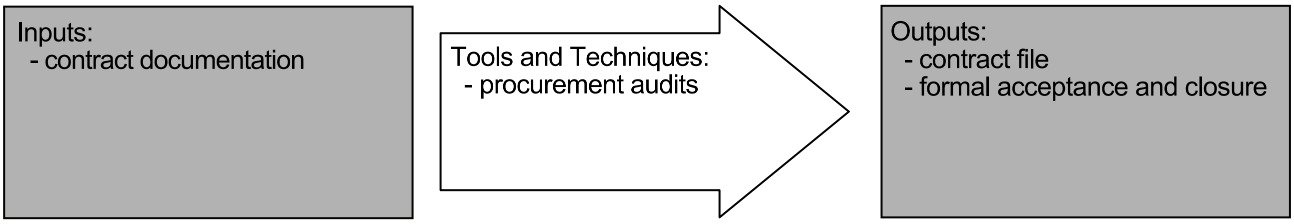
Correspondence comprises formal buyer-seller communication. Contract terms and conditions often require written documentation of some delivery aspects, such as warnings of unsatisfactory performance and contract changes or clarifications. Contract changes (approved and unapproved) are fed back through the appropriate planning and procurement processes, and the relevant documentation is updated as appropriate.

Payment requests authorise payments to the supplier. Payment requests are used, if the project uses an external payment system. If the project has its own internal system, the output would simply be payments.

Contract Closeout

Finally, the contract closeout phase, illustrated in Figure 46, takes place on the completion and settlement of the contract, including resolutions of any open items. The contract closeout is a kind of administrative closure. It involves both product verification (everything was completed correctly and satisfactorily) and administrative closeout (updating records reflecting final results and archiving information for future use). The contract terms and conditions may prescribe procedures for the contract closeout. A termination of a contract without delivery is a special case of contract closeout.

Figure 46. Contract Closeout



A contract file is a complete set of indexed contract records. The contract files should be prepared for inclusion with the final project records. Formal acceptance and closure is a written notice that the contract has been completed. Requirements for formal acceptance and closure are normally defined in the contract. The contract administration personnel should provide the notice to the supplier.

5.3. PROCUREMENT BY PÖYRY

This section is based on the *Procurement Manual*, although the content has been heavily modified. Most of the changes are due to the switch from the document-based view to the process-based view. The original text was ground down to bits and pieces, consisting of only the ideas of procurement in project implementation. This presentation is composed of these ideas and they are presented following the process-based view. The switch was necessary, because the process-based view was badly needed in the redesign of procurement and application development.

The best practice approach was more apparent when Jorma Halmepuro renewed the *Procurement Manual*[234] published in 1991. The aim of the manual was to establish the methodology to be used in the procurement function at Pöyry Oyj. The manual facilitates information transfer, training and resources utilisation with the company. It presents recommended procurement practices, guidelines and instructions, and advises in purchasing and contracting procedures of industrial projects. The *Procurement Manual* is widely considered to describe industry level best practices of procurement in industrial plant projects.

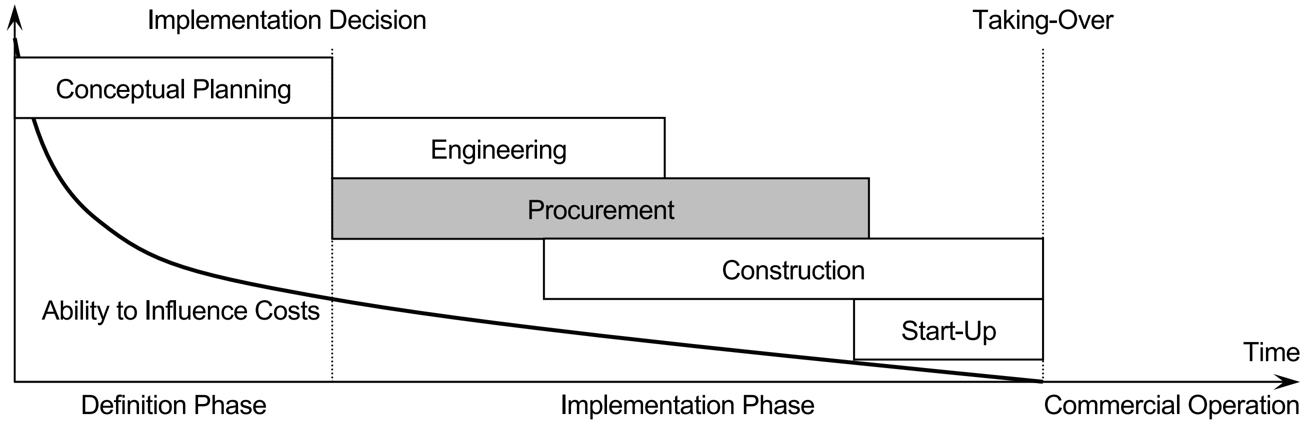
Procurement in Project Implementation

The thorough evaluation of all matters concerning financing and purchasing conditions is a critical task of project management during the initial project stages. Procurement of equipment and services comparably early is seen vital to the success of an industrial plant project. Procurement is recommended to be done in multiple, logical packages according to the progress of engineering. Procurement in project implementation is illustrated in Figure 47 on the next page.

[234] Pöyry Oyj: Procurement Manual (1991)

Procurement is intimately connected with engineering in industrial plant projects. Although it is crucial that procurement is in line with engineering, it is vital that it follows the selected procurement policy and local practices. Procurement should provide valuable results to the owner for his decision-making to meet cost, schedule and quality requirements.

Figure 47. Procurement in Project Implementation



Pöyry Oyj: Procurement Procedures, Appendix II/1 (adapted)

Organising Procurement in Projects

Procurement can be organised in three ways in project management. Each of them is based on a specific contract. The procurement responsibilities can be defined in a (1) main contract, (2) general engineering contract, or (3) project management contract.

If procurement is organised in the main contract, the engineering and project management, including procurement, are managed by the main engineering or the main consultant company. If the general engineering contract controls procurement, the future owner of the plant will control and manage the procurement function, starting from the comparison of tenders –stage. The owner might be involved already in earlier stages, like inquiry specifications and inquiry processing. Procurement and contract administration can be organised also by a project management contract.

Conceptual Planning of Procurement

The conceptual planning for procurement consists of selecting the procurement policy, establishing a procurement plan, developing a procurement schedule, and selecting appropriate contract models. Furthermore, the amount of the owner's participation in the purchasing must be clarified.

The procurement policy defines the recommended manner to purchase items; either piecewise or grouped into commercial or functional packages supplied by one or more suppliers. It is said that the procurement policy determines the implementation method of the project. It is equally true to claim that project implementation method determines the procurement policy.

I have described in Section 4.3 four project implementation methods: the construction manager method, the supplier packages method, the turnkey method and the lead consultant method. All of them carry their own features to procurement, thus having an effect on the procurement policy which has a definite and substantial impact on the success of the project. The owner's and consultant’s procurement knowledge plays an essential role in selecting an effective procurement policy.

Procurement planning in early project stages includes several tasks: identification of items with the longest purchasing time and items with high price inflation potential, inspections of prospective manufacturers, recognising the need and estimating the cost of major construction equipment, and customising purchasing procedures to fit the project.

The fast track project implementation method requires that the main purchases are made comparably early. It is recommended that area-specific process equipment with erection work are bought per area and all other equipment (as well as construction material) are bought in "horizontal packages" mainly by applying the unit price method.

The procurement schedule is subordinate to the target schedule and it has to follow the limits and the timing of the target schedule. All major contract parcels with an influence on the project implementation shall be included in the procurement schedules to avoid congestion. Thorough evaluation of all matters concerning financing and other conditions is a prerequisite for a realistic purchasing schedule. The creation of the purchasing schedule is one of the most important tasks for the project management in the initial stages of a project.

In the same way as procurement follows the pace of engineering, the project schedule depends to a great extent on the progress of purchasing. Changes in the planned purchasing schedule will influence the project schedule. If purchasing conditions change, it will first affect the procurement schedule and this way the project schedule. In most cases, the purchasing conditions are synonymous with the availability of cash or financing for the initiation of purchasing.

The requirements for establishing a meaningful procurement schedule are:

1) An early and final clarification of all matters related to financing. The availability and costs of local equipment, materials, supervision, and labour should be investigated. In some countries legislation includes restrictions concerning the importation of equipment.
2) An early definition of the procurement policy and purchasing routines to be followed.
3) An early definition of the start-up logic of the plant.

Procurement Flow

The major procurement phases are iterative. In principle, the same procurement tasks are carried out in every major procurement phase. The accuracy and elaborateness of the tasks grow along the major procurement phases. After the contract has been established, contract administration and cost control tasks are carried out to ascertain that the supplier's performance meets contractual requirements.

The procurement flow comprises three major procurement phases for investment items: a budget inquiry round, a tender inquiry round and final inquiry round. The budget inquiry round is carried out to ask a tender from several potential suppliers in order to establish the investment estimate. The tender inquiry round is processed to get a response to the purchase inquiry. The substance of the tender may still be amended considerably in mutual negotiations. The final inquiry round is carried out with the most successful negotiators of tender inquiry round. The final inquiry round establishes the supplier selection and continues to contracting, where the actual procurement flow ends.

The results of conceptual planning are used in the budget inquiry round to inquire budget tenders from the supplier candidates. Budget tenders provide the basic cost information for investment estimate, which supports the decision to implement or not to implement the plant.

If the decision to invest is made, the tender inquiry round begins. First, available information from basic engineering is organised as inquiry specifications. Purchase inquiries are sent to pre-selected supplier candidates who will answer to the inquiries with their tenders. The received tenders are compared. Mostly technical aspects of the tenders are studied and the most successful tenderers continue to negotiations. The tender inquiry round might end in a contract, if common understanding is achieved between the buying and the selling companies and all the contractual aspects are agreed upon. This would end the procurement flow of the item.

Normally, after negotiations, the final tender round is initiated. Final tender requests are sent to the most promising supplier candidates. They will answer to the inquiry with their final tender proposals. Technical, commercial and other tender aspects are carefully studied. The most successful tenderers continue to negotiations, which can lead to direct supplier selection or elimination of the least suitable supplier candidates. The contract negotiations require a thoroughly professional approach, as they are conducted in depth in a technical as well as financial and time scheduling respect. The result of the contract negotiations is a recommendation to the client, who makes the final decision. The “Award of the Contract” and its “Acknowledgment” finalise the contracting. The actual procurement flow ends in this stage.

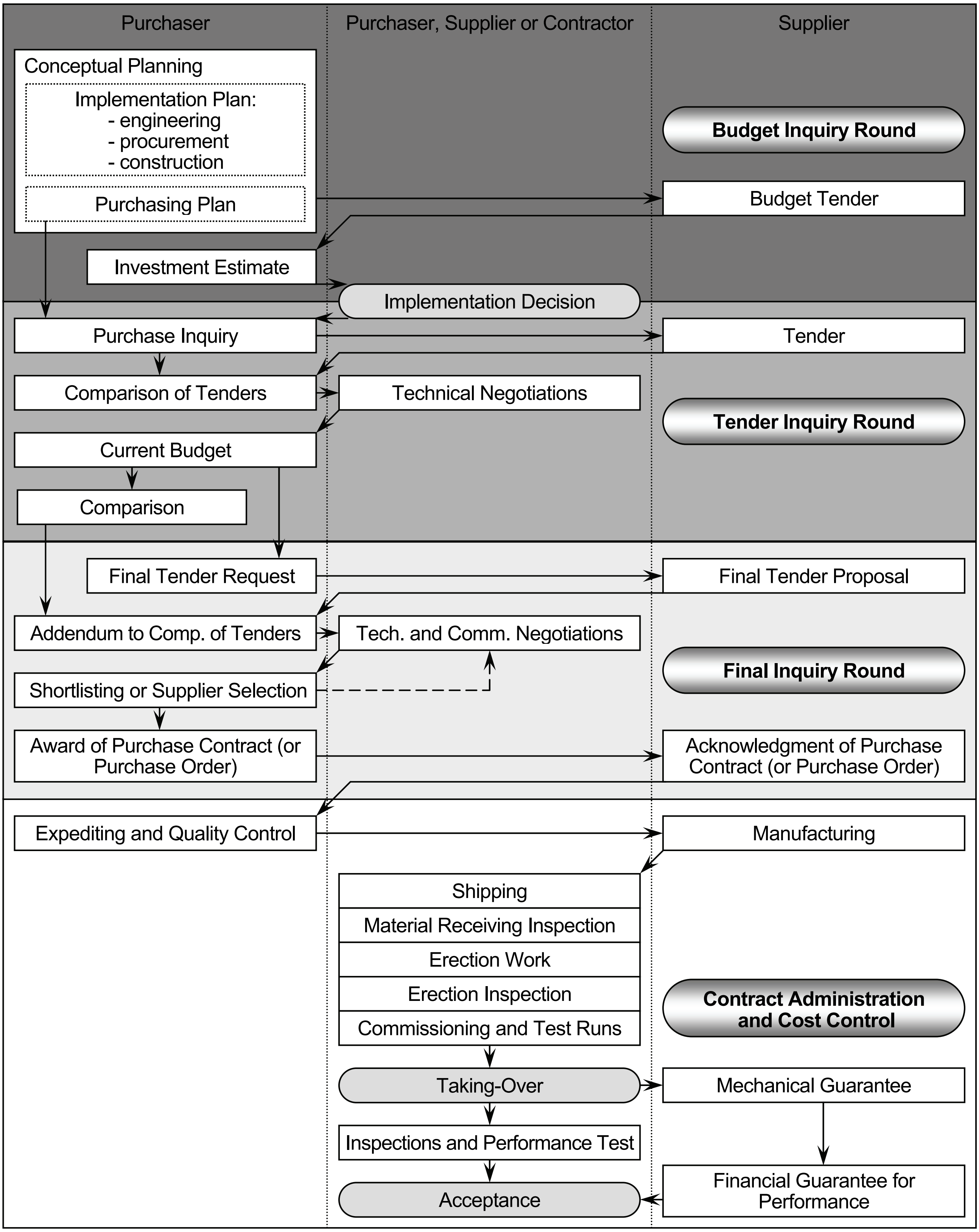
After the contract has been established and the actual procurement process has ended, contract administration and cost control tasks begin. They ensure that the supplier’s performance meets the terms of the contract. The tasks include expediting, material inspections, contract follow-up on site and contract closeout. Expediting is sometimes a neglected project activity, probably because the consequences of neglect expediting are revealed late. Normally they are noticed on the arrival of material to the site, making defects and delays irreversible. Inspections at supplier premises and reporting during manufacturing off the project site are necessary tools to secure adherence to the contract stipulations. The expediting work is based partly on delivery status and quality inspection reports sent by the supplier to the project organisation and partly on expediting visits to the supplier’s works. The subcontractors' works are also visited when necessary.

After the delivery of equipment, the contract follow-up is performed on site. It is one of the most pressing tasks on site to supervise and steer the progress of the contractor. The contract follow-up includes performance reporting (monitoring cost, schedule and technical performance), quality control (inspecting and verifying the adequate quality of the supplied equipment), and change control (ascertaining that the changes are necessary, approved of and all the parties are informed of the changes).

When the supplier has fulfilled its commitments, the contract will be closed. “Completion Certificates” are issued to constitute the end of the contractors' responsibility. There might still be some minor outstanding work and maintenance period duties. On completion of all work a “Final Completion Certificate” will be issued. If the final settlement leaves disputes regarding any aspect of the work, a claims procedure will be initiated. During the project it is advisable to clear the table of any disputes from time to time. The solved disputes have a positive effect on the general working climate.

Figure 48 (on the next page) illustrates the procurement flow. It presents major procurement phases, tasks and key decisions of a project. The tentative responsibility carrier of each task is proposed according to the construction manager method (applicable also in the supplier package method) to manage the project. Last, the figure shows contract administration and cost control tasks following the procurement tasks. These tasks do not belong to the scope of this study, but are necessary in successful project implementation.

Figure 48. Chronological Procurement Flow



Pöyry Oyj: Procurement Manual, Introduction, Annex I (adapted)

Contract Models

There is no absolute truth as to which pricing method or contract model should be used with a certain type of purchase. The following classification is not exhaustive; there are contract models that are not presented here, but can be applied in purchasing. Sometimes the buyer has an opportunity to choose between two or more contract models in seeking the most suitable bargain. Typically, contract models in large industrial plant projects include: (1) purchase contracts for supply with or without erection work, (2) purchase orders (3) blanket order agreements or specific purpose equipment, (4) blanket order agreements (unit price contracts), (5) call-off orders (release orders), (6) MEI (mechanical, electrical and instrumentation) and civil work contracts, and (7) construction manager's instructions (extra work orders at site).

The purchase contract model for supply with or without erection work is used for area-specific process equipment, service-specific process equipment (auxiliary process or standard equipment, i.e. refiners, agitators, pumps etc.), and shop-prefabricated tailor-made parts. The process equipment is purchased in the very beginning, since they determine the layouts and affect the main process design. They also have the longest delivery time. Shop-prefabricated tailor-made parts, such as chemical tanks, are produced in the supplier's workshop and delivered to the erection site as a package. Service-specific process equipment and shop-prefabricated tailor-made parts can be purchased also using purchase orders. Fixed pricing is used in these contracts.

Blanket order agreements with unit pricing or unit price contracts can be used for specific purpose equipment and construction materials. Specific purpose equipment includes the distributed control system, supervisory control system, mill-wide systems etc. The buyer can purchase general standard equipment, such as transformers, low voltage motors and pumps from adequately equipped special stores or directly from the manufacturers. Construction materials, such as steel beams, concrete, insulation materials and sawn timber, can be bought from a local hardware store or included in the MEI erection work or civil work contract. Call-off orders (release orders) are used to notify suppliers to make their deliveries.

MEI work comprises the installation work of the mechanical and electrical equipment, as well as instrumentation. Civil work contracts are used for earthmoving, construction work, low-voltage electrical installation and insulation of buildings etc. MEI and civil work contracts can include both material and labour or labour only. Verbal instructions for work are confirmations of verbal instructions given to a MEI work contractor or a supplier. These ad hoc orders can be used for minor tasks, such as cleaning and grass cutting. They can be used to react to surprises, basically anything starting from drying the materials after a flood etc. These contracts also use unit pricing. The unit price might be defined towards the volume of the type of work (earthmoving etc.), piece and length (piling), volume for each structure type (cast in site: basement floors etc.), type and volume of a part (prefabricated building parts: siding panels etc.), piece for each type (supplementary building parts: windows etc.), surface area (painting), length (railway tracks), area (road finishing), lump sum pricing (landscaping), depending on the nature of the work.

5.3.1. STANDARD PROCUREMENT DOCUMENTS

There are three main ways to standardise project documents: (1) standard documents, (2) standard document structures, and (3) standard layouts. Document standardisation saves valuable time and effort by limiting the amount of documentation in purchasing. It will also considerably speed up the utilisation of the procurement material and purchasing process. The document standardisation offers a particular advantage when the documents have to be translated to another language.

There are benefits in specifying all standard requirements in detail already at the inquiry specification stage, using standard procurement documents. They save much time and work at the purchase negotiations and contracting, because both parties are already acquainted with them. Normally, standard procurement documents are prepared in the conceptual planning stage of the project.

Standard procurement documents consist of general tendering instructions, mill standards and general purchasing conditions. The general tendering instructions inform the supplier candidates of the project and tendering process. The mill standards are issued in order to define the technical standards and quality level of the equipment to be purchased. The general purchasing conditions define commercial and legal aspects of the purchase.

Standard document structures ease the use of documents and make them easier to modify according to procurement needs. It is advisable to decide on the general grouping of technical data in the purchase contracts before the inquiries are sent out. Furthermore, the technical inquiry specification should be formed accordingly. Also amendments can be placed in a concentrated form in a specified document or a section of a document and carry them to the next procurement stage. It is an additional advantage that alterations to the amendments can easily be introduced even during the final negotiations.

Layouts of standard documents facilitate the use of documents. The information is located in the same place in each document. An inquiry covering letter is a good example. The body of the letter is the same in each letter, but the inquiry details change by the inquiry.

General Tendering Instructions

General tendering instructions give an overall view of the project, the mill and the tendering process. General instructions for tendering typically contain project specification, mill specifications for tendering purposes, principles for submission of tenders, delivery conditions, scope of the tender, obligations of the supplier and the purchaser, terms of payment and delivery and the time of delivery. The instructions are meant to be informative and they are supposed be attached to every purchase inquiry. “General Instructions for Tendering” may be issued in several versions: (1) detailed, (2) combined, (3) short, and (4) special versions.

Detailed versions of general tendering instructions contain a list of all technical and other stipulations issued for the project, preferably in the form of a check list to indicate which stipulations are applicable to the delivery, and attached to the purchase inquiry in question. Combined versions contain instructions, a complete set of mill standards, and a complete set of commercial and legal specifications and local conditions.

A short version of general tendering instructions is actually a summary of the main mechanical standards and the local conditions. Both the detailed and the short version might have to be issued in alternatives for imported and locally manufactured equipment. Special versions may be prepared for the purchase of certain equipment (electrical equipment, distributed control system, instruments, etc.).

Mill Standards

Mill standards are issued in order to define and maintain technical standards and quality level in the project. They inform prospective suppliers of the standards and mill conditions. Mill standards affect the equipment and service prices. The mill standards will, in an applicable number, be used as appendices to the purchase contracts. Mill standards consist of (1) technical specifications for pressure vessels, thermal insulation, piping, unpressurised tanks, surface treatment and painting of metallic surfaces, noise control and vibration abatement etc., (2) instructions for supplier's training and operating and maintenance manuals, and (3) general standards for inquiries and contracts.

General Purchasing Conditions

General purchasing conditions consist of commercial and legal considerations of the purchase. They define the supply of equipment or the provision of technical personnel for the erection supervision, erection and start-up of a plant. The purchasing conditions can be defined either by a well-known standard version or a special version of purchasing conditions. It is advantageous to use or refer to international or national general conditions, at least in inquiries. There are different standard versions of general conditions in common use:

- *General Conditions for the Supply of Plant and Machinery for Export*
  International standard version, prepared under the auspices of the United Nations Economic Commission for Europe, Geneva, March 1953.
- *General Contract Conditions*
  Multinational version, prepared by the Forest Industry Standardisation Group, Sweden.
- *General Conditions of Contract for the Supply of Equipment with or without Installation*
  National version, published in 1987 by the Standards Association of Australia.

General purchasing conditions for the supplies of equipment normally contain some open points. They define interest percentages, penalties and guarantee periods. Also, the general conditions for the provision of technical personnel are normally left undecided. The open points define the basic charges, daily allowances, hourly charges etc. These conditions have to be settled case by case with the suppliers. They may be also defined in the purchase contract text itself.

The general purchasing conditions in contracts vary a lot. Particularly, the appendices show a great variety. They can vary be from the size of a booklet down to one-page instructions printed on the backside of the purchase order forms. In any case, they have to be appended to purchase contracts. Some special commercial purchase conditions may also have been used. They define some details on payments, escalation, delivery terms etc. A typical example of standardised special conditions is Incoterms 2000 (trade terms in foreign trade published by ICC Publishing S.A.).

5.3.2. PURCHASING PROCESS

The aim of the purchasing process is to buy the most appropriate equipment or service according to the scope of the inquiry. The purchasing process covers inquiry specification, inquiry issuing, comparison of tenders, negotiations and contracting phases. In the real world, the procurement flow is iterative with feedback loops and reappearing sequential stages.

Purchasing is an iterative process which is normally carried out three times for expensive investment items. First, a budget inquiry round is carried out to establish the investment estimate. Second, a tender inquiry round is processed to ask a response to the purchase inquiry. Third, a final inquiry round is carried out to select an appropriate supplier and to make a contract.

Inquiry Specifications

Inquiry specifications define the scope of the purchase. They comprise technical, commercial and legal specifications of the purchase. It is common that some questions are still open when the first set of purchase inquiries is sent out. In these cases, incomplete versions of specifications have to be issued, although not all the details are established in time. Later, the incomplete inquiry specifications must be supplemented as soon as possible. However, no purchase inquiries should be sent out before the technical specifications are available and approved.

Inquiry specifications are prepared jointly by the engineering staff and the project management team. The engineering provides specifications, drawings and technical conditions. The project management team takes care of financial documents. The compilation of the tender documents requires a high level of skill because totally comprehensive documents cannot be produced at this stage of the project.

The purpose of the detailed inquiry specifying is twofold. First, the aim is to obtain clear, complete and comparable tenders. The second purpose is to transfer to prospective suppliers as much as possible of the known technical information (specifications, stipulations and other conditions). The inquiry specification process covers (1) equipment specifications, (2) quantity specifications, (3) pre-selection of supplier candidates, and (4) preparation and approval of inquiry specifications.

Inquiry specifications define the scope of the inquiry. The level of equipment specifications varies a great deal with the nature of the project and procurement policy. The instrumentation, for instance, may or may not be included in a supplier's package. The inquiry specifications should describe and clearly limit the equipment and services to be tendered, and, sometimes, offer to the potential supplier an opportunity to tender also alternatives or solutions of his own. If the owner purchases some equipment himself, detailed equipment specifications are especially needed. The project area engineer concerned prepares the equipment specification. Then, the chief design engineer approves the specification.

A typical equipment specification includes general description of the subject of the inquiry, technical data and guarantees, inquiry specification, delivery limits, and necessary appendices. Equipment specification describes the equipment to be tendered with all capacity data and details on standards, material selection, and other factors affecting the cost of the equipment. Delivery limits specify separately the equipment itself, erection, erection supervision and start-up services, and the engineering of the supplier. The most common appendices are flow sheets and layout drawings.

Quantity specifications (bills of quantities) determine the physical extent of the delivery. Although it is not always possible to specify the quantity figures exactly, estimates should be provided to the supplier candidates. The estimates should include all known items, even where drawings do not allow a straightforward take-off. The quantities are given in order to provide the suppliers an idea of the delivery size. Sometimes it is advisable to buy spare equipment with the original contract. For civil and service purchases, estimated quantities are given according to previous experience from similar projects, construction drawings or according to flow sheets.

Pre-selection of supplier candidates is necessary because a large project is likely to attract a vast interest. This can be made by a pre-qualification inquiry that reveals abilities and true interest in a particular project. Also the ability of already selected contractors should be considered in pre-selecting the supplier candidates. The list of prospective suppliers is prepared by the purchasing organisation (normally the purchasing manager and project engineer concerned). The list will be sent to the client's project secretary for comments. Finally, the project manager will approve the list.

Preparation and approval of inquiry specifications should preferably be prepared and approved in time to have them issued with, or at least, mentioned in the purchase inquiries. The necessary documents are prepared jointly by the engineering staff (specifications and drawings) and the construction management (general conditions and financial documents). The forming of the inquiry specification documents requires a high level of skill in order to serve in varying situations. Totally comprehensive documents can not be produced at this stage of the project.

The owner should approve the inquiry specifications preferably quite early in the project. Since technical inquiry specifications define mill standards and a quality level, they consequently define also cost levels. Thus, the approvals should be done clearly, and non-committing approvals should be avoided.

Inquiry Issuing

The supplier candidates are selected and inquiries are issued to the prospective suppliers. Inquiry issuing consists of all activities in obtaining tenders from supplier candidates. It starts with collecting inquiry documents, continues with distributing inquiries to the prospective suppliers, and ends with receiving the tenders. Copies of all inquiry documents, covering letters and summary sheets are kept in the project file. They are distributed to the client and the project organisation in accordance with the project instructions.

The inquiry documents are prepared in co-operation with the client, the project organisation, and the main engineering company (or the consultant company). The purchasing organisation collects the technical inquiry specifications from the respective sources, and assembles them together with the covering letter. Technical inquiry specifications cover technical data and performance guarantee requirements. They contain also the necessary descriptions for general delivery limits, the installation arrangement agreement and mill specification for tendering purposes. The covering letter gives the inquiry number, the client's name, the subject, deadline for tender and distribution of tenders to the supplier candidates. It contains also contact persons and a list of enclosures. Whichever party has prepared the documents is also responsible for their correctness.

Normally, the consultant company distributes the inquiries to the prospective suppliers. The project manager or, in his absence, another authorised person from the project organisation signs the covering letter. The summary letter of the sent inquiries is delivered to the client. In some cases, a client may prefer to distribute the inquiries himself. In this case, the consultant company provides him with all necessary documents, and the client himself signs the covering letters.

The inquiries are issued according to the list of prospective supplier candidates. The list has to be agreed on with the client. The distribution of the inquiry and the expediting of the tenders are best to be performed by the person who will compare the received tenders. Normally, the consultant company receives the tenders in at least two or three copies. On arrival they are stamped and marked with the project number in question, and distributed to the project organisation. One of the copies remains with the purchasing personnel, the others are sent to the project group in accordance with the project instructions.

The purchasing organisation keeps their copies on file as long as they are of any interest, or at least until the corresponding purchase contract is concluded. The tender copies are then transferred to a separate file for out-of-date tenders, in which they are kept as long as they are considered to be of any value as reference material. Parts of specific interest may be separated and kept for a longer period, other parts may be discarded earlier.

Comparison of Tenders

The comparison of tenders demands ample time and efforts in the formulating of recommendations. The recommendations must be discussed with and approved by a person in a responsible position in the project or the line organisation, before the comparison of tenders is released to the client. The corresponding procedures are followed in the project instructions.

There are two main reasons for the comparison of tenders. First, the comparison makes the tenders comparable from all technical, commercial and other aspects. Second, it makes recommendations regarding equipment and potential suppliers. The preparation of the comparison frequently requires direct contacts with prospective suppliers in order to clear up questions that may arise.

The comparison of tenders as described here is not to be confused with tender summaries. Tender summaries are sometimes made in order to check the contents of large packages, e.g. a complete paper machine and a finishing line. Such a tender summary may, however, be the basis for or a part of a comparison of tenders. The main parts of a comparison of tenders are (1) introduction, (2) technical comparison, (3) commercial comparison, and (4) summary and recommendations.

Introduction is a short discussion of the equipment covered by the tenders and the comparison situation. Technical comparison covers several aspects according to the type of equipment and the extent of the tenders. A summary of the relevant technical points in the tender is also presented in this part, either in the text or as an appendix. Technical aspects are listed in Table 14.

Table 14. Technical Comparison Aspects

Main technical aspects	**Detail aspects**
Discussions of tender subject	• Suitability of the equipment for the specified purpose • Tender's adherence to the technical inquiry specification and the delivery limits • Tender's completeness from an operational and maintenance point of view • Necessity of additional or auxiliary equipment • Special requirements on buildings or civil construction
Technical specifications	• General dimensioning, normal and spare capacity • Material selection, allowances for corrosion and wear • Standards. • Necessary inspection and testing before delivery • Mechanical guarantees • Expected life time of the equipment or its essential parts
Operational aspects	• Consumption of raw materials, heat, power and other consumables • Operational efficiency, degree of automation, required operators' qualifications • Special requirements on the raw materials • Performance and availability guarantees
Environmental aspects	• Pollution of air and water • Noise, vibrations • Waste and waste disposal
Erection related aspects	• Erection time • Need of supervisors, skilled and unskilled workers • Need of special tools, lifting gear, special foundations or temporary facilities
Maintenance aspects	• Need of maintenance and shutdowns for maintenance purposes • Need of spare parts and spare or stand-by units • Special requirements on maintenance equipment
Reference aspects	• Supplier's references and experience of identical or similar plants

The commercial comparison can vary depending on the equipment, the tender type and the supplier's market position. A calculation of the comparative prices is presented in this section, either in the text or as an appendix. Commercial comparison aspects are listed in Table 15 on the next page.

Table 15. Commercial Comparison Aspects

Main commercial aspects	Detail aspects
Equipment price possibilities	• As tendered • As delivered at the site • As erected including commissioning and taking-over the plant
Price corrections	• Necessary additional equipment • Buildings or civil constructions required • Differences in materials, standards or expected life time of the equipment • Differences in performance and availability and consumption or raw materials • Differences in required operating personnel • Differences in costs related to environmental and maintenance aspects • Differences in terms of payment, escalation clauses and financing costs • Differences in time of delivery and customs duties

It is advisable to present the conclusions and recommendations in the very beginning of the report. The majority of readers will concentrate their interest on the conclusions and recommendations. Details and possible calculations can be presented at the end or in the appendices. The extent of necessary details may well be decided, project by project, since some clients may not demand a lengthy repetition of details that can be found in the tenders themselves.

The summary and recommendations section contains a brief introduction, a discussion of the equipment covered by the tenders, a conclusion of the comparison and recommendations. The recommendations normally include the type of equipment to be purchased and information on which supplier candidate the purchase negotiations are initiated with. There might also be some other considerations in the comparison of tenders. They may include e.g. supplier information of engineering, research and manufacturing facilities. The financial status and manufacturing capacities of the potential supplier can be mentioned. They can also list references and previous deliveries.

Negotiations

The consultant company takes part in the purchase negotiations to the extent the client desires. No particular advice for these activities can be given, but it is recommended that the activities of the consultant company are early and clearly defined. An early agreement on the purchase contract model and appendices to be used is also extremely important for carrying out the purchase negotiations without loss of valuable time.

In any case, all the contractual documents covering technical data and other conditions should be distributed to the prospective supplier candidates well ahead of the purchasing negotiations. This gives the suppliers an opportunity to acquaint themselves with them and express the tendered price accordingly. Time should be reserved for discussions of the finer technical points and questions related to financing, payments etc. This guarantees that the contractual aspects unanticipated beforehand can be dealt with to a proper degree. When all the tenders have been reviewed and completed, and technical negotiations have been carried out, the conductor of the negotiations shall recommend a supplier. After the client's approval, the final commercial negotiations will take place with the supplier.

The area manager or the chief design engineer will normally carry the chairmanship of the negotiations. The chairman prepares the agenda and selects the persons taking part in meetings: process engineer(s), electrical engineer(s), instrumentation engineer(s) and the purchasing manager. The chairman should notify the client and the supplier of the participants sufficiently in advance. After the negotiations, a supplier recommendation is provided to the client. The client makes the final decision. A letter of thanks will be prepared and sent to the non-selected suppliers who participated in the inquiry.

Contracting

An early agreement between the client and the consulting company on the structure of the purchase contract and its appendices is important for carrying out the purchase negotiations without loss of valuable time. Once the negotiations have ended and the choice of the supplier is to be approved, a Request for Purchase (RFP) will be prepared and presented to the client. The RFP can be submitted as a procurement step in every purchasing process irrespective of the issuing person or/and amount of order. RFP consists of technical and commercial documents, the latest comparison of tenders, the technical and commercial meeting reports, and the final tender proposal from the selected supplier.

When the client's approval for the purchase returns, a letter of intent shall be prepared and sent to the supplier. It is faxed or emailed to the supplier in order to save time. The letter of intent can be mutually signed as a sign of successful negotiations and completed supplier selection. It can be also a buyer's unilateral announcement to the supplier that they have been selected.

The procurement process is finalised by "Award of the Contract" and its acknowledgment. The result, the purchase contract, is mutually approved and signed. After the contract has been established, contract administration and cost control begin. These tasks include expediting, material inspections, contract follow-up on site and contract closeout. They are carried out to ensure that the supplier's performance meets the terms of the contract.

5.3.3. PURCHASE CONTRACTS

Normally, a purchase contract can be divided to three parts: (1) commercial matters (prices, payment terms, delivery times and legal stipulations) (2) technical matters (schedules for deliveries of documents, technical data and guarantees, equipment specifications etc.), and (3) appendices.

The commercial part of the purchase contract includes the purchase contract text, general contract conditions and insurances. The purchase contract text may be extremely standardised. It can be comparatively few pages in relation to the appendices it is accompanied with. At best only the amendments have to be written individually for each purchase contract, all the other sections remain the same. The commercial part is officially signed.

The commercial part of the purchase contract covers a brief definition of the equipment, as well as the names of the purchaser and the supplier. The commercial part also includes specification of the attached appendices, with a statement to the contract overruling the appendices, and the applying order of the appendices. The list of appendices may be in the form of a check list indicating the appendices attached to the contract. Moreover, the commercial part describes the general scope of the purchase order with references to the technical data and specifications and the general price terms of payment with reference to the corresponding appendices. Finally, the commercial part specifies delivery times, penalties, tests, guarantees, and amendments to the standard appendices.

General purchase conditions are normally decided in project level inquiry specifications. They might contain some open places to be decided in contract negotiations. They define interest percentages, penalties, guarantee periods etc. They should be filled in before the signing of the purchase contract. Last, insurances are also defined in the commercial part of the purchase contract.

The technical part of the purchase contract specifies the equipment. It comprises technical data and guarantees, technical specifications, delivery limits with drawings, the project schedule, instructions for documentation and the schedule for delivery of documents, regulations regarding standards etc.

The appendices of the purchase contract can be classified according to their nature as standard appendices, non-standard appendices and standard forms. Standard appendices, like mill standards, remain unchanged and identical in all purchase contracts, as stated above. Non-standard appendices are individually written for each purchase contract. Typical non-standard appendices are all specifications of the equipment, prices etc. Standard forms are predefined documents to be used in the project.

Prices and payment conditions are in many cases regarded as confidential information. The whole purchase contract can be regarded as confidential, if technical and commercial data are mixed in the contract. This easily leads to the situation that the technical data in their original form become unavailable for the technical personnel. For this reason a purchase contract should be prepared in such a way that it can be divided strictly into a commercial part and a technical part. Both parts should have their own appendices. In this way either part can be separately handled and distributed to the persons concerned.

Instructions on Equipment Specifications

The need for detailed equipment specifications may be seen from three different views: the owner's, the supplier's and the consultant's views. Sometimes the views vary significantly. The owner's primary interest may not concern the details in the contractual specifications. However, the maintenance personnel will need detailed information for operating, preparing and maintain the plant.

The supplier may for several reasons want to leave himself a certain freedom in the way of less exact specifications in the purchase contract. The engineering might still be under way, competing solutions are weighted, but the final construction design has not been decided yet.

The consultant needs detailed specifications, both in the purchase contract and later during the engineering work. Engineering, erection planning, construction and maintenance need exact specifications. Only the supplier can deliver the required specifications. However, this specification work involves an extra cost. Therefore, the specification work has to be defined beforehand, for example in the purchase contract.

Purchase Contract Classification

There are four general contract types used in industrial projects. The classification presented here has been deliberately made quite coarse and it does not even cover all the contract models of the purchasing plan presented above. The purchase contract classification presented here differentiates between (1) delivery contracts, (2) blanket order agreements, (3) work contracts, and (4) ad hoc orders. In reality, the contracting possibilities vary nearly limitlessly.

Delivery contracts are agreements to supply or supply and erect specified items in the project. The number of items, the timing of the delivery and all the other contract details are well known. There are no universally accepted models for delivery contracts for process equipment. Whichever model is used in contracting equipment, the main elements remain about the same. The Swedish SSG-group has developed quite a popular model for delivery contracts.

Blanket order agreements are recommended to be used when the purchases have to be made without knowing the exact final quantities to deliver. Blanket order agreements are made in such a way that the actual quantities and details, e.g. measuring ranges, may be given to the supplier at a later date in the form of a release order, when the engineering has proceeded sufficiently to present these data. This means that the blanket order agreements stipulate specifications, unit prices, delivery conditions and estimated quantities (based on statistic data of selected historical projects). The actual quantities and some defined engineering data (e.g. pump data) will be released within an agreement period in the form of a purchase requisition instructing the supplier to proceed with the manufacturing. The actual units are listed in the detail engineering stage.

From the purchasing point of view, blanket order agreement items differ from the equipment of the delivery contracts in several respects. Blanket order agreement items are in general standardised and the main design features are known in the specification stage. The main technical inquiry specifications can be presented in the form of data sheets and typical drawings.

In most cases, the general standard equipment and construction materials can be purchased based on unit prices. They can be purchased even according to published price lists with a negotiable price reduction depending on the volume of the purchase. There are normally several deliveries for blanket order agreement items. Purchase requisitions constitute release orders after the client has issued them. Suppliers are requested to acknowledge received release orders.

Work contracts are made to contract labour of the project. They can include materials of work. There are several pricing possibilities, like a fixed slump sum, a target sum, a production fee, a fixed overhead and hourly rate pricing.

Ad hoc orders are additional purchase orders. Ad hoc orders are used when there is no need or time to carry out a full procurement process. In these cases, there is not any contract that covers the subject of the ad hoc order. No matter how exactly the delivery limits are specified or the plant is planned, some minor tasks have the tendency to slip outside the contracts. Normally, the project manager has power to make small ad hoc orders to contribute to the project implementation. Ad hoc orders are typically named as construction manager's instructions, confirmations of verbal instructions or extra work orders.

5.3.4. PROCUREMENT FOLLOW-UP

The primary purpose of procurement follow-up is to keep all the stakeholders of the project informed the status of procurement. As a project advances, procurement status reports will be issued describing the state of the procurement. The information for the procurement status report is gathered from the project personnel, the suppliers and their subcontractors.

The procurement follow-up is the purchasing manager's responsibility. He issues monthly a report of the procurement status, the “Procurement Status” report, which is supported with charts to quantify the progress. The “Procurement Status” report summarises the project position, stating inquiries, tenders, orders, and expediting as appropriate. It should give a summary picture of the procurement situation giving an overall view, together with any highlights and major problems requiring attention. Unnecessary details should be excluded. However, changes in scope and schedules should be mentioned.

Special forms (the “Supply Status” and the “Subsupply Status” form) are developed to gather the information of the suppliers’ and subcontractors’ supply statuses. These forms are used to quantify the progress and to support the suppliers' reporting. The progress reports are based on the supplier's manufacturing schedule and on the technical specification given in the contract or order. Divergences from established plans will be stated and the supplier's proposed corrective plan should clearly be presented and attached to the report. Expediters will analyse carefully received reports to verify that the information complies with the project requirements. Consequences of delays, suspected delays and any suspected "critical situations" shall be investigated together with project staff in charge and the results shall be reported.

The “Supply Status” report includes information on the state of engineering, work planning, manufacturing and workshop erection at the supplier’s works and, if so agreed, at the subcontractors' works. Each activity should be described with information on the start and finish of the activity. The reporting is intended to present possible delays in weeks. To obtain an accurate picture of a delay, the supplier may be requested to specify the delay as a percentage of work completed or planned. If the supplier would rather use his own supply status forms instead of the purchaser's he should obtain the purchasing manager's permission.

The “Subsupply Status” report includes information on the supplier's main subcontractors, raw materials, standard components, etc. The form gives item and other numbers, the subcontractors' address, the point of dispatch and destination, the mode of transport and the delivery for all equipment.

Follow-Up of Schedules

Schedules are intended to direct and influence the performance of the activities they describe. In order to be effective, procurement schedules must be followed up closely and regularly and any deviations discussed for possible rectifying measures. On the other hand, the schedules must remain sensitive to the actual progress of the project and to difficulties encountered on the project site.

The procurement status is typically reported to the client once a month. The actual progress of the procurement activities is marked with the follow-up line on the procurement schedule. The future progress of the activities is also estimated and reported.

Follow-Up of Costs

As the procurement progresses, commitments, invoices and payments are registered and compared with the final budget, enabling the prediction of total costs, cashflows and assets. The primary goal of project cost control is to ensure cost efficiency. It encourages and promotes cost consciousness in all phases of project implementation.

Commitments are recorded from purchase contracts and purchase orders. The commitments are delivered on the cost areas and cost objects to provide a foundation for calculating the assets. Commitments are also used in calculating commitment cashflow and estimated cashflow.

The other major task in cost follow-up focuses on the progress of invoicing and payments. Cost control gathers information of received invoices, invoice approvals and payments in order to provide accurate and real-time data on the cost status and outlook. Finally, it highlights any unfavourable cost conditions and trends prompting for corrective action. The actual cashflow is calculated and cashflow estimates based on commitments, invoices and payment are delivered to the project management and to the future owner of the mill.

5.4. REVIEW

Procurement in industrial projects extends from the markets to inside the company gate. Procurement should ensure an optimal supply, which must be geared towards the needs of construction and scheduling. Therefore, buyers have an important role in the projects. They should be able to translate technical aspects of the bargain to the supplier's terms. General knowledge of procurement in project environments is helpful in understanding Pöyry procurement instructions. This knowledge was needed in building additional features and increasing the adaptivity of the software. The knowledge of fast tracking project implementation with concurrent engineering was necessary for proper insights of procurement in industrial plant projects.

Artto and Wikström's study and my own literature survey (presented in Section 1.2.) confirm that there are only scarce academic articles describing procurement in industrial plant projects. However, I have described three generic value configuration models (value chain, value shop and value network) and three procurement process models (supplier-oriented, item-oriented and fast tracking). While the value shop model illustrates the business of Pöyry Oyj, the fast tracking model describes the procurement function in project environments. I have also presented the procurement section of the *PMBOK Guide*. It is a well known and widely accepted general description of procurement in project environments. The presentation in the *PMBOK Guide* gives suitable process view to procurement.

The fast tracking in project implementation involves the overlapping of project phases supported with early purchasing and supplier involvement. The procurement takes place under uncertainty as concurrent engineering makes item specifications gradually more detailed. In Pöyry project methodologies the uncertainty is managed by sequential inquiry rounds. Conceptual engineering provides generic specifications for budget inquiry rounds. In the next stage, basic engineering delivers project specifications used in tender inquiry rounds. Finally, detail engineering finishes the item specifications and they are used in the final inquiry rounds and contracts.

Just as the project management instructions, procurement instructions resulted from evolutionary business process development, carried out at Pöyry Oyj in the late 1980s and the early 1990s. The procurement instructions present the procurement knowledge accumulated in the company from hundreds of industrial projects. The procurement instructions describe how to purchase equipment and services to build or renovate a plant. The procurement instructions of Pöyry Oyj are seen to comprise all the necessary project management knowledge for industrial plant projects and peak procurement knowledge. I was appointed to the rewriting of the *Procurement Manual*, as a secretary.

The procurement instructions had a strong influence on the application, because they were used as software specifications. They described the tasks which the procurement software was designed to handle. The weight of Pöyry's needs is so overwhelming that if they had been contrary to general knowledge, Pöyry's opinion would have won. The problem was that these instructions could not be applied directly in the programming. The first two application versions were programmed along the instructions, but they were not great successes. Business process redesign was needed in designing more sophisticated software versions, as will be described in Chapter 8.

Likewise the *Project Management Manual*, the *Procurement Manual* has been in use for ca. 15 years. The *Procurement Manual* has guided and supported the procurement function in numerous projects. Even the customers expect Pöyry Oyj to follow these procurement instructions, which describe favourable procurement practices within Pöyry project methods. The well-established procurement processes are regarded as a guarantee of quality. Projects following the *Procurement Manual* closely are considered to be more likely successful.

6. GENERAL PLANNING OF INFORMATION SYSTEMS

This chapter covers the planning and design stages of software development, both crucial for the successful implementation of any software. In my research, software development is considered a lot wider work than programming. The software development acquainted me with change process management and strategic planning of information systems. I admit that I see them as parts of proper project management. Later, years after the actual software development, I was introduced to the technochange approach that describes IT projects in implement organisational changes.

From the managerial point of view, the development of the procurement software was never formally projectised. In the beginning, the work was carried out as an ordinary task included in my employment at Pöyry Oyj. Later, I continued the development work as a "hobby" targeted to facilitate my work as ERP Project Manager. Therefore, I also had to control the development work.

This chapter describes the life cycles of information systems, general design stages of information systems and general design of procurement software. Section 6.1. gives a managerial view to information systems to gain a wide understanding of constructing and maintaining information systems. Section 6.2. presents the general planning framework. The general design of the procurement software and the implementation decisions are discussed in Section 6.3.

Information Systems

Information systems[235] are work systems whose business process is devoted to capturing, transmitting, storing, retrieving, manipulating and displaying information, thereby supporting other work systems. They can be described as systems helping to run a company. They gather financial, production and other information that managers need to operate a business. The terms "information system" and "management information system" are close synonyms in many ways. They refer both to an organisational system that employs information technology in providing information and communication services and the function that plans, develops, and manages the system.

The objectives of information systems[236] are to meet an organisation's information and communication needs, improve productivity, add value to processes and assist organisational strategy. The systems apply information technology and information resources to increase functionality and performance in products and services. The systems also improve quality and scope in analysis and decision-making, communication and sharing in co-operative work.

Business Roles of Information Systems

Information systems are utilised almost in every function in companies. In business, information systems enable and support business processes and operations, decision making, and competitive strategies. Information systems can be classified by the nature of the activity they support. The support might be operational, managerial or strategic by nature[237].

Operational support is the most basic role of information systems. Operational systems deal with every day operations in companies, such as working hour reporting or placing a purchase order. These operational systems are used by supervisors, operators and clerical workers. The supported

[235] Alter: Information Systems: foundation of e-business (2002)
p. 6

[236] Davis: Management Information Systems (1998)
In Cooper and Argyris (eds.): The Concise Blackwell Encyclopedia of Management, p. 375

[237] Turban, McLean and Wetherbe: Information Technology for Management: Transforming Business in the Digital Economy (2002)
pp. 58-59

activities are short-term by nature. Most of these systems can be placed into transaction processing, management information or simple decision support systems.

Managerial support is important for the middle level management. Managerial systems include short-term planning, organising and control. The most basic and most versatile managerial support tool is the spreadsheet, but spreadsheets are not user friendly. Managerial support systems provide statistical summaries, periodic, exception and ad hoc reports, comparative analysis, projections, early detection of problems, routine decisions, and connections with other members of the company.

Strategic support systems are either systems used in a long-term strategic planning or systems supporting a company's competitive positioning. Strategic planning tools can, for example, pilot the internal value chain of the company. These systems are typically labelled as "Business Workflow Analysis" or "Business Workflow Management". The systems create process networks, which they use to pilot a set of company functions. The company's competitive positioning can be supported either by strengthening the company's core competencies, or creating barriers to entry.

A core competency[238] has three identifying elements: (1) a potential access to a wide variety of markets, (2) a significant contribution to the perceived customer benefits, (3) difficult to imitate by competitors. All successful companies have one (or more) functions that they do better than their rivals. If a company's core competency gives it a long-term advantage, it is referred to as a sustainable competitive advantage. To establish a sustainable competitive advantage, it must be unique, sustainable, difficult to mimic, superior to the competition, and applicable to multiple situations.

There are many possibilities for achieving sustainable competitive advantage. Examples include superior product quality, extensive distribution contracts, accumulated brand equity etc. Particularly IT-dependent strategic initiatives are used to contribute to sustained competitive advantage[239]. IT investments create, grow, or maintain barriers to entry in numerous ways. Even the fact that an IT investment requires funds (capital requirement) makes it a barrier to entry. However, some claim that in the fast changing competitive world, none of these advantages can be sustained in the long run. They claim that the only truly sustainable competitive advantage is to build an alert and agile organisation that will always find an advantage, no matter what changes occur. Information systems have to be designed to support sustainable competitive advantage, because the speed of change has made access to valid information critical.

6.1. MANAGING INFORMATION SYSTEMS

This section gives an overview of managing information systems. It is useful to discuss managing information systems in order to understand the development of information systems. The managerial view gives a wider picture of developing, using and terminating software.

Three complementing views of managing IT systems are represented. First, expanded systems development life cycle (ESDLC) is used to describe the entire course of the software. Second, implementing software is inevitably a change process from the old to the new solution. Together, they describe the behaviour of the solutions used in the same environment. Third, the technochange approach is introduced to explain organisational behaviour before, during and after IT projects.

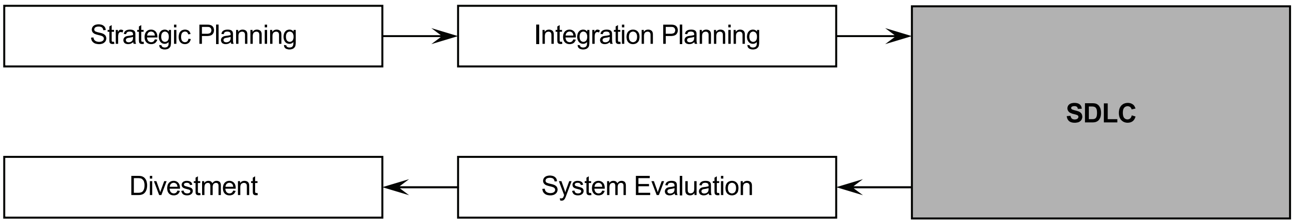
[238] Prahalad and Hamel: The Core Competence of the Corporation (1990)
Harvard Business Review, Vol. 68, No. 3, pp. 79-91.

[239] Piccoli and Ives: IT-Dependent Strategic Initiatives and Sustained Competitive Advantage: A Review and Synthesis of the Literature (2005)
MIS Quarterly, Vol. 29, No. 4, pp. 747-776.

Expanded System Development Life Cycle

The expanded Systems Development Life Cycle (ESDLC)[240] illustrates modern emphasis on planning, assessing and evaluating systems. While the systems development life cycle (SDLC) consists of the system development stages, the ESDLC includes also strategic planning, integration planning, evaluation and divestment stages, as illustrated in Figure 49. The additional stages serve to extend the SDLC, which is applied to a single system, to a broader organisational context.

Figure 49. Expanded Systems Development Life Cycle



The Concise Blackwell Encyclopedia of Management, p. 486 (adapted)

The strategic planning phase involves the development of an IS strategy. It is intended to derive from, and it is directly intended to support, the business strategies. Strategic planning consists of two major elements: (1) translation of organisational goals and strategies into data, applications and technology, and (2) assessment of “product-market” opportunities that may be supported by existing and planned information resources. Strategic planning affects in two opposite directions. The translation of organisational goals and strategies has effects on the information systems. On the other hand, information systems have influence on the business goals and strategies.

The system integration planning primarily involves the system integration functions. The need for integration was originally recognised because companies had developed information systems independently and the systems were found to be incompatible. The systems might operate effectively individually, but they could not be integrated together to provide information for other systems. System integration planning may well be carried out in the form of “information system master plan”. The “information system master plan” demonstrates the intended relationships among the various systems and subsystems, which the organisation operates or plans to develop.

The two phases after the traditional SDLC - evaluation and divestment - reflect the growing attention paid to the formal evaluation of systems and the need to terminate systems. It has been widely recognised that an information system, like any complex system, has a finite useful life span. Planning is needed for the shutdown, replacement and phasing out of the system. In the evaluation phase, the information system is evaluated. The traditional cost, time and technical performance measures are commonly complemented with user satisfaction and business value assessments.

Change Process

A successful information system project moves a system from its current state to a desired new state[241]. This movement involves passing through three system stages: (1) unfreezing, (2) moving, and (3) refreezing, as illustrated in Figure 50 on the next page. The efforts needed to accomplish a stage depend upon the nature of the system, the developers, the end-user organisation, and the management actions used in the transition. Implementation involves all the project stakeholders, i.e.

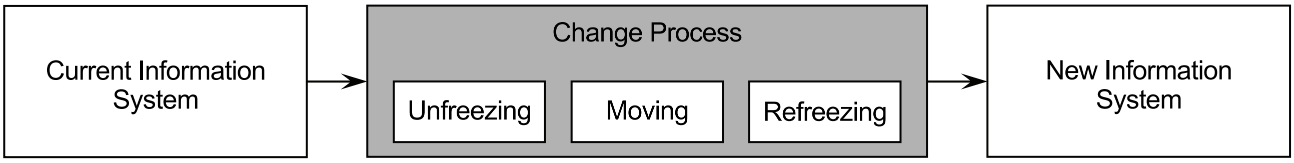
[240] King: Planning for Information Systems (1998)
In Cooper and Argyris (eds.): The Concise Blackwell Encyclopedia of Management, pp. 485-486

[241] Chervany and Brown: Implementation of Information Systems (1998)
In Cooper and Argyris (eds.): The Concise Blackwell Encyclopedia of Management, pp. 282-283

all the people inside and outside the organisation whose work will be affected by the project; not only the developers. In addition, there are project stakeholders whose actions can change the project outcome, but whose work is not directly affected by the project.

The change process, described here from a system (or project) point of view, can also be utilised on lower levels of the information system. Instead of the application, the subject of the change can be a functional area of the application (a group of programs), a program, or a subprogram.

Figure 50. Change Process



The Concise Blackwell Encyclopedia of Management (1998), p. 283 (adapted)

The unfreezing stage involves gaining recognition and acceptance from the project stakeholders that the information system needs to be changed. When unfreezing a system successfully, the reasoning must be acceptable on all organisational levels. The business reasoning revolves around projected improvements in organisational performance and increase in value that the project will bring to the organisation. They can comprise increases in sales, gains in market share, reduction in costs and improvements in quality. In the individual reasoning, the interest focuses on what benefits and costs the project will produce for the individual personally, not for the organisation in general.

The moving stage involves changing the functionality of the system, which is likely a software development process in case of information system development. The specified functional requirements are implemented in hardware, software, management policies and procedures. Later, the new system will be taught to users. A successful system development project achieves the projected benefits and costs which were used as evidence in the unfreezing stage. It is not rare that the system implementation will bring with some unforeseen benefits and costs.

The refreezing stage involves ensuring that the new system becomes institutionalised. The new system creates new standards for work behaviour. The focus is on demonstrating the benefits and costs which are delivered to the project stakeholders. These benefits were projected in the unfreezing and captured by the analysis and design efforts in the moving stage.

Technochange Approach

Markus[242] has studied situations in which IT projects have triggered major organisational changes. She calls them technochange (for technology-driven organisational change). Markus claims that the technochange approach is fundamentally different from both IT projects and organisational change programs. Unlike the technical-minded IT projects, technochange involves great potential impacts on people, processes and organisational performance. On the other hand, technochange differs sharply from traditional organisational change programs, because information technology and technical methodologies are so prominently involved in it.

Technochange projects are expected to improve organisational output significantly, such as process efficiency or cycle time. Organisational change programs may have performance improvement goals,

[242] Markus: Technochange management: using IT to drive organizational change (2004) Journal of Information Technology, Vol. 19, No. 1, pp. 4-20

but many are diffusely expected to enhance organisational culture or “effectiveness”. IT projects usually have narrower goals than technochange initiatives: they focus on improving technical performance (e.g. reliability, speed, functionality) and decreasing the costs (total cost of IT ownership, maintenance costs, etc.). IT projects do not necessarily require much effort from the IT users; upgrading a server might improve response times remarkably without any participation of the end-users. The differences of the approaches are summarised in Table 16 on the next page.

The technochange process includes idea generation, solution design, solution implementation and benefit capture. The process can be structured as a life cycle of sequential phases with no iteration loops. Alternatively, the process can be described as iterative series of many small cycles, indicating prototyping approach coping with limitations of the designers’ foresight. The prototyping approach can be loosely understood as trying something and using the results of the experiment as a basis for deciding what to do next. Some describe prototyping as a “plan, do, check, act” -cycle (or “design, implement, evaluate, correct” -cycle), which is repeated until satisfactory results are achieved.

Markus states that it is useful to think of technochange in terms of what happens before, during and after an IT project. Before the project, an idea of technochange is proposed, reviewed, approved of and funded. During the project, the solution is developed and technology is acquired or built. After the project, technochange efforts can be divided somewhat arbitrarily into two stages: shakedown and benefit capture. In the shakedown stage, the start-up problems are attempted to be eliminated. The goal is to reach stable operations and make them routine. In the benefit capture stage, the expected and the unanticipated benefits are sought for. They might occur considerably after the shakedown stage when the employees learn to use the technology and fine-tune it. Not all initiatives reach the shakedown or benefit capture phases. Quite a few projects have been terminated because of shakedown problems. Also, an organisation might “declare a victory” for a technochange but stabilise operations at a lower level of performance improvement than expected.

Merely combining IT projects and organisational change management approaches does not produce the best results. First, the additive approach does not address the many failure-threatening problems effectively. Problems are likely to arise over the lengthy technochange process. Second, the additive approach is not structured to produce a good technochange solution. The technochange process means a complete intervention to business processes consisting of IT and complementary organisational changes. The technochange should provide an implementable solution with minimal misfits with the existing organisation. Finally, the organisation must be primed to appropriate the potential benefits of the technochange solution.

Markus claims that proper project management is important, but it has little to say about managing the risks associated with people’s “resistance to change”. Organisational change management believes to have the solution to the problem of resistance, because their efforts focus on the people affected by the change and the problem. Redesigning jobs or organisational structures and involving employees in the planning stages of the change are seen to benefit the change. On the other hand, organisational change management has little to say about how IT alters organisational problems.

With hard work and care, the combined IT project management with the organisational change approach can be made to work. However, an iterative, incremental approach to implementing technochange might be a better strategy in many cases. Markus claims that the essential characteristic of the technochange approach is prototyping. Each phase involves both new IT functionality and related organisational changes, which are tested in real situations. Based on the gained experience, the next prototype is created and tested, to see if it would match the requirements better.

Table 16. Technochange versus IT Projects and Organisational Change Programs

	IT projects	Technochange situations	Org. change programs
Targets	Performance, reliability, project in schedule and budget; cost of operation and maintenance	Organisational performance improvement	Improvement in performance and/or organisational culture
Solution	New IT solution	New IT applications, often with complementary organisational changes	Interventions focused on human resource management (people, organisation, culture etc.)
Example	Replacing outdated reporting with data warehousing. Reduces the need of ad hoc reports requested by business managers, saving the work of in-house IT personnel.	Restructuring of the procurement function. With new purchasing software: centralised contracting process, key suppliers, and consolidating purchases for deep discounts	Transforming a mature, underperforming organisation by making people more innovative, customer-focused and empowered to take initiative and make decisions.
Basic approach	IT project led by Project Manager The project is expected to produce a working system that meets stated specifications in time and within the budget.	IT project followed by implementation efforts Implementation efforts are a “program” of change initiatives including IT project, business or company process redesign, job redesign, training, etc.	Organisational development Methodologies including improving managers’ attitudes and behaviours, development of resources, training, company culture, job redesign, etc.
Role of managers	Oversight Managers approve the project, provide funding for the project, and possibly start the project by identifying the needs and specifying the requirements.	Leadership Managers initiate the project, act as change sponsors and provide key design inputs. They explore the options enabled by the new technology. They realise organisational changes.	Leadership Managers initiate the change effort and change their own management styles and behaviour. They reward the desired new behaviour and achieved objectives, etc.
Role of IT specialists	Central IT specialists carry out most of the work including project management. They co-operate with business managers, suppliers and consultants.	Central IT specialists work together with managers and other specialists to design a technochange. They lead and staff the IT project meshing with other changes.	Negligible
Role of other specialists	Technology suppliers and consultants may perform various tasks.	Internal and external specialists in management and technology, and technology suppliers may all play key roles.	Internal HR management, external organisational development and management consultants play key roles.
Key success factors	Project management, technology and suppliers	Co-ordination of stakeholders in organisational change program and IT project	Managers, internal and external organisational change consultants

Markus: Technochange Management: Using IT to Drive Organizational Change (2004), p. 6 (adapted)

6.2. GENERAL PLANNING STAGES

“Well planned is half done”, says an old wisdom. The more complicated the task is, the more planning is needed. Ultimately, the planning for information systems is expected to follow the overall business objectives. It takes place at a number of different levels in the organisation and different stages of the expanded system development life cycle. This section focuses on the general planning stages in the ESDLC, i.e. strategic planning and integration planning.

Information system design[243] involves the consideration of alternative methods for employing information, computing and communications in line with the objectives of the organisation. The design involves the specification activities, resources and relationships in a single project. The target of the project might be to develop a new computer system, install new hardware and software, or perform any other task involving computer resources.

Gregor and Jones[244] propose designing information systems for flexibility and continuous development to face the uncertain future. System flexibility minimises the need of an improvised solution. Within the system, flexibility supports improvisation. Improvisation has its value in solving unexpected situations, but it should not be allowed to characterise the whole design work. Ciborra[245] argues that improvisation is a much more grounded individual and organisational process than planned decision-making. Instead of trying to eradicate improvisation through automation, improvisation should be appreciated because of its flexibility and effectiveness. As a consequence, there is a risk to automate ungrounded organisational processes, if IT is used to automate structured decision-making. This may be an explanation why so many automated routines make little sense.

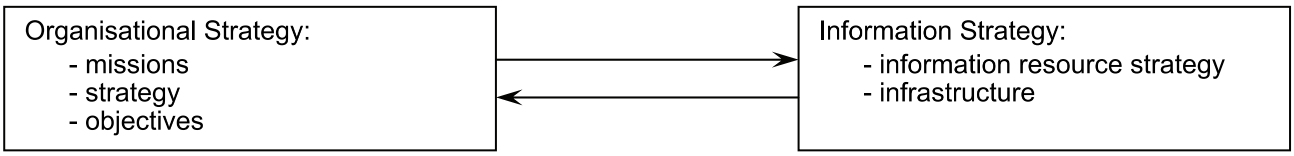
6.2.1. STRATEGIC PLANNING FOR INFORMATION SYSTEMS

Churchill's quotation[246] below describes my personal attitude towards plans and planning: planning is important and helps to achieve goals, but the plans themselves are not so essential. An unexpected change can make well-balanced plans worth the paper they are printed on.

> "Plans are of little importance, but planning is essential."

The idea to derive the information system strategy directly from the overall organisational strategy has had profound effects on information system planning and development[247] (illustrated in Figure 51). The organisational objectives and strategy are supposed to be translated into data, applications, technology and communications. The idea leads to developing the information resources to support the organisational strategies. It involves the assessment of the business opportunities that are supported by existing and planned information resources. They may suggest opportunities that may make the organisation more competitive in the markets.

Figure 51. Strategic Information System Planning



The Concise Blackwell Encyclopedia of Management (1998), p. 485

243 King: Planning for Information Systems (1998)
In Cooper and Argyris (eds.): The Concise Blackwell Encyclopedia of Management, p. 484

244 Gregor and Jones: The Formulation of Design Theories for Information Systems (2004)
In Linger, Fisher, Wojtkowski, Zupancic, Vigo and Arold (eds.): Constructing the Infrastructure for the Knowledge Economy: Methods and Tools, Theory and Practice, pp. 83-93.

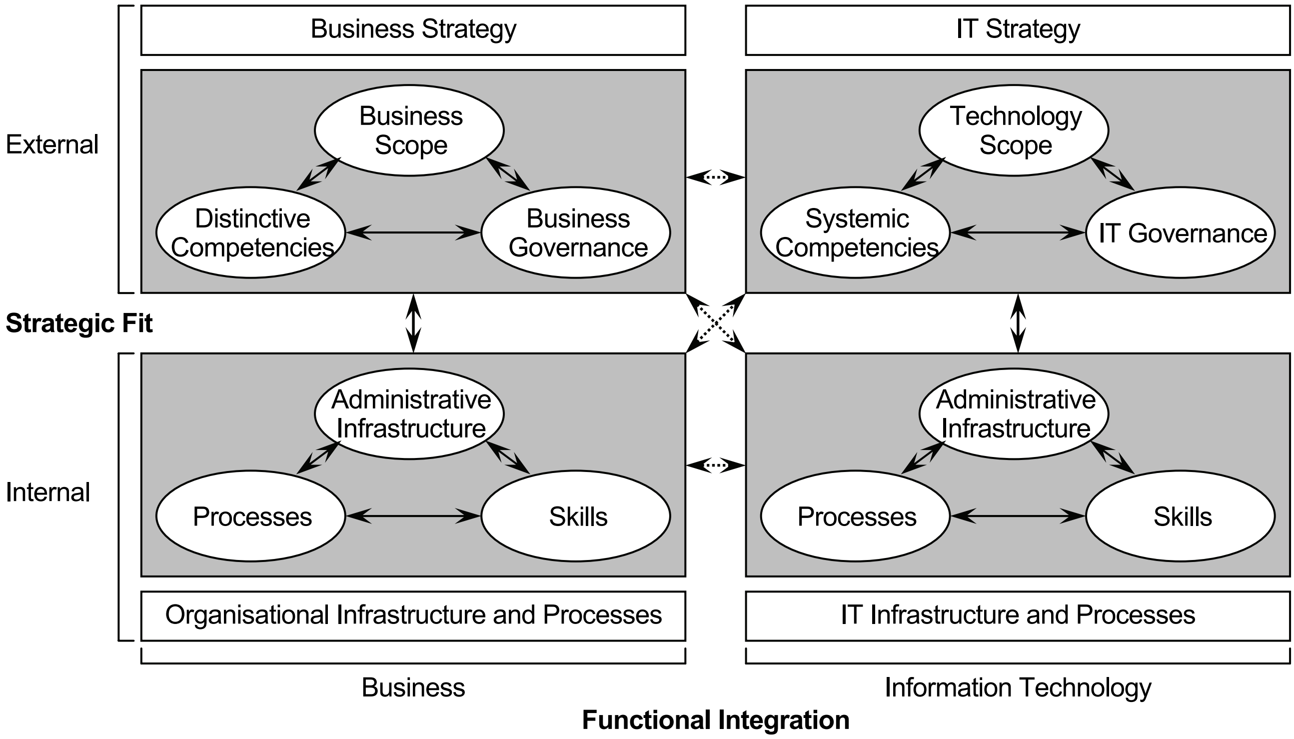
245 Ciborra: Improvisation and Information Technology in Organizations (1996)
Proceedings of the Seventeenth International Conference on Information Systems

246 Winston Churchill, 1874-1965

247 King: Planning for Information Systems (1998)
In Cooper and Argyris (eds.): The Concise Blackwell Encyclopedia of Management, pp. 484-487

Henderson and Venkatraman[248] have developed the Strategic Alignment Model illustrated in Figure 52, for conceptualising and the directing strategic management of information technology. The model is defined by four domains of strategic choice: (1) business strategy, (2) information technology strategy, (3) organisational infrastructure strategy and processes, and (4) information technology infrastructure and processes. The model explains two key characteristics of strategic management: strategic fit (the interrelationships between external and internal components) and functional integration (integration between business and functional domains).

Figure 52. Strategic Alignment Model



Henderson and Venkatraman: Strategic alignment: Leveraging…, IBM Systems Journal 32:1 (1993), p. 7

6.2.2. INTEGRATION PLANNING OF INFORMATION SYSTEMS

The integration[249] issue arises when the software best suited for a single purpose must be used in conjunction with other software for a different purpose. This will inevitably lead to the requirement that the new software has to be integrated with the organisation's other IT systems. The integration is expected to increase the user-value or to decrease the maintenance costs.

The integration[250] can be organised on four "levels" or using four integration approaches. First, interoperability can be achieved through import and export facilities. Second, enterprise application integration can be arranged using middleware and building wrappers, adapters, or other type of connectors. Third, integration can take place on the data level through the use of common databases. Last, integration can be achieved on the source code level by merging the code, which might provide an experience of a homogenous system.

[248] Henderson and Venkatraman: Strategic alignment: Leveraging information technology for transforming organizations (1993) IBM Systems Journal 32, No 1, 4-16.

[249] Alter: Information Systems: foundation of e-business (2002) p. 30

[250] Land and Crnkovic: Software Systems Integration and Architectural Analysis – A Case Study (2003) Proceedings of the International Conference on Software Maintenance (ICSM'03)

6.3. GENERAL PLANNING OF PROCUREMENT SOFTWARE

This section describes the general planning and implementation decisions for the procurement software. The general planning includes strategic planning presenting the justification of the procurement software and integration planning describing the co-operation with other software, i.e. the required interfaces towards the applications of the adjoining functions. The implementation decisions clarify the arrangements and decisions needed to develop the procurement software.

The general planning and implementation decisions at Pöyry Oyj were mostly made before the first software development round. The only exception was the interface for the working hour reporting, which took place in the last (sixth) development round. This additional interface was programmed for an automated procurement status estimation based on the estimated and working hours.

6.3.1. STRATEGIC PLANNING OF PROCUREMENT SOFTWARE

The basic goals for the procurement software were derived from Pöyry Oyj's business strategies (see Section 2.1.). The *Project Management Manual* translates the business strategy as the success of the clients' projects (Subsection 4.3.1). Thus, the procurement software should support smooth project implementation in time and within the budget.

Strategic planning guided the selections of the hardware and 4GL tool. The right hardware and 4GL tool helped develop the procurement software matching the business environment Pöyry Oyj. The software, in turn, gave and maintained the competitive edge of Pöyry Oyj in project management.

6.3.2. INTEGRATION PLANNING OF PROCUREMENT SOFTWARE

Originally, only scheduling was intended to have an import/export interface. Due to timetable pressures, the scheduling interface was not programmed to the first software version. This missing interface was the most important reason for the second software development round.

The interface for working hour reporting was needed for automated procurement status estimation. The estimation based on estimated and actual working hours. Although the procurement software was decided to have working hour reporting features, it was decided that it would be unrealistic to expect all the projects to use them instead of the original payroll and working hour reporting software. This interface was realised in the sixth software development round.

6.3.3. GENERAL IMPLEMENTATION DECISIONS

Pöyry Oyj had clarified best practices in project management. The best project management and procurement practices were described in the rewritten project manuals. The natural extension to the institutionalisation of the best practices was to support these best practices also with project management tools. The procurement tools were badly outdated and therefore the development of a new procurement application was initiated.

At first, the application was supposed to manage only the main procurement workflow as a stand-alone system. Later, the software was required to operate as a networked multi-user application. Also the functionality of the software was extended; cost estimating, scheduling and documentation management were included. Some fairly independent and irregular project tasks were decided not to be included in the software. It was seen that the gains of computerisation did not exceed the programming costs of these irregular tasks.

The designing and programming of the procurement software was preceded with three general implementation decisions: (1) selection of the hardware, (2) selection of the 4GL tool, and (3) organising the programming and testing of the software. These decisions fixed the programming environment and guided the way towards the current procurement application.

Hardware Selection

The hardware selection was intertwined with the selection of the 4GL tool, i.e. the selected software should work on the hardware. The direct hardware requirements were easily listed: the hardware should be scalable from portables to office systems and it should be cheap to acquire and maintain. The efficiency was thought to be achieved by purchasing decent hardware. The hardware requirements should at least exceed the minimum operational system with a safe margin.

The portable, networked PCs were considered to speed up project start-ups. The idea was that professionals would carry their laptops with pre-installed software to a site office, connect cables, and start working. The transferability of the applications made sense also from the learning point of view. If the same tools are used both in offices and at sites, the users are familiar with the project tools. This will make also data transfer from the office to the site a lot easier.

I was not involved in the hardware decision, but the software was decided to base on PC technology. The PC hardware was cheap, available everywhere and most of the project professionals were able to maintain their own hardware and applications. The networking requirement could be also fulfilled with PC technology. A server was needed to connect two workstations, but the same server machine could well serve 50 workstations. The connected workstations could be very ordinary and cheap, equipped with a suitable network card. The client-server architecture of DataEase made the networking cheap, efficient and scalable.

4GL Tool Selection

I was not involved in the 4GL tool selection, either. The development tool was already selected when I started working for Pöyry Oyj. In retrospect, I think that DataEase was a reasonable choice. It was among the first 4GL tools which could operate on the PC platform. It had very advanced features both in organising and retrieving data in databases. Furthermore, DataEase was one of the major 4GL tools on PC platform in the late 1980s.

DataEase was designed to use relational data structure, which made it possible to create a complicated and compact software. The relational data structure enabled data integrity; a piece of information was entered to the system only once and it was immediately in every one's use. The relational data structure also enabled the modularity of the software. The modularity was pursued, because it improved the efficiency of the software, helped in system maintenance, and facilitated modifications. Modularity also enabled installing only sub-applications, if the entire software was not needed. Finally, it speeded up the software development and learning of the software.

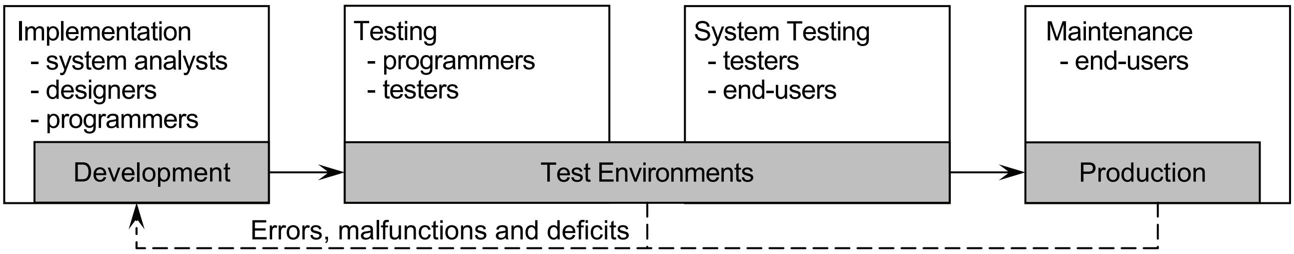
Furthermore, the relational data structure made data security much easier. It made it possible to use the record locking principle in data security. This was a vast improvement in data processing in local networks. Before 4GL, the most common data security setting was to lock the entire table in order to gain data security. The additional factor influencing the selection was that some employees were already familiar with DataEase. There was some experience of the 4GL tool in the company. According to their opinion, DataEase was very easy to learn, use and operate.

Organising Programming and Testing

Programming was carried out in three environments: development, test and production environment. Each environment had its own purpose and users, as presented in Figure 53. Programs were created in the development environment, tested in the test environment, and used in the production environment. When a program was accepted in its environment and was seen to function properly, it is transferred to the next environment. If any problems were found there, the program would be transferred back to the development environment. The process was iterative and transfers backwards were very common.

The development environment was in a single PC with a full DataEase installation. When the program was supposed to be ready, it was delivered to the test environment. In the test environment the application was installed as an ordinary user version. Programs passing the testing were delivered to the production environment, normally a large industrial plant project.

Figure 53. Program Flow



6.4. REVIEW

My research regards the development of the procurement software as much wider work than programming useful software. This chapter described the management of information systems and the general planning of the procurement software. The Pöyry project management and procurement instructions had given me a clear picture of procurement in industrial projects. I used the project management instructions as environment descriptions and procurement instructions as functional definitions of the software. These manuals established the background of the general decisions for the procurement software.

A managerial view to information systems was given to present the systems generally. The view was presented from the angles of expanded system development life cycle, change processes and technochange approach. First, the ESDLC model is used to describe the entire life span of the software. Second, implementing and developing software is a change process from the old to the new solution. The change process approach gives the basic ideas of upgrading software concurrently in use and managing different software versions. Together, they describe the behaviour of the solution which has more than one active version. Third, the technochange approach is introduced to explain organisational behaviour before, during and after IT projects.

General planning included strategic planning, integration planning and general implementation decisions. Strategic planning presented general reasons, or justification, for the software. Integration planning deals with the interfaces to other project software. The general implementation decisions clarify the general hardware and software decisions and the general arrangements needed to develop the procurement software. The general implementation decisions included the selection of the hardware and the 4GL tool and the organising software development environment.

7. DIRECT SOFTWARE DEVELOPMENT

In this chapter, I describe the direct software development, which followed closely the procurement flow presented in *Procurement Manual* (see Figure 49). This straightforward approach was applied in the two first development rounds before redesigning the procurement flow. A new DataEase version with the table-view feature ended this direct software development. The table-view enabled windowing of data tables, which eased the programming of the procurement as a cyclical process.

I programmed the first two software versions along with the project manuals. The software automated some routine tasks and helped in the manual work, but it was not a great success. The discomfort of learning new software and the fear of loosing control over their work made some project professionals despise the procurement software. The application decreased the flexibility of work and forced the workers to follow the procurement flow rigorously. The workers felt their tasks moderated and they regarded that their influence to their own work was diminished. They simply did not gain anything to compensate for the changes in their work. I faced the "resistance to change" problem for the first time.

The overview section introduces the various system development life cycle (SDLC) methods and presents the major steps in an information system development. Section 7.2. gives a more detailed picture of the waterfall approach in software development. Section 7.3. focuses on the two first development rounds of the procurement software, which were accomplished before the redesigning procurement flow.

7.1. SYSTEM DEVELOPMENT LIFE CYCLE (SDLC)

Systems Development Life Cycle (SDLC)[251] presents the major steps, the life span, of an information system development project. The expression has two distinct meanings: (1) an SDLC can be a general conceptual framework for all the activities involved in system development or acquisition, or (2) an SDLC can also be a very structured and formalised design and development process.

The systems development life cycle (SDLC) has many variations, such as waterfall SDLC, prototyping SDLC, spiral SDLC and object SDLC. All SDLC models cover the software development process, but they emphasise different aspects and are intended for different software implementation cases. If the software is purchased, the implementation stage would not include all the sub-stages. For example, programming might not be needed at all.

Waterfall SDLC

The waterfall SDLC is regarded as a proven approach. It is considered comprehensive, detailed, well-planned, but time-consuming and rigid development model. Royce[252] has presented a well-known variation of the waterfall SDLC model which includes iterations in the design. The extremely simplified SDLC comprises only system analysis and coding phases. Complex models have several phases more. For example, the DOJ SDLC[253] comprises ten phases: (1) initiation, (2) system concept development, (3) planning, (4) requirements analysis, (5) design, (6) development, (7) integration and test, (8) implementation, (9) operations and maintenance, and (10) disposition.

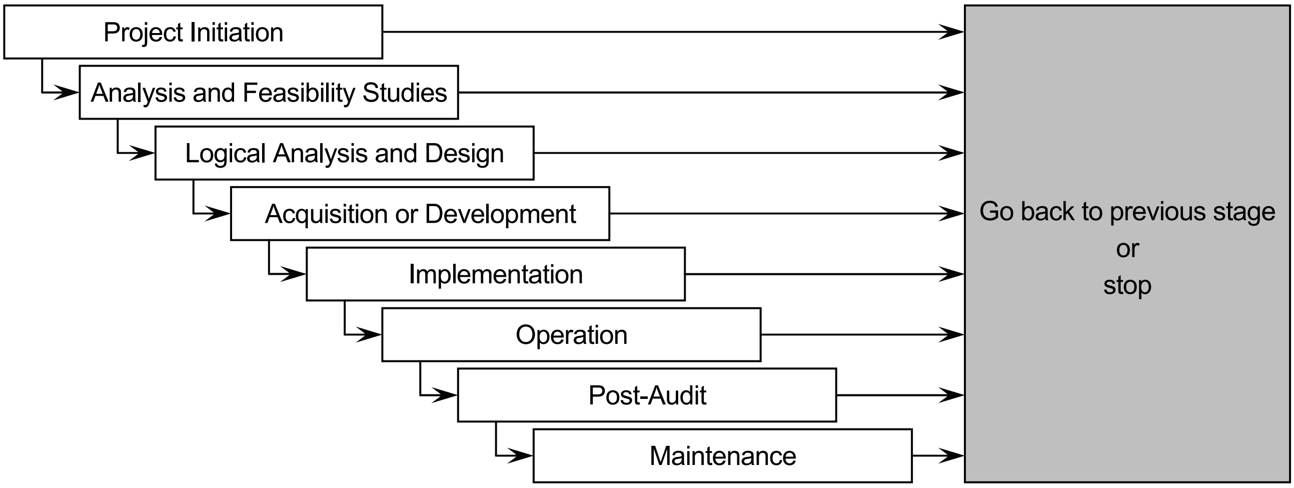
[251] Turban, McLean and Wetherbe: Information Technology for Management: Transforming Business in the Digital Economy (2002) pp. 607-610

[252] Royce: Managing the Development of Large Software Systems: Concepts and Techniques (1970) Proceedings of the IEEE WESCON, August 1970, pp. 1-9

[253] United States Department of Justice > Resources > Publications by Agency > IRM Systems Development Life Cycle http://www.usdoj.gov/jmd/irm/lifecycle/ch1.htm#para1.2 (15.05.2006)

Turban et al. have represents an eight-stage waterfall SDLC, illustrated in Figure 54. Besides the software implementation (either programming or initiating the use of the purchased software) the model emphasises managing the development efforts. Their waterfall model comprises project initiation, system analysis, logical analysis and design, development, implementation, operation, post-audit and maintenance stages.

Figure 54. Waterfall SDLC



Turban et al: Information Technology for Management… (2002), p. 610

Prototyping SDLC

The basic philosophy underlying the prototyping approach[254] assumes that succeeding with a single strike in the development of the unstructured information system is difficult, if not impossible. The users cannot specify their needs and wishes clearly enough to the developer. Therefore, it might be more productive to design and build a rough working model (prototype) based on preliminary meetings instead of spending a lot of time producing very detailed specifications. The users examine the prototype and ask for improvements, based on which the developer redevelops the system and presents the next version of the prototype to the users, and so on.

In effect, the four major phases of the SDLC - analysis, design, coding, review - are combined into one phase, which is repeated several times. The software evolves gradually through this process of trial and error, as the system is refined incrementally. Only cursory attempts are made in conceptual modelling. Prototyping is normally supported with rapid application development (RAD) methodologies and tools in order to make the system development faster. Prototyping typically takes place in graphical development environment and uses a code generator and reusable components.

Spiral SDLC

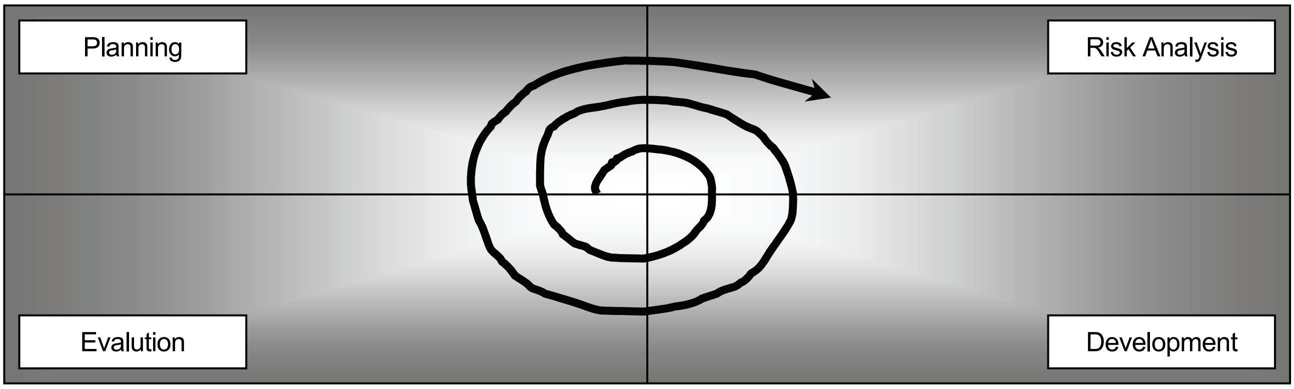
The spiral model[255] is also an evolutionary and iterative development life cycle which incorporates risk assessment with software development. The spiral model was developed in recognition of the fact that system development projects tend to repeat the stages of analysis, design and code as part of the prototyping process. The spiral SDLC is illustrated in Figure 55 on the next page.

[254] Dennis, Burns and Gallupe: Phased Design: A Mixed Methodology for Application System Development (1987) ACM SIGMIS Database, Vol. 18, No. 4, pp. 31-32

[255] Boehm: A Spiral Model of Software Development and Enhancement (1988) IEEE Computer, Vol.21, No. 5, pp. 61-72

Each spiral consists of four main activities: (1) planning, (2) risk analysis, (3) development, and (4) evaluation. Planning sets project objectives, defines alternatives, and carries out further planning for the next spiral. Risk analysis focuses on analysing alternatives, identifying risks and attempting to solve them. Development activities include designing, coding and testing etc. in increments. Evaluation comprises the user evaluation of each software version.

Figure 55. Spiral SDLC



Boehm: A Spiral Model of Software Development and Enhancement (1988), p. 64 (simplified)

Object-Oriented SDLC

Despite the diversity in object-oriented SDLCs[256], most object-oriented development methodologies follow a defined system development life cycle. All of them incorporate some form of iteration, parallelism and incremental development. The various phases are intrinsically equivalent for all the approaches, typically proceeding as: (1) requirement phase, (2) object-oriented analysis phase (determining what the product is to do), (3) object-oriented (detailed) design phase, (4) implementation phase, 5) implementation and integration phase, and 6) maintenance phase.

There are two main streams in the object-oriented SDLC[257]. The first main stream seems to focus almost entirely on programming language issues. Discussions of software development are held in terms of the syntax and semantics of the chosen object-oriented programming language. The evaluation requires that the evaluator understands the target platforms for which the methods are intended. The second main stream is interested in formality and rigour. The object-oriented SDLC is assumed to be an engineering process with well-defined deliverables. The quality of the resulting products (and the process itself) can be evaluated in a quantitative and qualitative manner.

In general, an object-oriented SDLC[258] does not begin with the task to be performed, but with the aspects of the real world that must be modelled to perform that task. Object technology enables the development of purchasable, sharable and reusable objects available in a worldwide network of information systems. A standard object-oriented language encompasses techniques and notations, which are called unified modelling language (UML).

[256] Schach: Object-Oriented and Classical Software Engineering with UML and C++ (1999) pp. 83-84

[257] Singh and Kotzé: An Overview of Systems Design and Development Methodologies with Regard to the Involvement of Users and Other Stakeholders (2003) Proceedings of SAICSIT 2003, September 2003, pp. 37 – 47

[258] Turban, McLean and Wetherbe: Information Technology for Management: Transforming Business in the Digital Economy (2002) pp. 621-623

7.2. SOFTWARE DEVELOPMENT IN WATERFALL SDLC

The most common SDLC, the waterfall model[259] has become the basis for most software acquisition standards in governments and industries. The model presents the system development steps following the elaborateness of the system being in construction. The waterfall SDLC[260] was the first model to recognise the iterative relationships between successive development phases. The model includes iterations with the preceding and succeeding steps but rarely with the more remote steps in the sequence. It scopes down the change process to manageable limits during the progress of the design, because after the requirement analysis the model maintains a firm baseline to which to return if unforeseen design difficulties arises. The second major conceptual improvement in the waterfall model was the initial incorporation of prototyping in the software life cycle, the "build it twice" step.

This section concentrates on the main development phases of the waterfall SDLC: determination of requirements, design, implementation (programming, testing and documenting), and maintenance. The phases of the waterfall SDLC are discussed assuming that programming is included in the life cycle of the information system. An independent subsection has been dedicated to the acceptance of the information systems, because it is a crucial part of any information system. Unluckily, I faced also the "resistance to change" problem.

7.2.1. DETERMINATION OF REQUIREMENTS

As described shortly when discussing the constructive research in Information Systems (Subsection 1.6.2), there are different strategies for determining information system requirements[261]. The requirements can be specified as (1) asking directly, (2) deriving from an existing information system, (3) synthesis from characteristics of the utilising system, and (4) discovering from experiments with the evolving system.

First, the requirements can be asked directly from the intended users. The requirements are obtained from employees by asking them to describe their information requirements. The direct asking allows the users to adjust their initial requirements. From a conceptual standpoint, it is assumed that the users have a mental model (or can build one) to explain their information requirements. These conditions may hold in stable systems established for example by law, regulation, or other outside authority.

Second, the requirements may be derived from an existing information system. In this strategy, the users and analysts start with the existing system and adjust the requirements to match the present needs. This is particularly true for deriving requirements for future systems that replace the existing system, for a system in similar organisation, and for a proprietary system or package. The descriptions of the old system in textbooks, handbooks, industry studies, etc. can be used in designing the new system. If the information system performs fairly standard operations and provides fairly standard information for stable business processes, the use of the existing system as an anchor point may be appropriate.

Third, the requirements may be defined through a synthesis from characteristics of the utilising the system. The primary requirements of organisational needs can be studied through normative analysis, strategy set transformation, critical factor analysis or process analysis. The requirements for

[259] Royce: Managing the Development of Large Software Systems: Concepts and Techniques (1970) Proceedings of the IEEE WESCON, August 1970, pp. 1-9

[260] Boehm: A Spiral Model of Software Development and Enhancement (1988) IEEE Computer, Vol. 21, No. 5, pp. 61-72

[261] Davis: Strategies for Information System Requirements Determination (1982) IBM Systems Journal, Vol. 21, No 1, pp. 4-30

the system can be studied with decision analysis, socio-technical analysis or input-process-output analysis. Information systems facilitate another system, which utilises the provided information. The requirements for information stem from the activities of the object system carrying out the business processes. The questions focus on activities and responsibilities that lead to the need for information. This approach is seen especially appropriate when the business processes are changing or the proposed information system is different from the existing systems in content, form, complexity, etc.

Fourth, the requirements can be discovered by experimenting with an evolving information system. In many cases, the requirements cannot be obtained directly and established completely in the beginning. The users may not be able to formulate information requirements because they have no existing model (normative, prescriptive or experiential) to base the requirements on, they find it difficult to deal in abstract models or to visualise new systems. Therefore, the users may need to anchor on concrete systems from which they can make adjustments and modification suggestions. Prototyping or heuristic development can be applied to overcome these difficulties. First, an initial set of requirements is used to build a prototype. Afterwards these requirements provide an anchor point, additional requirements are discovered through use. As the users employ the system, they come up with additional requirements. In principle, this is an iterative method for determining the requirements.

7.2.2. DESIGN

The design[262] of databases takes place in two substages: logical and physical design. Logical design is followed by physical design, which translates the abstract logical model into technical specifications for the target hardware and software. The resulting specifications must not be incomplete, ambiguous or contradictory.

Logical design does not refer to any technical environment. Logical design acts as a model of how the system will satisfy the user requirements. It reflects underlying business rules and activities rather than physical constraints. On the basis of the selected technical environment, logical design is translated to physical design, e.g. platform, programming language, database etc. Physical design produces program specifications for a selected target hardware and software. Physical design includes data design (data to be stored in a database), output design (reports and displays), input design (forms, screens and dialogues), and program design.

The entity-relationship model (E-R model)[263] can be applied to construct a conceptual data model. E-R models are typically used in the first design stage of an information system. They are used for example to describe the information needs and/or information types to be stored in the database. The E-R models express the entities of the system environment, the relationships among those entities and the attributes (properties) of the entities and their relationships. An E-R model is normally graphically presented with entity-relationship diagrams (E-R diagrams).

The E-R model[264] views data on multiple levels:

1) Information concerning entities and relationships which exist in our minds.
2) Information structure (organisation of information)
3) Access-path-independent data structure
4) Access-path-dependent data structure.

[262] Turban, McLean and Wetherbe: Information Technology for Management: Transforming Business in the Digital Economy (2002) pp. 612-614

[263] McFadden, Hoffer and Prescott: Modern Database Management (1999) pp. 85-87

[264] Chen: The Entity-Relationship Model: Toward a Unified View of Data (1976) ACM Transactions on Database Systems, Vol.1, No. 1, pp. 1-36.

7.2.3. IMPLEMENTATION

The aim of the implementation phase is to deliver documented operational programs with their training materials. The implementation phase includes programming, testing and creating user documentation of the software. These tasks are entwined and they can overlap considerably. For example, programs can be tested at the same time by the same test arrangement as the user documentation is inspected. The testing may produce new documentation, such as on-line helps for each program, for the tested programs.

The purpose of programming[265] is to translate the detailed design into a programming language. Testing is carried out to guarantee that the implementation satisfies the specifications, and to reveal as many errors as possible in the software. The documentation of software should facilitate the communication between the people in the development group, and later the documentation should support the operation and maintenance of the software. Software documentation[266] covers all the documentation during the life cycle of the software and it can be divided to two major groups: user documentation and system documentation. The user documentation is designed to help the users to learn and use the software. The system documentation is targeted at maintaining and developing the software.

Programming

In the programming stage, a design is converted into a complete information system. This conversion task is usually called computer programming, programming or coding. Programming takes place with a programming tool to develop the designed software. It includes acquiring and installing the system environment, creating and testing the databases or preparing the test case procedures, preparing test files, coding, compiling and refining programs, performing test readiness review, and procurement activities[267].

Ideally, the most suitable programming tools can be selected according to the programming tasks. In business environments, the question of the appropriate programming tools does not arise, because the tools can seldom be freely decided upon. The tools might have been selected by the customer (internal or external), or the situation (platform, the programming skills of the appointed personnel) can determine the programming tools.

Testing

Software testing[268] is a process of determining whether a program or a system operates in the desired manner. The first versions of most programs contain errors and inappropriate features, regardless of how carefully they were written. These flaws can either crash the software altogether or produce incorrect or inappropriate program behaviour and results. Actually, testing can never establish the total correctness of software. It can only find defects, not prove that there are none.

265 Pomberger: Software Engineering and Modula-2 (1984) pp. 62-63, 150

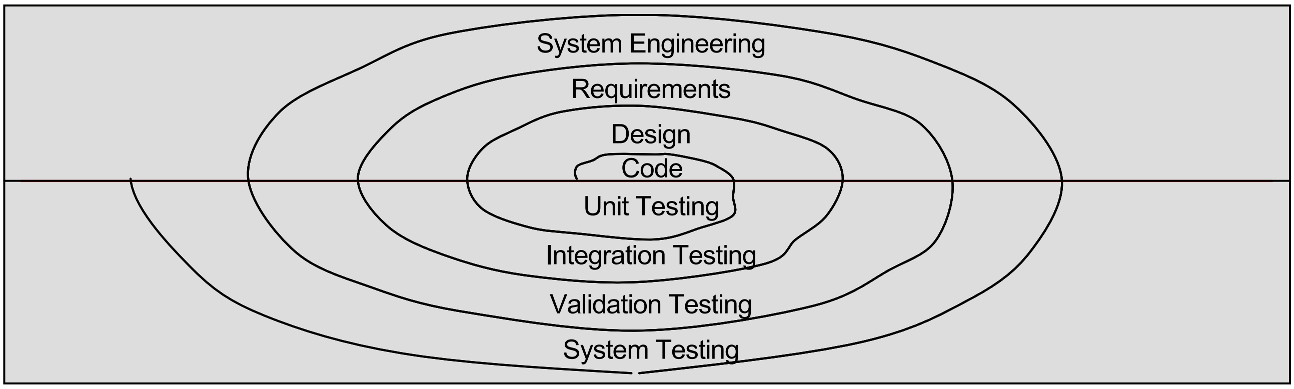
266 Brookshear: Computer Science: An Overview (1997) pp. 250-251

267 United States Department of Justice > Resources > Publications by Agency > IRM Systems Development Life Cycle http://www.usdoj.gov/jmd/irm/lifecycle/ch1.htm#para1.2 (15.05.2006)

268 Alter: Information Systems: foundation of e-business (2002) pp. 354-356

Software testing can be illustrated as a testing strategy spiral[269], as illustrated in Figure 56. The testing strategy spiral places different tests, i.e. unit testing, integration testing, validation testing and system testing in the context of SDLC. Each test is targeted towards the outputs of the corresponding software development stage. Unit testing begins in the centre of the spiral. It concentrates on each software unit as it is programmed. The testing progresses by moving outward along the spiral to integration testing, where the testing focuses on the design and the software architecture. Taking another turn outward, validation testing is encountered. Validation testing is conducted against the established requirements of the software. Finally, system testing takes place. In system testing, the software and other system elements are tested as a whole. To test the software, the scope of the testing broadens in each turn.

Figure 56. Testing Strategy Spiral



Pressman: Software Engineering: a practitioner's approach (2001), p. 481

Unit testing focuses on verification of the correctness of a particular unit of the source code. The goal of unit testing is to isolate each program feature and show that the individual parts are correct. Each test case is supposed to be separate from the others and should clearly show whether the program works correctly or not in the case. The correctness of the code is determined against the written program definition or requirements, which must be satisfied.

Integration testing is a technique for constructing the program structure while at the same time conducting tests to uncover errors associated with interfacing. The objective is to take tested components and build program structures that have been dictated by the design. There are two opposite approaches in integration testing: big-bang (comprising all the components and testing them at once together) and incremental integration, which gradually covers a larger and larger area of the software, helping the isolation the discovered errors.

Validation testing can begin when the software is assembled as a complete package. The validation can be said to succeed when the software functions in the manner expected by the customer (internal or external). The software requirements are supposed to describe all the user-visible arguments of the acceptable software.

System testing is the testing phase whose primary purpose is to fully exercise the computer-based system. System testing is carried out to verify that the system elements have been properly integrated and perform the allocated functions on the platform on which it will be deployed. System testing might be performed by trained testers without programmers by using the black-box-testing approach.

[269] Pressman: Software Engineering: a practitioner's approach (2001) pp. 477-499

Documentation

Documentation is likely the most undervalued task in software development. The programmers who know the programs intimately, do not normally use time for documentation. They say that their task is to write working programs, not explanations of how the programs work. Some of them even claim that the program with its source code explains every aspect of the program. Lientz[270] has found that the quality of documentation is the most severe technical problem in software maintenance.

> "If it not documented, it does not exist."[271]

Vartiainen, my former supervisor at Pöyry Oyj, used the sentence above to emphasise the essence of the system and the user documentation. Documentation is the way to overcome difficulties and ease the introduction and use of the application. He stated that the most brilliant applications may fail if they are difficult to learn and use. Software without documentation can be used as a personal procurement tool, but it will never reach general acceptance. The application will stay on the developer's responsibility forever. Furthermore, no one can help in the maintenance of the application and the developer will have to make all necessary modifications.

Effective software documentation[272] has common features which should be pursued. Good technical documentation is (1) accurate, (2) clear, (3) concise, (4) coherent, and (5) appropriate. These qualities might be difficult to achieve, but they should be striven for, nevertheless.

Accuracy can be defined to be careful conforming to facts or truths. Accuracy has three main aspects: document accuracy, stylistic accuracy and technical accuracy. Document accuracy refers to the proper coverage of the topics on the appropriate level. An accurate document needs a clearly defined focus. Stylistic accuracy concerns the careful use of language in expressing meanings. Technical accuracy requires stylistic accuracy but is not solely based on it. The technical document must be grounded on technically accurate understanding and representation of the subject.

Clarity refers here directly to ease of understanding. It is a special problem in technical documentation: specialised languages, mathematically detailed analyses and complex conceptual schemes can make technical subjects hard to grasp. Even expert readers have sometimes difficulties in reading documentation in their own field.

Conciseness has a special importance in technical fields. It is so tempting to include everything that could be relevant to the subject. It is difficult to limit the writing to contain only the relevant material to the current document. This is best helped by defining a clear focus to the document. A concise document conveys only the needed information. Narrowing the document scope, a clear introduction and a detailed outline can offer control over the document's length and scope.

Coherence is the quality of the documentation, which provides readers an easy path through the documentation. Writers promote coherence by making their material logically and stylistically consistent. Coherence can be improved by organising and expressing ideas in specific patterns. Emphasising the relationships among document elements strengthens its impact. Coherence can dramatically improve the understanding of the material by promoting its flow or readability. It is highly valued in science and technology because of the inherent complexity of the subjects.

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270 Lientz: Issues in Software Maintenance (1983)
Computing Surveys, Vol.15, No. 3, p. 276

271 Vartiainen, Pöyry Oyj: Discussions of documenting procurement software (1990)

272 Mayfield Handbook of Technical & Scientific Writing > Planning and Producing Documents
(Perelman, Barrett and Paradis: Mayfield Handbook of Technical & Scientific Writing)
https://mit.imoat.net/handbook (09.12.2004)

Appropriateness is largely determined by the audience, the readers' knowledge and experience determining the comprehension of technical material. The documentation should be appropriate to the writer's goals in writing it, the audience's purpose in reading it, and the institutional contexts in which it is written and read. For example, a fact expressed in a complex mathematical equation may not be effective (or even understood) in a report which is addressed to general management.

7.2.4. SOFTWARE MAINTENANCE

Information systems do not remain static after the start-up, but are subject to requests for enhancements, for adapting to different environments and to changing domain knowledge, in addition to simple bug-fixing. To be useful, the software must not only meet its specification, it must be also maintainable. The software should be easy to modify to meet changing requirements[273].

According to Lientz's studies[274], the interest towards software maintenance has increased recently for three reasons. First, the growing number of systems has increased the volume of software enhancement and maintenance, which in turn restricts the resources available for new development. Second, there is a growing awareness that the tools and aids used in software development may have little effect on operational systems. Third, the management of information systems has become more important, because of the costs and resource utilisation of software maintenance.

Lientz states that the five most severe problems in software maintenance are the quality of software documentation, user demand for enhancements and extensions, competing demands for maintenance programmers' personnel time, difficulty in meeting scheduled commitments, and personnel turnover in user organisations. Of the most severe problems, three are concerned with users, two with the, and only documentation can be considered as a technical issue. The predominance of other than technical issues is striking.

Four main forms of activities[275] have been identified in software maintenance: corrective, adaptive, perfective and preventive maintenance. **Corrective maintenance** concentrates on eliminating errors in the program functionality. **Adaptive maintenance** comprises modifying the application to meet new operational circumstances (such as a new environment). **Perfective maintenance** aims at software enhancements (new functions and refinements to old functions). **Preventive maintenance** is carried out to modify programs to improve future maintainability.

Lientz, Swanson and Tompkins have carried out exploratory survey of organisations involved in software maintenance and enhancement[276]. The primary conclusions of their study are:

1) Maintenance and enhancement do consume much of the total resources of systems and programming groups.
2) Maintenance and enhancement tend to be viewed by the management as at least somewhat more important than new application software development.
3) In maintenance and enhancement, problems of management orientation tend to be more significant than those of technical orientation.
4) User demands for enhancements and extensions constitute the most important management problem area.

[273] Lano and Haughton: Software Maintenance Research and Applications (1992) NordDATA'92 Preceding, p. 123

[274] Lientz: Issues in Software Maintenance (1983) Computing Surveys, Vol.15, No. 3, p. 271-278

[275] Leonard, Pardoe and Wade: Software Maintenance – Cinderella is Still not Getting to the Ball (1988) BCS/IEE Conference on Software Engineering 1988, pp.104-106

[276] Lientz, Swanson and Tompkins: Characteristics of Application Software Maintenance (1978) Communications of the ACM, Vol. 21, No. 6, pp. 466-471

In general, more attention in software maintenance should be paid to management problems. In practice, the maintenance work should be managed in a more detailed manner. Project reporting systems should provide the information of maintenance and enhancement, including maintenance type and task information. The handling of user requests for enhancements should be examined to determine improved means for evaluating and satisfying the use requests. In particular, consideration should be given to designing, with future enhancements and extensions in mind.

7.2.5. ACCEPTANCE

Information systems do not differ from any other knowledge management systems regarding the difficulties in system start-up and gaining the acceptance of the end-users. Not all difficulties arise from technical problems. Many challenges in gaining the acceptance of the end-users origins from the fact that groups are different from organisations or individuals.

Groupware are multi-user software, but smaller than systems serving organisational goals. An organisation will not restructure itself for a new application the way it does, for example, around a new ERP system. On the contrary, small software must adapt to the organisation and fit into existing work patterns, appealing to everyone who must support it. Unfortunately, the management is less committed to the less expensive groupware. On the other hand, groupware often benefit from the end-users' familiarity with other similar computer systems, the relative homogeneity of the end-users, and shared goals of many groups.

Grudin[277] describes in his article challenges of accepting a groupware. He has also made some recommendations to overcome the behavioural and social challenges facing multi-user software development and use. It can be said that awareness of the possible challenges and understanding the situation can help in developing and implementing multi-user software. Because of the social and political factors of group work, it is trickier to achieve acceptance for a groupware than for a single-user product. Grudin has identified eight specific problem areas for groupware: (1) disparity in work and benefit, (2) critical mass and prisoner's dilemma problems, (3) disruption of social processes, (4) exception handling, (5) unobtrusive accessibility, (6) difficulty of evaluation, (7) failure of intuition, and (8) the adoption process.

The disparity in work and benefit in introducing and using the groupware is nearly inevitable. Multi-user software never provides precisely the same benefit to every group member. The costs and benefits of new software depend on preferences, prior experience, roles and assignments. Although new software is expected to provide a collective benefit, some people must adjust more than others. Ideally, each employee benefits, even if they do not benefit equally. However, this favourable situation is seldom realised. Information systems often require additional work from people who do not perceive a direct benefit from the use of the application. Most groupware require some people to do additional work to enter or process information required or produced by the application.

Critical mass means that most multi-user software are only useful if most of the group members use it. For example, different individuals may choose to use different word processors but two co-authors must agree on the co-authoring tool. Achieving a "critical mass" of users is essential for any information system, which demands the input of group members. In an idealised situation, where every individual will benefit once critical mass is achieved, the early adopters may well abandon the application before the critical mass of users is reached. Multi-user software can fail because it never reaches the point when any user has any advantage of the use of the application. The prisoner's

[277] Grudin: Groupware and social dynamics: Eight Challenges for Groupware Developers (1994) Communications of the ACM, Vol. 37, No. 1, pp. 92-105

dilemma is a situation where the result is worse not only for the group but also for each individual if everyone acts to further his or her personal best interest. Therefore, the success of the groupware is not guaranteed, even if the application provides a net benefit and benefits for all users.

Disruption of social processes may result from groupware. Workers may resist groupware if it interferes with the subtle and complex social group dynamics. Computers need explicit, concrete information and clear commands to operate efficiently. However, group activities have social, motivational, political and economic features that are rarely explicit or stable. Our actions are often unconsciously guided by social conventions and our awareness of the personalities around us. This knowledge is not available to any computer. Tacitly understood personal priorities are very often tactfully left unexpressed. Unless such information is made explicit, the application will be insensitive to it. For example, secretaries know that managers' unscheduled time is seldom really free.

Exception handling, error handling, and improvisation are characteristics of all human activities. Normally people know when the "spirit of the law" takes precedence over the "letter of the law." Information systems should accommodate the wide range of exception handling and improvisation that characterises group activities. Work processes can usually be described in two ways: the normative way describing the ideal process and the descriptive way presenting the real process. Software supporting only standard procedures can be too rigorous in heavily varying situations. If the solutions are not able to solve the problem, this could bring the work to a halt instead of supporting it.

Unobtrusive accessibility and integrated support to individual activities will give a good starting-point to groupware. Communication and co-ordination are important social elements, but they are needed less frequently than features supporting individual work processes. Many organisations are structured in order to minimise the overall communication requirements and social interdependencies. As well known, an increase in organisation size can lead to a decrease in efficiency by increasing the communication and co-ordination needs. Features supporting information handling and work control are normally used relatively infrequently. They must not obstruct frequently used features, yet they must be known and accessible to the end-users.

The difficulty of evaluation might diminish the success. Task analysis, design and evaluation are more difficult for multi-user applications than for single-user applications. The groupware must interface simultaneously to all the users with different and sometimes shifting roles, preferences and backgrounds. Test situations and partial prototypes can seldom capture complex but important social, motivational, economic and political dynamics reliably. Situation differences prevent us from learning from experience. Generalising from experience can be misleading, because establishing the success or failure of an application is easier than identifying the factors that brought the success (or failure). Even when a full implementation is available, scheduling a meaningful test is a logistical challenge. For instance, a highly motivated group might find a way to use a seriously flawed product efficiently. On the other hand, a badly managed installation can cripple a good product.

The failure of intuition can shadow the implementation of groupware. Decision-makers rely heavily on informed intuition. A manager can fail to appreciate the intricate demands on a groupware application that requires participation by a range of users. In particular, decision-makers are drawn to applications that selectively benefit one user group: the managers. This is understandable – every one of us has ideas about what will help us do our job. Unfortunately, managers often underestimate the unwelcome extra work that an application will require from other users, which can result in negligence or resistance. A converse intuition failure also occurs sometimes. A decision-maker does not recognise the value of an application that primarily benefits the non-managers, even when it would provide a collective benefit to the group or organisation.

The adoption process has to be carried out more carefully than the developers have been used to. It might be difficult for developers to assist in an introduction of an application and to help in gaining acceptance, but they may have to. Through involvement with the adoption process developers can contribute to it and learn to build support for the adoption into the application itself.

7.3. DIRECT PROCUREMENT SOFTWARE DEVELOPMENT

It has taken a lot of time and effort to reach the current state of procurement application. From the very first unsophisticated programs, a streamlined procurement application with automated progress follow-up and data warehousing. It has been a winding road to travel from a stand-alone PC application to networked software.

The procurement software development was initiated at Pöyry Oyj in the late 1980s. In order to maintain the competitive advantage, Pöyry Oyj started restructuring of the project instructions to meet concurrent business requirements. During the development project, rewriting the instructions were considered a necessary, but not sufficient means to carry out efficient project management. If the project management tools are badly outdated, the brightest ideas might be worsened to an unacceptable level by poor project management. In best practices, modern tools are needed and have to be utilised as far as possible. The situation can even turn upside down; the modern tools might provide new or improved best business practices. All this led to a decision to develop better and more efficient tools for project management.

Six development rounds were carried out bringing improvements and new features to the procurement software. The final target has always been the same: improve the software. Some improvements increased the functionality, efficiency and flexibility of the procurement software, while others fixed errors. Also some new hardware solutions were taken into use.

The whole life cycle of the procurement software resembles more iterative models, such as spiral SDLC, as discussed in the next subsection. In developing the releases of the procurement software, I tried to follow the waterfall model. This section focuses on the two first development rounds in which I attempted to follow the project instructions directly in developing the software.

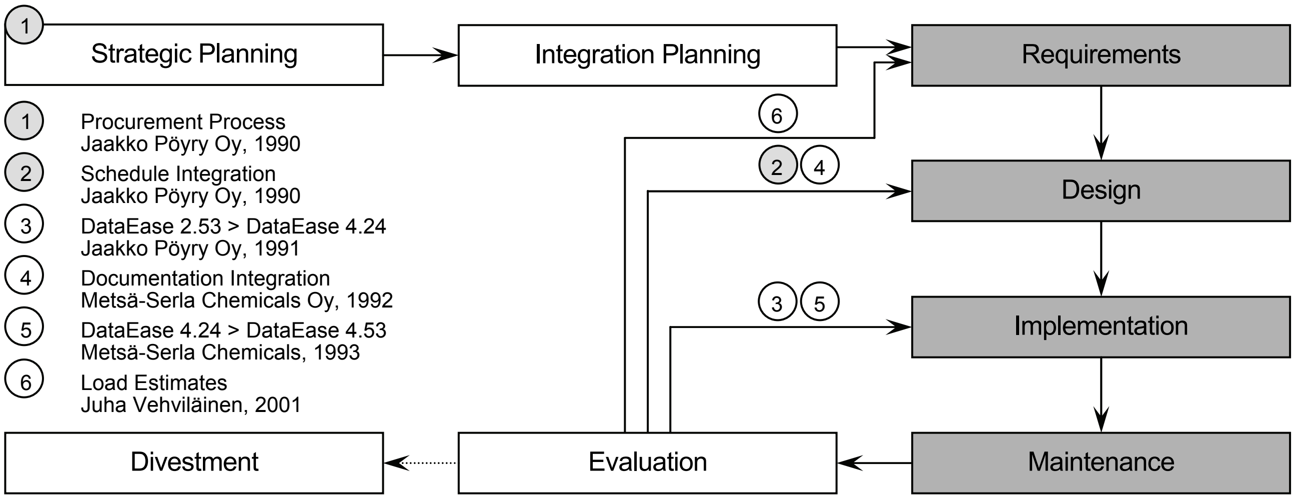
Development Cycles

So far, the development of the procurement software has made six iteration rounds. The original aim to make a simple procurement tool matching the procurement instructions was severely pursued after. The first version carried out only purchasing tasks and reported the purchasing actions. Although the software helped the purchasing, it was considered inadequate and the development had to continue. Finally, after the sixth development round, the current state of the software was achieved. During the development, my employment at Pöyry Oyj was terminated. However, I kept improving the software, because I needed project management features in ERP projects. I also felt that there might be some scientific interest and I still regarded the software development as a way to improve my skills.

I use ESDLC combined with waterfall model to describe the development rounds. The original development round with the determination of the requirements created a baseline for the development of the software. Later, the following cycles were initiated by a new end-user, project management or a system need, which had stayed hidden before.

The iterative picture, Figure 57, illustrates two dominant features in software development: growing user demands and the development of the IT tools. User demands tend to grow, because users can seldom describe all the needs in the initial round. It is also quite difficult to imagine the consequences of the use of the new tools and work methods. If growing user demands are assumed to pull the application development forward, the improvements in IT push the applications further. New hardware and software are invented and they are applied in order to make more efficient IT systems.

Figure 57. Development Rounds of Procurement Software



It is obvious that eventually every application will be discarded. Corporate level tools live only as long as they are useful for the company. The use can end because of various reasons. An arrival of a more efficient or cheaper similar tool, incompatibility with newer operating systems or other corporate applications, and operating costs can cause the divestment of the procurement application. The software can also become outdated by changes in procurement process undermining the usability of the application. From Pöyry Oyj's point of view, they have divested the procurement software. They do not use any version of the procurement software.

The procurement software has special features concerning the termination of its use. It was thought that every project has important project information (implemented plant, suppliers and equipment data) and this information is supposed to be worth saving. Therefore, data saving procedures were already programmed in the software. The features were included, because every project ends in one way or another and the software has to be shut down at the site. The recorded information was designed to be transferred from the project site database to a common enterprise data warehouse to accumulate the supplier and cost information.

7.3.1. REQUIREMENTS FOR PROCUREMENT SOFTWARE

The procurement software was defined by placing requirements for the software. I considered the project manuals as metadefinitions for the procurement software. The *Project Management Manual* portrayed the operating environment and the *Procurement Manual* described workflows as they should function. On the other hand, the flexibility requirement pointed out that some additional features should be programmed to facilitate the currently used workflows. Luckily, there was a unified view of the basic purchasing workflow. In scheduling and progress calculations the ideas were more diverse and the software had to be built to carry out several methods for progress calculations.

Otherwise, I had free hands to design and construct the procurement software. My supervisors reminded me sometimes that the software should be very functional, because after the programming I would be using and maintaining it. In all, the system definitions were a kind of moving target, because new project approaches, work methods, and the advance of information technology added new application requirements.

The procurement software definitions included the determination of the general, functional, flexibility and efficiency requirements. Also, some requirements for user interface features were placed. Moreover, the *Procurement Manual* described the layout of the key printouts. The establishing of the system definitions was a two-way effort. On the surface, it was an engineering task to implement the procurement software. Inside, there were implicit requirements to support procurement in varying environments by enhancing the flexibility of the software.

General Application Requirements

The general application requirements were derived from the general procurement features in the project business. Procurement is team work of numerous professionals, and Pöyry Oyj has normally several projects going on at the same time. An efficient procurement function requires that the software is able to handle many simultaneous users and projects.

The software had to enable sharing of information without duplicating it. All the produced information had to be at once in every one's use and in the right format. It was, and still is, very common in project management that a piece of information is produced by one person, modified by the next employees, and finally used by other persons. The software should also be able to carry out many projects at the same time. The personnel might work in several projects at the same time and they must have access to their projects. The access to multiple projects makes it easy to evaluate current bargains both in the light of historical data and with comparison of other running projects.

A single database in a stand-alone PC can contain many projects, but it cannot efficiently share information with anyone. This implies the need of networking to share and distribute information. Local area networking (LAN) was decided to be the suitable technology, because the workstations are normally quite close to each other either in the office or in site premises. LAN is also the fastest networking model, where response times from servers are quite close to those achieved within a PC.

Functional Requirements

The procurement software was intended to follow the instructions of the *Procurement Manual*, which was generally thought to present the state-of-the-art for procurement in industrial plant projects. Following closely the procurement instructions, I assumed to achieve adequate quality in the procurement software. The additional benefit of the software was that it forced the purchasing personnel to use the programmed workflows, which presumed the use of best procurement practices. In turn, the procurement software changed the procurement practices, which had to be recognised in the *Procurement Manual*. The software created new, more efficient ways to carry out procurement tasks.

Procurement instructions established the basis for the functional requirements of the procurement software. The key idea was to implement a procurement application in the way that the software would carry out the workflows described in the project manuals. The manuals stated clearly both the environments of the software and the preferable workflows in procurement. The manuals defined the advisable workflows, described the operating environments for the software, and presented examples of standard procurement printouts and reports. These functional requirements described how the software was expected to work. These requirements were presented in Sections 4.3. and 5.3. They included workflows, data warehousing, and standard printouts and reports.

The workflows of the procurement software had to be programmed strictly in the way Pöyry Oyj operates the procurement function in large industrial plant projects. The workflows comprise procurement, scheduling and follow-up processes. These workflows cover purchasing from inquiry specifications to contracting. Originally the procurement workflow was programmed as a single linear process. In the third software development round, the procurement process was redesigned and changed to a more compact cyclical form. The redesign split the single procurement flow to several iterative cycles, commonly organised as budget inquiry, tender inquiry and final inquiry rounds. The redesigning efforts are described in Section 8.3.

Data warehousing was seen to be necessary for collecting cost information. Data warehousing was required for sharing the information of completed and running projects between all users. Company and cost information was demanded to be collected automatically during the procurement flow. If anybody saved a new address or a cost item, the information should be available immediately for all. The integrated data warehousing changed data warehousing from archiving to a support function.

There are some standard printouts in purchasing, such as “Inquiry Covering Page”, “Inquiry Summary Letter”, “Final Tender Request” etc. The printouts were designed according to the standards of the *Procurement Manual*. The printouts coped with their principal tasks, but nothing more. These printouts could be also used as templates and they could be modified for each tender request, if needed. Some reports were required for the procurement follow-up as well. It was clear that pre-defined reports were necessary. Reports were normally printed on paper, but they could also be directed either to the screen or a file. A preview feature was asked for, in which a user prints a report first on the screen and after the inspection prints it out.

Flexibility Requirements

Flexibility was regarded to promote the usefulness of the procurement software. The software was demanded to be operational in very different conditions. It was demanded that flexibility had to be kept in mind in building the software. The selected solutions were supposed to fit varying needs and support several procurement approaches. The project experience pointed out that some projects need additional coding systems to satisfy the customer needs. Software flexibility was programmed to ensure that some irregular work methods outside the procurement instructions would still be available. While the procurement instructions described the working methods, the descriptions of used ad hoc project solutions indicated the need of flexibility in the procurement software.

The software structure and the relational database behind the software helped to construct flexibility into the application by using additional (presented or hidden) data fields with or without defined relations to the other tables. First of all, data entries were designed to happen only from one direction. If simultaneous data entry was needed to more than one table, fixed windows were programmed to support the data entry, and the data was saved only in one place. From the user’s point of view the fixed windows are merely a group of fields in the program. Finally, relational databases are easy to modify to meet altered data processing needs.

The second way the structure supported software flexibility was designed into the classification features for recording information (items and events) in the database. The direct classifications were designed to take place by related coding tables, where the users had free access. No free-text or choice fields were provided for direct classifications to prevent typing errors. Also, additional text fields were placed in the programs. Although they were supposed to carry the user notes of events and items, they could be used in additional indirect classifications.

Last, flexible interfaces were planned for data transfer from and to other programs. The interfaces used translation tables to solve mismatching of different coding systems in separate applications. The interfaces were also designed to support different data structures. For example, scheduling used one-dimensional coding system for procurement activities while the procurement function used a hierarchical coding.

Field definitions were made according to the worst case scenario to improve software flexibility. The classification code fields were always defined to be longer than the original requirement. A typical example is the project code. Pöyry Oyj had a five-digit project code. In the application it is a ten-character field instead of five. The other way to contribute flexibility was to use a less limiting field type. At Pöyry Oyj, the process area codes were always two-number coded. In the software, the process area code is defined as an alfa-numerical field to allow letters in process area coding.

Flexible reporting was regarded to be achieved with an in-built report generator of DataEase, called Quick Reports (a query-by-example tool). It provides ad hoc reporting tools for unforeseen reporting needs. It enables everyone to create additional reports according to their needs. Quick Reports allows the users to select the fields in normal data entry form to be reported. After selecting the fields and calculation definitions, DataEase creates the report automatically. Quick Reports was taught to the end-users, and it is described in DataEase manuals and the *User Interface Guide*.

Altogether, the flexibility demand was vaguely described. I was instructed to use my imagination and invent things to support flexibility. The only defined requirement was that the users should be able to create new reports easily without programmers. I made my best to fulfil the flexibility requirements. I organised the whole application to support flexibility. Flexibility (compared to the original functional requirements) can be found in the software structure, field definitions and reporting.

Efficiency Requirements

There were no exact efficiency requirements for the procurement software. My supervisors instructed me that in data entry the system should be able to swallow all the typing that an average secretary is able to do. In reports and layouts a small delay would be accepted, if it did not disrupt the workflow. For database maintenance tasks they provided no guidelines. Naturally, my supervisors hoped that the described efficiency level should be achieved with a modest PC.

The selected 4GL tool, DataEase, took care of the efficiency aspects. DataEase was one of the most powerful database engines at that time and provided adequate data processing capabilities. Also, the hardware development introducing increasingly efficient computers helped to keep the software on an acceptable efficiency level.

User Interface Requirements

Although I did not design screen layouts on paper beforehand, I used DataEase to compose drafts to screen layouts. DataEase had already in the late 1980s a nice cut-and-paste function for replacing fields on data entry programs. I normally made a preliminary layout for a data entry program, which the users tested and then they gave their opinions on the program and its layout. Their experience was used in constructing the final layouts of the data entry programs.

I decided that the user interfaces would follow simple design principles: (1) efficient data entry, (2) user-friendly interface, and (3) transparent data processing. These features support each other. Transparent data processing can well result from user-friendly interface and improve the efficiency of data entry.

The first design principle, efficient data entry was expected to be achieved by using the same basic layout for every data entry program. Likewise, reports were also designed to use similar layouts. The similarity between the programs of the same class (data entry programs, reports and menus) was thought to help the learning and adoption of the application. Efficient data entries minimise work and errors, and maximise the speed of data processing. Robustness was demanded, because an application must tolerate errors accumulating from the users, software and hardware. The most probable errors were planned to have error handling procedures. For example, data types were used to prevent typing errors. Each data entry was checked and unsuitable data entries were neglected.

The second design principle, user-friendly user interfaces was more difficult to reach. The term “user-friendly” is vague and its definition is subjective, depending on the user. The common meaning in software development is based on adequacy, clearness, understandability and learnability. Adequacy means that only necessary data entries should be required. The rest only complicate the application and make it difficult to comprehend and use. Clearness comes from layout properties. The use of colours, the proportional locations of fields and field labels and the grouping of the fields determine the clarity of the user interface. Also the naming and length of the fields affect the clarity. Understandability and learnability make the learning of the system easy. Similar cases should be processed in similar ways. The program functions should stay the same in each program and they should be initiated in the same manner in each program. The manuals and instructions should be well written and cover the whole application.

The third design principle, transparent data processing, was supposed to be achieved by designing the user interfaces to present the fields in a natural order. The English reading order (from left to right and from top to bottom) was used to show the importance or timing of the fields. The most important fields are placed on the top and left hand side of the screen. The less important fields were found on the bottom and right hand side of the screen. The timing principle dictated locations of event processing programs and fields. Normally, the event order matched the data entry order. The transparent data processing was expected to minimise typing and understanding errors.

7.3.2. DESIGN FOR PROCUREMENT SOFTWARE

I used the entity-relationship model to construct a conceptual model of the procurement software. The requirements of the procurement software decided the data needed to be stored. On the other hand, the *Procurement Manual* described the procurement flow and the necessary documentation. These information sources together guided my efforts to define the E-R diagram of the procurement software[278]. The illustration was quite simple; it showed only the entities and their relations.

The E-R diagram of the procurement software was primarily targeted to document the database structure. The model was useful in programming the procurement software, because the used 4GL tool (DataEase) has inseparable database and data processing programs, i.e. the defined data tables had in-built data processing functions. This combined database and database engine forced me to follow a relational database model, which made the E-R model sufficient for most design cases. Later, it was used in implementing new features (interfaces) towards other project management software and in introducing to other IT professionals to the procurement software.

[278] Vehviläinen, Pöyry Oyj: Project Management Database and Programs (1990), chart

7.3.3. DIRECT IMPLEMENTATION, MAINTENANCE AND EVALUATION

The software implementation was full of programming efforts. As long as the application was not used anywhere, I could continue programming and unit testing on a single PC. The code was written, tested, rewritten, and tested again, and so on. I struggled to create reasonably well-behaving programs and to deliver them in time.

Just before the first project, general testing phases were carried out. The future users of the software tested the application in a separate test environment. After some modifications, the software passed the tests and it was ready to be used. The first start-up was exciting; will everything work like anticipated or will it crash totally? Neither happened, the system worked and stayed operational. Not beautifully, but it clearly worked. The start-up of the first version did not end the programming of the procurement software. On the contrary, now the programming efforts were divided to the maintenance of the first version and the development of the second version. I kept them united as far as I could to avoid double work of programming the same features twice.

User experiences accumulated and development ideas gained attention. Some improvements were expected to appear as soon as possible to the procurement software and were decided to be implemented even during the first project. This created a new situation: how to deliver the improved program versions? Luckily, DataEase had transfer tools for delivering new programs to the application. These tools were used to upgrade the running procurement software at project sites.

Development Round 1 – Procurement Process

The first development cycle created a procurement software, which was able to carry out all the required procurement. The original idea was to program the software directly along the project instructions. The project management instructions were used as environment requirements and the procurement instructions as metadefinitions of the software. The procurement software was programmed, but it was not a great success. The application helped in routine tasks by automating some manual work. There were no interfaces to other systems and all the data transfers had to be done on system level. The user interface was quite primitive and not very efficient due to functional weaknesses in the application.

Because the software was seen as promising, although unfinished, it was decided to continue the software development. My supervisors saw that the original idea to build the procurement software along Pöyry procurement instructions was sound. They also considered that strategic planning and the determination of the software requirements were carried out properly, only the implementation was not right. My supervisors saw that the major problem was the lacking support for scheduling. They believed that the “resistance to change” would be abated, if the software errors were eliminated and a scheduling interface was added.

Also I felt disappointed with the first version of the software. It was clumsy and inefficient. It had far too many independent features to be a straightforward solution to project management problems. The maintenance of the application was difficult and caused much more work than I had anticipated. I also had to program some new reports and add some classification fields to the procurement software.

Development Round 2 – Schedule Integration

The purchasing and implementation schedules were normally made in MS Project, Primavera, Artemis etc. The schedules had to be transferred to the procurement application to guide the timing of purchasing actions. The need of scheduling features was noticed already in the design phase, but these features were left out due to the limited programming time. After the introduction of the procurement software, the scheduling features were regarded so valuable that the development of the second version was initiated to provide an interface to the scheduling programs.

I implemented the features as add-ons to the original procurement software. The procurement software processed the schedule information to match the purchasing workflow. Also, the scheduling changes made in the procurement software had to be transferred back to the scheduling program. The need of flexibility was demonstrated, when two fairly simple applications were integrated with each other. It was also the first time when mismatching item coding was recognised and data translation tables were created. This second version of the procurement application gained some support, mostly because it minimised work in scheduling procurement activities.

The alternative solution for scheduling would have meant training the scheduling personnel to use system facilities to data transfers. This option was ruled out, mostly because it threatened the data security. If scheduling professionals without IT background had administrative rights, it would eventually be likely to cause major data losses accidentally. This option would also have meant a lot of training of the schedulers.

Maintenance and Evaluation

After the launch of the first version, the need of maintenance was recognised. The maintenance was centralised in the Helsinki office of Pöyry Oyj, because the best software understanding was there. In principle, the procurement software was modified for each project to meet the requirements of the project management. The hopes and desires of project leaders were implemented and the application was adapted to prevailing practices and conditions indicating adaptive maintenance. Immediate user feedback supported all the maintenance tasks. The best solutions were used in the development of the procurement software.

Naturally, I had to fix the programming errors in the software, making the maintenance mostly corrective. The fixing of errors was prioritised and recognised bugs were removed as soon as possible. Moreover, software maintenance was sometimes perfective, when I programmed new reports and added some fields to the database. Preventive maintenance occurred when I fixed software structure in order to ensure the quality of the data.

The requirements for the software included the idea that project professionals should be able to make elementary administration tasks, like backups and printer settings on project sites. Some project professionals learned to modify programs and soon the site installations were different compared to the original version. Flexibility and rigorous software control simply do not match.

Neither Pöyry Oyj nor customers evaluated procurement software officially. The decision on procurement tools was considered free. The customers bought procurement services from Pöyry Oyj, which included personnel, their skills and tools. The project professionals used the programs they were accustomed to use. In practice, the user experience and opinions measured the usability of the procurement application. The project professionals had a very pragmatic view towards the software: they used to say that it was the only application available to them, so they used it.

7.4. REVIEW

This chapter has described the first two software development rounds before redesigning the procurement flow. The direct programming following the project manuals ended when a new DataEase version with the table-view feature enabled the windowing of data tables, which facilitated the programming of the cyclical procurement flow.

In the two first development rounds, the procurement flow was designed directly after the rewritten *Procurement Manual*. Moreover, the manual described the layouts of the key procurement printouts. The future users of the procurement software placed some requirements to the flexibility, efficiency and user interface. After creating an E-R diagram and some general guidelines for the user interface, programming started. The created programs were tested first as individual programs and later as packages. After passing the system test, user instructions were written and the software was ready to be released.

Although the first two software versions were programmed following world-class project instructions, the procurement software was not a great success. The software automated some routine tasks and helped in manual work, but it was not enough to gain general acceptance at Pöyry Oyj. The discomfort of learning new software and the fear of loosing control to their work made some project professionals suspicious of the procurement software. The application decreased their control over their work and forced them to follow the procurement flow rigorously. They did not gain enough benefits to compensate for changes of their work. I had faced the "resistance to change" problem for the first time.

The first software version was able to carry out all the required purchasing tasks, but there were no interfaces to other systems. The second version introduced an interface to scheduling programs. Maintenance had to be organised for the procurement software. Solutions for overlapping maintenance of the first version and the development of the second version were sought for and found. The 4GL tool, DataEase, provided adequate tools for transferring programs from and to separate database applications.

The procurement application was developed in cycles, but nearly all the general planning decisions were made already in the first software development round. The only exception was the interface for working hour reporting. The interface towards working hour reporting was implemented in the sixth development round. It was planned, designed, and programmed in 2001.

In retrospect, it is not a surprise that it took six development rounds to achieve the final version of the construct. International project management lays down hard conditions for project tools. Projects, user needs and project environments vary remarkably, which increase the requirements for the software. They must fulfil several, partly conflicting requirements.

8. PROCUREMENT PROCESS REDESIGN

The aim of this chapter is to show that tearing down man-made-limitations can enable far better results. The first two procurement software versions were programmed along the rewritten project instructions, but the software was not a great success nor did it gain a wide acceptance. The critique towards the software was unexpected, because the software followed the project manuals closely, which were supposed to peak the project management knowledge. Although "follow-the-manuals" –approach had reached its limits, the software was not functioning well. Something else had to be done to find better ways to support the procurement function in project management. It proved out that both the procurement function and the software needed redesigning.

Initially, business process redesign (i.e. re-engineering) [279] was defined as the analysis and design of workflow and processes within and between organisations. BPR aims at radical redesigns of organisational processes in order to achieve significant improvements in the organisation. Later, the focus of BPR was extended from the original complete restructuring of companies to redesigns of individual processes[280]. In my research, the software development would have ended much earlier, if I had not applied the techno-change approach, a variation of the BPR approach.

The resistance towards the software indicated that the benefits of the software should be striking, or otherwise the success would be limited. The development of the procurement software continued, but I had a feeling that I was not making any real progress. The software grew bigger and more complicated making it more difficult to control and comprehend. The original target of an easy, efficient and flexible purchasing tool was nearly lost. To simplify the software, redesigning was started. Luckily, a new DataEase version provided a table-view with windowing possibilities, which made possible to program more understandable and efficient applications.

In this chapter, I describe the revolutionary development of the procurement function and the software, i.e. the redesigning actions carried out in the procurement flow and the software. The redesigning of the procurement flow took place in order to make the procurement software more efficient, flexible and adaptive. The chapter includes a BPR overview section, a paradigm change section, and a section describing the four biggest re-engineering topics in the procurement software.

8.1. BUSINESS PROCESS REDESIGN OVERVIEW

Hammer and Champy's basic work of business process redesign, *Reengineering the Corporation*[222] states that re-engineering is not making marginal or incremental improvements but achieving quantum leaps in performance. To re-engineer properly, a company must radically redesign its processes into cross-functional ones, the focus should be on looking at complete processes from materials acquisition, to production, to marketing and distribution. This will lead to changes in organisational structure, culture, incentives and information technology.

Davenport and Short[281] have stated that business process redesign (i.e. re-engineering) is the analysis and design of workflows and processes which reorganises human work. They define a business process as a set of logically related tasks performed to achieve a defined business outcome. It has a strong emphasis on how work is done within an organisation. Davenport and Short claim that processes have two important characteristics: (1) they have internal or external customers, and (2) they cross organisational boundaries occurring across or between organisational units.

279 Hammer and Champy: Reengineering the Corporation: A Manifesto for Business Revolution (1993), 240 p.
280 El Sawy: Redesigning Enterprise Processes for E-Business (2000), 196 p.
281 Davenport and Short: The New Industrial Engineering: Information Technology and Business Process Redesign (1990) Sloan Management Review, pp. 11-27

Järvenpää and Stoddard[282] have represented another view to re-engineering. They describe re-engineering as a two-phased process, which comprises design and implementation phases. Only one of the two re-engineering stages needs to be revolutionary. Järvenpää and Stoddard suggest that re-engineering begins with radical designs, but it does not necessarily need a revolutionary approach for change. Their study presents that the radical design phase is at the heart of re-engineering. Organisations that seek to re-engineer have to start with the radical design phase. The radical design phase creates the enthusiasm and momentum needed for the changes. Breakthrough designs provide a long-term road map for changes and instil motivation in ways that more moderate plans cannot.

Järvenpää and Stoddard continue that the implementation of BPR is not necessarily radical. If the organisation is in the midst of a survival crisis, the changes may have to unfold in a revolutionary fashion. If the organisation has time, a more evolutionary approach allows implementing the changes in a managed and measured fashion. It could mean though compromise goals and take more time to involve the staff. Because the risk and cost of revolutionary tactics, a revolutionary implementation might not be feasible. Few companies can afford to fully implement their radical designs the first time around. Revolutions are disruptive and they are generally viewed as unduly risky and counter-cultural. For example, sudden unplanned executive changes may stop the change program altogether.

Caron, Järvenpää and Stoddard claim that BPR[283] is like fighting a guerrilla war against an organisation's antibodies. The organisation's defence mechanisms see BPR as a foreign organism and try to defeat it relentlessly. The only way to win is to wear the enemy out. You have to keep repeating the message. The moment you ease up you have lost. Caron et al. state that redesigning is about trying and trying once again. They have summarised their experience of BRP projects as recommendations: (1) diffuse and leverage learning from each project, (2) learn from failures, (3) foster commitment and ownership at all levels, (4) exploit "clean slate" opportunities, (5) tailor reengineering to the characteristics of the environment, (6) ascend to higher forms of reengineering over time, (7) move fast to achieve results, (8) communicate truthfully, broadly and via multiple forums, (9) select the right people, and (10) focus - most of all - on a mindset change.

The most difficult challenge of reengineering is the cultural change that typically must accompany the process changes that are underway. It is therefore important to acknowledge up front that all employees will have to participate in a mindset change to enable the success of the initiative.

Business Process Redesign and Quality Management

Davenport[284] notes that quality management, often referred to as total quality management (TQM), refers to programs and initiatives emphasising incremental improvement in work processes. Improvements in work processes and outputs are achieved in an endless time period. This endless improvement period is a contrast to the BPR approach which refers to discrete initiatives that are intended to achieve radically redesigned and improved work processes in a bounded time frame.

Davenport concludes that TQM and BPR share a cross-functional orientation. He observed that quality specialists tend to focus on incremental changes and gradual improvements of processes,

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282 Järvenpää and Stoddard: Business Process Redesign: Radical and Evolutionary Change (1998) Journal of Business Research, Vol. 41, No. 1, pp. 15-27

283 Caron, Järvenpää and Stoddard: Business Reengineering at CIGNA Corporation: Experiences and Lessons Learned (1995) MIS Quarterly, Vol. 18, No. 3, pp. 233-250 (SIM Paper of Year for 1994)

284 Davenport: Process Innovation: Reengineering Work Through Information Technology (1993), 352 p.

while re-engineering proponents often seek radical redesign and drastic improvement of processes. Davenport has summarised the contrast between the two as shown in Table 17.

Table 17. Total Quality Management and Business Process Re-Engineering

	Total Quality Management	**Business Process Re-Engineering**
Level of change	Incremental	Radical
Starting-point	Existing process	Clean slate
Frequency of change	One-time/continuous	One-time
Time required	Short	Long
Participation	Bottom-up	Top-down
Risk	Moderate	High
Primary enabler	Statistical control	Information technology
Type of change	Cultural	Cultural/structural

Davenport: Process Innovation (1993), p. 11

Role of IT in Business Process Re-Engineering

Hammer[285] considers IT as the key enabler of business process re-engineering. He states that IT challenges the assumptions of work processes. The work processes have existed long before the advent of modern computer and communications technology, and they do not necessarily notice the IT possibilities. He argues that at the heart of re-engineering is the notion of discontinuous thinking. It involves recognising and breaking away from the outdated rules and fundamental assumptions underlying the operations. The work processes are based on assumptions about technology, people and organisational goals that do not necessarily hold any more. Hammer suggests seven principles for re-engineering with IT:

Principle 1: BPR should be organised around outcomes, not tasks.
Principle 2: Users of the process output perform the BPR process.
Principle 3: Information processing work is included into the real work producing the information.
Principle 4: Geographically dispersed resources are treated as if they were centralised.
Principle 5: Parallel activities are linked instead of integrating their results.
Principle 6: Decision points are located in the working place, and control is built into the process.
Principle 7: Information is captured once and at the source.

Davenport and Short[286] argue that BPR requires taking a broader view to both business activities and IT, and the relationships between them. Business activities should be seen more broadly than as a collection of individual or functional tasks. A process view is necessary for maximising effectiveness. IT should be viewed as more than an automating or mechanising force: it is fundamental to BPR to reshape the way business is done. IT and BPR can be seen to have recursive relationship. IT capabilities support business processes, and business processes are operated within the IT capabilities. Davenport and Short state that this broadened, recursive view of IT and BPR is the new way for industrial engineering.

[285] Hammer: Reengineering Work: Don't Automate, Obliterate (1990)
Harvard Business Review, Vol. 68, No. 4, pp. 104-112

[286] Davenport and Short: The New Industrial Engineering: Information Technology and Business Process Redesign (1990)
Sloan Management Review, pp. 11-27

Business Process Re-Engineering Methodology

Davenport and Short[287] present a five-step approach to business process re-engineering: 1) develop business vision and process objectives, 2) identify the processes to be redesigned, 3) understand and measure the existing processes, 4) identify IT levers, and 5) design and build a prototype of the process.

1) Develop business vision and process objectives
   BPR is driven by a business vision, which implies specific business objectives, such as cost reduction, time reduction, product quality improvement, quality of the working environment, learning etc. The key is to prioritise objectives and stretch targets.
2) Identify the processes to be redesigned
   Most companies use the high-impact approach, which focuses on the most important processes (bottleneck or critical processes) or most business vision-conflicting processes. Some companies use the exhaustive approach that attempts to identify all the processes within an organisation and then prioritise them in order of redesign urgency.
3) Understand and measure the existing processes
   Identifying and understanding the nature of the current problems is important for avoiding and repeating old mistakes. A baseline for future improvements should be established.
4) Identify IT levers
   Awareness of IT possibilities should influence the process design, giving the limits of the available IT systems. Brainstorming would help in revealing new approaches.
5) Design and build a prototype of the process
   The actual design should not be viewed as the end of the development process. Rather, it should be viewed as a prototype, which will be improved in successive iterations. The prototyping is seen to align the business process re-engineering with quick delivery of results, and the intention to involve and satisfy the customers.

8.2. SOFTWARE REDESIGN

Software is often used to carry out the business rules. As these rules change, the software must also adapt to changes[288]. Managers work to modify the business rules to achieve greater effectiveness and competitiveness, the software must follow. In some cases, this results in the creation of new computer-based systems. In many other cases, it means redesigning, modifying and rebuilding existing applications.

If BPR is conducted effectively, the information systems will be better integrated into the business. At the business level, redesign focuses on the business process with the intent of making changes to improve competitiveness in some area of the business. At the software level, redesigning examines information systems with the intent of restructuring or reconstructing them in order to make them match the prevailing business conditions better. The results of BPR often define the ways in which information technologies can support the business. Even if the business process redesign strategy is rejected by the company, software redesign is something that must be done. Legacy applications have to be kept up-to-date in order to maintain the competitive edge of the company. Therefore, organisations need pragmatic strategies for software redesign.

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[287] Davenport and Short: The New Industrial Engineering: Information Technology and Business Process Redesign (1990) Sloan Management Review, pp. 13-18

[288] Pressman: Software Engineering: a practitioner's approach (2001) p. 820

Process-Oriented View

Floyd argues in favour of the process-oriented view, which might replace the product-oriented view as the ruling paradigm[289]. She says that the two views coexist and they are, at least to some extent, complementary. According to her, the paradigm change does not imply giving up the product-oriented view in favour of the other but rather improving our understanding of their interaction. She proposes that the process-oriented view inheritably involves prototyping, which I do not see obligatory.

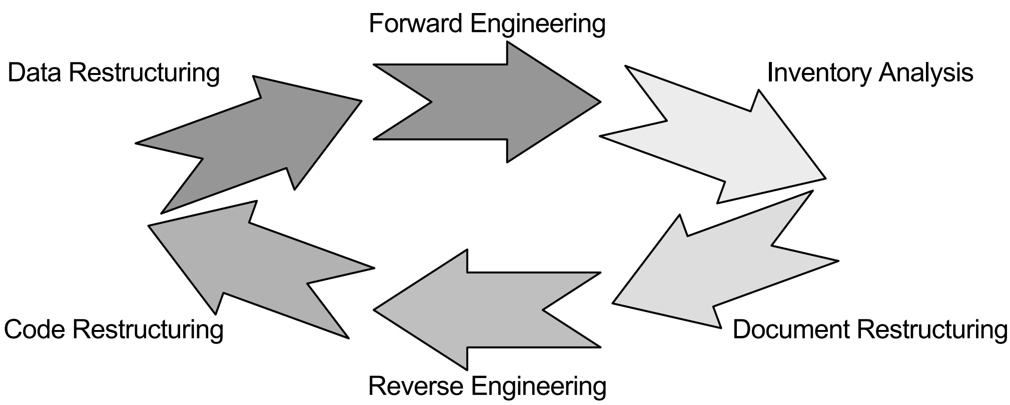
Floyd claims that the process-oriented view regards software in connection with human learning, working, and communication, which occur in both software development and use. It considers that software takes its place in an evolving world with changing needs. During the development work, software is the object of these processes. In use, software acts both as support and constraint of the processes. The product is perceived to emerge as the result of the interleaved processes of analysis, design, implementation, evaluation and feedback. Each process is carried out by different people, who are involved in system development in various roles.

Software Redesign Process

Software redesign[290] is a rebuilding activity. A cyclical model can used to present the rebuilding of software. The cyclical approach expects that each of the activities may be revisited. For any cycle, the process can be terminated after any one of these activities. In some cases, the activities occur in a linear sequence, but not always. For example, reverse engineering (understanding the internal workings of a program) may have to take place before document restructuring can commence.

Software redesign encompasses a series of activities that include inventory analysis, document restructuring, reverse engineering, program and data restructuring and forward engineering, as shown in Figure 58. The intent is to create versions of existing programs that enable higher productivity and better maintainability. Inventory analysis enables assessing the software systematically, with the intent of determining which applications are candidates for redesigning. Document restructuring creates a documentation framework which is necessary for the long-term support of an application. In reverse engineering, an application is analysed in an effort to extract data, architectural and procedural design information. Finally, forward engineering rebuilds the software with modern software engineering practices and information learned in reverse engineering.

Figure 58. Software Redesign Process



Pressman: Software Engineering: a practitioner's approach (2001), p. 807

[289] Floyd: Outline of a Paradigm Change in Software Engineering (1987)
In Bjerknes, Ehn and Kyng (eds.): Computers and Democracy – A Scandinavian Challenge, pp.191-210

[290] Pressman: Software Engineering: a practitioner's approach (2001)
p. 799-820

8.3. BUSINESS PROCESS REDESIGN OF THE PROCUREMENT SOFTWARE

After the second version of the procurement software, the redesign of the software was initiated. There were two main reasons for the software redesign: (1) the need of better procurement solutions pushed the redesign onwards and (2) the development of the 4GL tools pulled (or lured) to doing the redesign. I was convinced that there was a better way to implement the procurement software.

The original requirements of the procurement software were nicely targeted, well defined, and fairly easy to achieve. After the implementation of the two first versions, the purchasing task force was fairly satisfied. The problem was that the other project professionals (engineers, schedulers and cost controllers) were not pleased at all. Although their workload stayed the same, they had to learn new software and adjust their work methods to match the procurement software. They did not feel that they would gain anything by using the procurement software.

I started to question my basic program structure, when I reprogrammed the third software version. I doubted whether the linear succession of the tables (according to the chronological order of the events) was the appropriate way to program the software. I had structured the software along the world-class knowledge of Pöyry Oyj, and the application was still not successful. The linear structure had reached its limits and I was forced to change my views to procurement to construct better procurement software. As a result, I began to apply process thinking instead of document-oriented thinking in redesigning the procurement software.

Following the framework of the *PMBOK Guide*, I redefined the executing and controlling processes in procurement. I divided the whole procurement process into three executing subprocesses: budget inquiries, tender inquiries and final inquiries. Document flow management was seen as an important auxiliary process for the executing subprocesses. The controlling processes comprise the follow-up of the schedules and the workload. Scheduling experts produced procurement schedules and the procurement function was expected to follow these schedules. A comparison between schedules and reality was seen important for the follow-up of the project implementation. Finally, I considered data warehousing to form a totally separate process belonging to the over-all project administration.

Shift of View in Programming the Procurement Software

The redesigning of the procurement software was based on a switch from the documentation-oriented view to the process view. So far, I had followed the procurement flow as Pöyry instructions indicated. They presented procurement as a set of discrete tasks producing well-defined documents. Now I started to use the actual procurement process as the basic planning subject. This meant that I shifted my perception of procurement from the documentation-oriented model to the process model.

The documentation-oriented model had led me to think of procurement as a set of discrete tasks producing the necessary documents. Instead of that, it was time to start thinking of procurement as a process. Chaining the defined procurement tasks together turned out to be simplest way to create a procurement process. In practice, the difference between the process and documentation flow models can be small. In most cases, it can be even ignored, because they lead to the same result.

The shift of thinking can be easily detected by comparing Section 5.3 and the original *Procurement Manual*. They describe exactly the same process, use the same terms and examples, but the documents are different. It is like looking at a coin; on one side you can see heads and on the other you see tails, both belonging to the coin. The difference in procurement can be pointed out by comparing the two possible ways of thinking presented in Table 18 on the next page.

Table 18. Comparison of Documentation-Oriented and Process-Oriented Thinking

Documentation-Oriented View	**Process-Oriented View**
• Procure Item1 - make specification documents - make inquiry documents - make comparison documents - make contract documents • Procure Item2 - make specification documents - make inquiry documents - make comparison documents - make contract documents • Etc.	• Procure (specify, inquire, compare, negotiate and contract) - Item1 - Item2 - Item3 etc.

Redesigning the Procurement Software

The redesigning of the procurement software did not happen as a single effort. It took place during the years of using and developing the software. The process thinking principles were applied in redesigning the software. There was no need to develop any business vision or process objectives, because they were already defined in the rewriting of the project instructions. Also the scope of the redesign was clear; the redesign was aimed at the procurement process and its subprocesses. Thorough understanding of the phenomena had been already gained in the rewriting process and in programming the two first versions of the procurement software.

The aim of the redesigning was to make the procurement software more effective. The software should provide more information to support the decision making[291]. The redesign was also motivated by the possibility to automate follow-up calculations and data warehousing. These auxiliary procurement processes were difficult and error-prone tasks to carry out manually.

The redesigning of the procurement software began with redefining the subprocesses of the procurement flow. As a consequent, budget inquiries, tender inquiries and final inquiries program sets were united into a single program set. Automated follow-up calculations and data warehousing were integrated with the procurement flow, because they had the same data and database as the procurement flow.

Excluded Features

I have decided to leave out of my research a lot of software which I planned, designed and programmed at Pöyry Oyj for project implementation. I have omitted purchase request, cost controlling and cashflow features, because they do not support the procurement flow. I consider these adjoining features a natural extension direction for further research and software development. As described above, the research scope was determined by the scope of the procurement process as defined in the service contracts between Pöyry Oyj and its clients.

I have decided that the contract signing ends the procurement process, because it is the typical ending point of procurement tasks and responsibilities. At that point purchasing tasks are normally transferred from Pöyry's procurement software to the client's ERP software. There are several stages in the procurement flow after the contract signing (delivery, inspections, payment, guarantee etc.), but they have been intentionally left out of this doctoral dissertation.

[291] Eisenhardt: Making Fast Strategic Decisions In High-Velocity Environments (1989) Academy of Management Journal, Vol. 32, No. 3, pp. 543-576.

8.3.1. REDESIGNING THE PROCUREMENT PROCESS

I studied the chronological procurement flow closely (illustrated in Figure 48). Instead of thinking of procurement as a monolithic process with varying details, I concentrated on the appearing iteration cycles in the procurement process. I noticed that the budget inquiry round, tender inquiry round and final inquiry round were similar. For me, the similarity presented remarkable improvement possibilities, if I could combine them instead of programming them separately. The aim was to program all the inquiry rounds in a single set of procurement programs in order to make the software more compact.

I divided the whole procurement process into three executing subprocesses: budget inquiries for cost estimating, tender inquiries for soliciting facilities and delivery capacities, and final inquiries for purchasing. In the chronological view towards procurement they correspond to the budget inquiry round, tender inquiry round and final inquiry round, respectively. It might be useful to describe the procurement subprocesses first separately and then unite them.

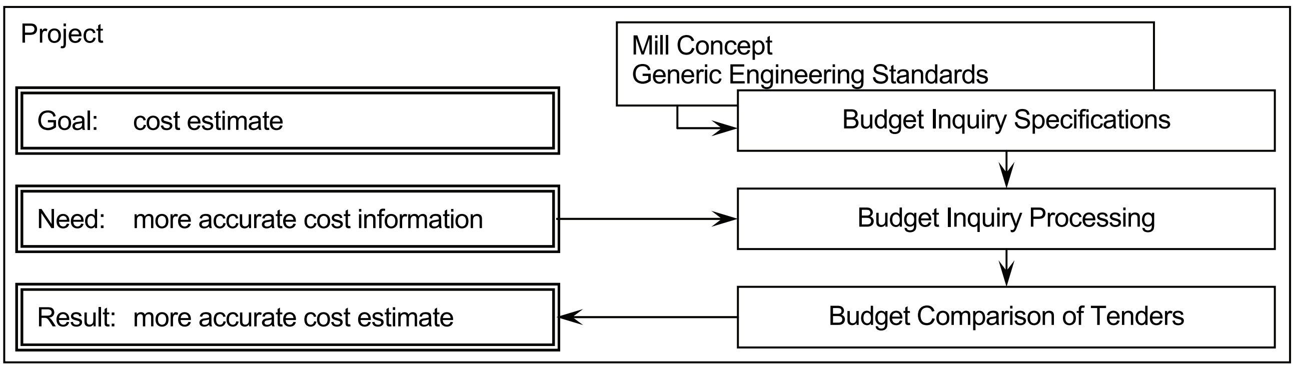
Budget Inquiry Round

Budget inquiry rounds, illustrated in Figure 59, are carried out in the early stages of the project (at the feasibility or conceptual planning stage). Budget tenders can be asked for different kinds of cost calculations, investment estimates and studies. The aim is to gather available cost information to establish a reliable cost estimate for the whole project. The estimate is used to estimate the profitability of the project and give a solid background for the project implementation decision.

A budget tender is asked from several potential suppliers in order to establish the cost level in the calculations. The preliminary inquiries are based on conceptual planning, and the inquiry specifications can be inexact. The preliminary inquiry may be very brief; e.g. a letter or a telex referencing to some previous delivery. The inquiry might well refer to an inquiry of another project. The received budget tenders are compared, and the most promising tender is used as the base in the cost estimate.

Budget inquiries were normally omitted, if there was reliable enough cost information available for the cost estimation. The adequate cost files could be based on previous projects, cost information from the client or long term agreements. The cost files were normally applied for minor equipment and services which were not inquired to calculate the cost estimate. The cost files could be used to ensure that the budget tenders gave reliable information of the price level.

Figure 59. Budget Inquiry Round

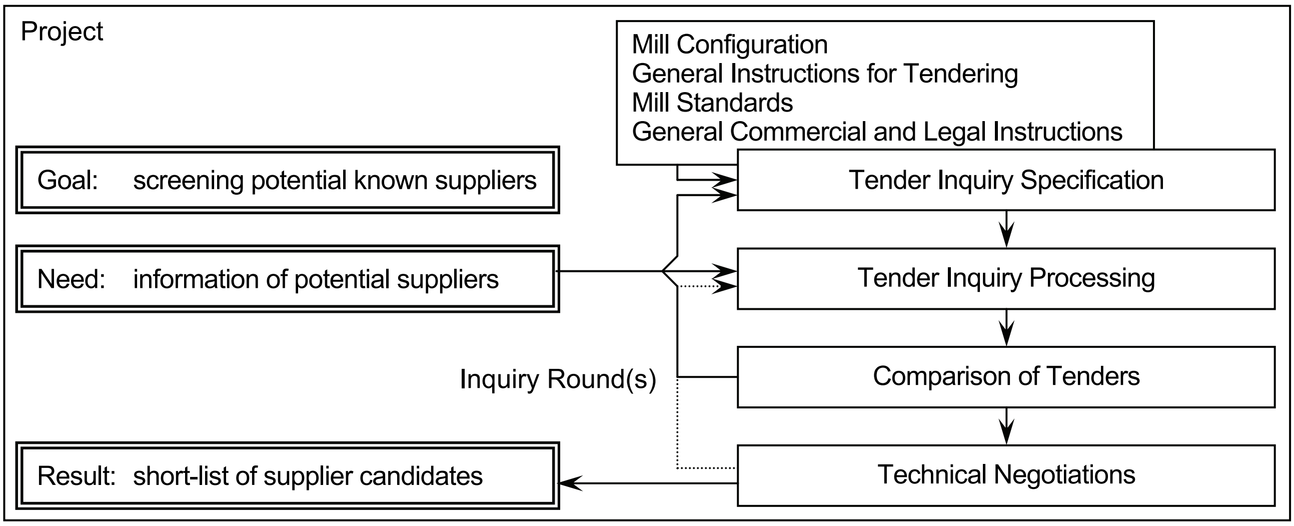


Tender Inquiry Round

When the client has decided to implement the project, the process is directed to find the most appropriate item. In the tender inquiry round, illustrated in Figure 60, a tender is asked for as a response to an inquiry. The aim of the tender inquiry round is to screen the known suitable suppliers. This facility inquiring is intended to clarify the supplier status in terms of its free production capacity, engineering capability and delivery capability. The inquiry specifications are more detailed than in the budget inquiry round. They comprise the main technical specifications, and some preliminary commercial and legal terms are enclosed as well.

The processing of the inquiry is more intense than in budget inquiries and it is followed by a technical comparison of the tenders. The substance of the tender may be amended considerably in negotiations. If all the details can not be clarified, it is advisable to arrange an additional inquiry round. Additional rounds can also be employed to acquire more acceptable technical solutions or even to change the preferred technology. A new inquiry round can invoke some additional potential supplier candidates. The final inquiry round is arranged with the most successful supplier candidates.

Figure 60. Tender Inquiry Round

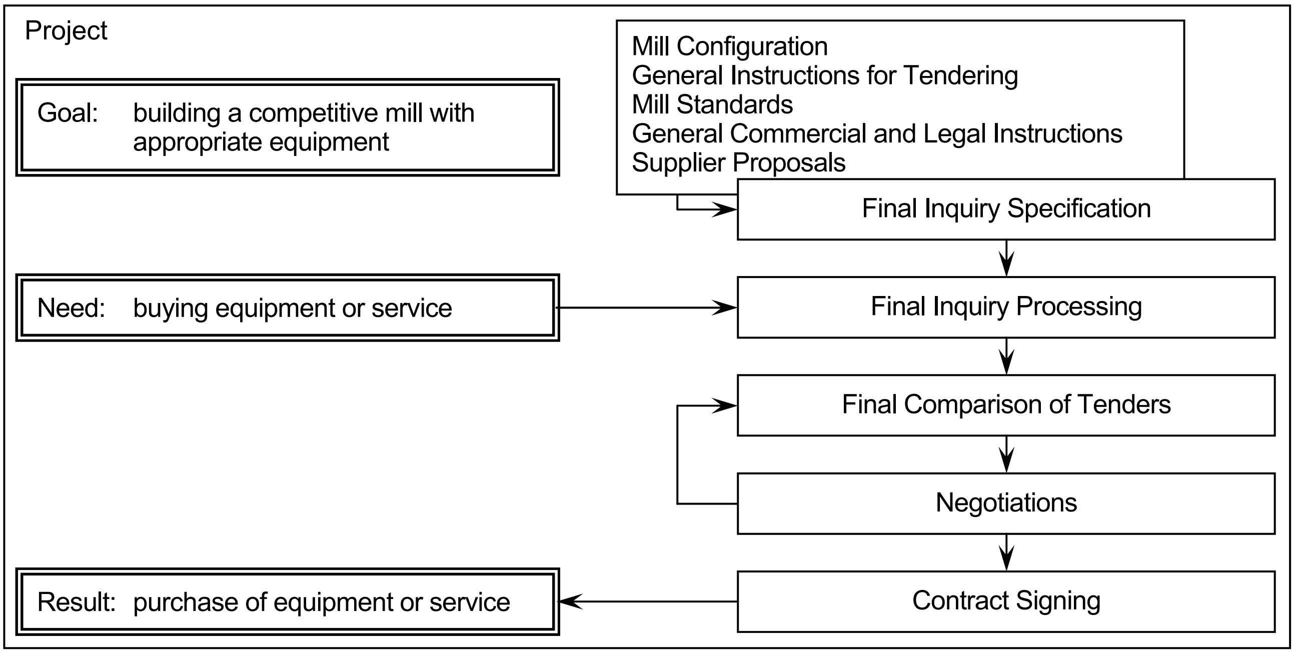


Final Inquiry Round

When the shortlist of supplier candidates is prepared, procurement is aimed at buying the most appropriate item. The aim is to buy according to the scope of the equipment or service at the lowest total life cycle cost. The detailed inquiry specifications comprise technical, commercial and legal specifications of the purchase. The final inquiry round, presented in Figure 61 on the next page, is arranged with the most successful supplier candidates. A final tender proposal will be asked from them and their final tenders are the basis for contract negotiations.

After the final tender proposals are received, the tenders are compared. The comparison of tenders concerns all aspects of the tenders, because price comparison is seldom enough. After the comparison, the construction manager holds contract negotiations with the most promising tenderer(s). The negotiations require a thoroughly professional approach as they are conducted in depth in technical, financial and scheduling aspects. The result of the negotiations is a recommendation to the client, who makes the purchasing decision. Signing the contract and its acknowledgment finalise the purchasing process.

Figure 61. Final Inquiry Round



Comparison of Procurement Rounds

I had noticed earlier that budget inquiry, tender inquiry and final inquiry rounds were alike, as the comparison in Table 19 shows. They were so similar that sometimes three separate rounds were combined to one or two rounds. The more standardised the item was, the more likely the tender inquiry and final inquiry rounds were combined, i.e. an inquiry round would be carried out only once before contracting. On the other hand, if the bargaining was more difficult because of technical or commercial reasons, the tender inquiry round in the middle could be carried out numerous times.

Table 19. Comparison of the Budget Inquiry, Tender Inquiry and Final Inquiry Rounds

Budget Inquiry Round	**Tender Inquiry Round**	**Final Inquiry Round**
• Inquiry specifications • Inquiry processing • Comparison of budget tenders	• Inquiry specifications • Inquiry processing • Comparison of tenders • Technical negotiations	• Inquiry specifications • Inquiry processing • Comparison of final tenders • Negotiations • Contract signing

I realised that budget inquiries, tender inquiries and final inquiries could be combined, because the separating differences were mostly superficial. Final inquiries have more process stages than budgeting and tender inquiring, but the existing stages in each process are the same. Because the purchasing process covered every feature in cost estimating and facility inquiring, I could program all the necessary features into one set of programs. In principle, only a classifying field would distinct the different inquiry types. The users of the procurement software just omit the features they do not need. In the final version of the construct, the budget inquiries, tender inquiries and final inquiries were combined. They were implemented in a single set of procurement programs.

Comparison of Tenders

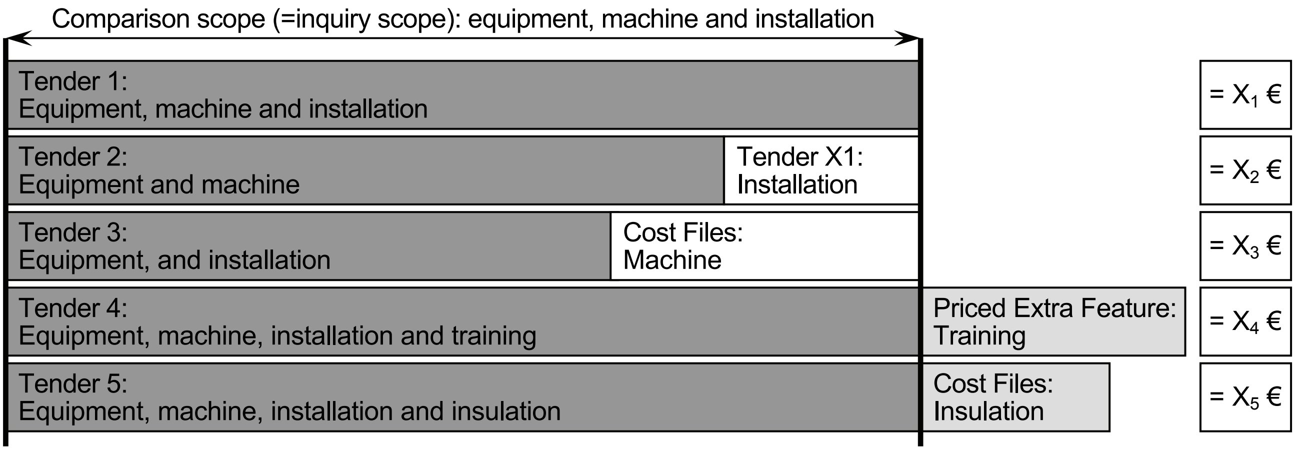
Comparison of tenders is a subprocess in each inquiry round which is carried out to evaluate the tenders from all technical, commercial and other aspects, and to make recommendations regarding the equipment and tenderers. The technical parts comprise the tenderers' technical answers to the inquiry specifications, which might vary from tenderer to tenderer. The commercial parts may be standardised to the point that only price information varies, following the structure of the technical parts. The legal parts are normally well standardised and they are equal in each tender.

Although the inquiry specifications should clearly describe and limit the equipment and services to be tendered, the received tenders do not necessarily have an equal scope. Potential suppliers are sometimes encouraged to tender alternative solutions. In these cases, the supplier candidates are expected to bring out their views of the most appropriate solution for the area.

The tenders are equalised to match the comparison scope, as illustrated in Figure 62. In the ideal case, the comparison scope equals the inquiry specifications. Sometimes it is easier to form a separate comparison scope (for example, one of the received tenders) to measure the received tenders. If a separate comparison scope is used, it could affect the scopes of the other inquiries. The received tenders are matched either by excluding or adding cost information of additional or missing tender parts, respectively. The cost information is preferably taken from valid contracts. If this is not possible, the cost information of other tenders can be used. The last source for cost information is the cost files gathered from other projects. This historical cost information will normally need adjustments due to inflation, exchange rate changes, business situation differences etc.

The adjusting of the tender scopes leads to hierarchical presentation of cost information. Every priced part of the tender is recorded and the total price is calculated from its components, unless the tenderer has indicated otherwise, normally stating the tender as a packet consisting of inseparable parts. In principle, the cost information is recommended to follow the item structure including all the priced parts, services and other tender components.

Figure 62. Adjusting Scope Differences in Comparison of Tenders



It is nearly impossible to overestimate the importance of the writer's skills, knowledge and proficiency in the comparison of tenders, because it is seldom a simple price comparison task. The writer must devote ample time and efforts to form his recommendations. Particularly the quality and compatibility aspects are very difficult to express in monetary values. Sometimes the ranking of the tenders is a subject of heavy critics. The software allows any ranking order that the writer sees fit.

8.3.2. REDESIGNING PROCUREMENT FOLLOW-UP

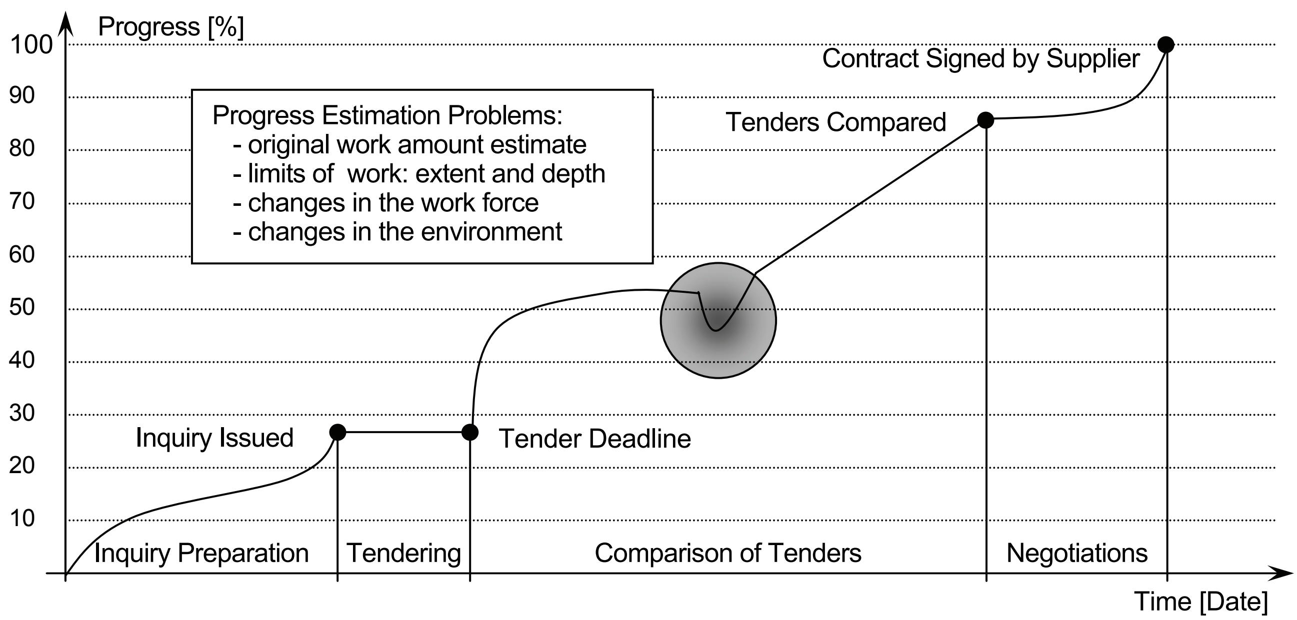
The procurement follow-up was redesigned to utilise the new opportunities enabled by the redesigned procurement flow. The redesigned procurement flow gathered all the necessary information of procurement plans and actual events for follow-up. The procurement follow-up comprises two controlling procedures: schedule follow-up and workload follow-up. It was an important idea to combine the procurement follow-up with the procurement flow. The combined processes eliminated quite a lot of data transfer between procurement and reporting tools. The integrated procurement follow-up proved to be even more beneficial, because it made it possible to automate the procurement follow-up. It used the recorded procurement events directly; no action was needed or allowed in the controlling and reporting of purchasing events.

The scheduled follow-up tries to answer the question "When". It observes the activities and compares the planned timing with the actual events. The focus is on the timing of the procurement actions, not the hours or days needed to accomplish the tasks. The workload follow-up is another controlling process. It monitors follow-up items (normally inquiries) and the cumulative working hours used to purchase the item. The follow-up of the workload concentrates on estimating "How much work remains".

Pöyry Oyj as a project management consultant was not very interested to use workload-based follow-up calculations in controlling the projects. The general idea was that if the normal working hours are not enough for the project tasks, there are plenty of hours before the next morning. I claim that motivated and committed project professionals made tight schedules possible. Later, when I started to work with ERP systems, I began to understand the importance of the workload calculations. Sometimes the personnel resources were so scarce that a single delay in a project schedule inevitably caused a delay in the whole ERP project.

Figure 63 presents the typical progress of the purchase in which the progress is measured in working hours. The progress is estimated as a percentage, which is calculated by comparing the realised and estimated total working hours known at the reporting moment. The figure also shows the procurement stages and procurement events used as milestones in the scheduling. Finally, the figure presents the most common estimation problems which normally cause reductions in the progress estimates.

Figure 63. Progress of the Purchasing Process



Schedule Follow-Up

Schedules are intended to direct and influence the performance of the described activities. The schedules must remain sensitive to the actual progress of works and to difficulties encountered on a project site. All major procurement items with an influence on the project implementation are included in the procurement schedules to avoid congestion. Minor purchasing activities, although plentiful, will follow suite during the project implementation, and need only simple schedules. In order to be an effective tool for management, schedules must be followed up closely and regularly. If any deviations are noticed, they should be discussed for possible rectifying measures.

The schedule follow-up pursues the progress of the procurement and compares the schedules with the actual events. The schedules can be created manually, or more likely, imported from a specialised scheduling program. The schedule can be rearranged and modified in the procurement application. The changes in the procurement schedule and the realised working hours can be transferred back to the original scheduling program. This way the scheduling software can be used to report the progress of the procurement.

Workload Follow-Up

The main idea of the workload follow-up is very simple: procurement advances, if somebody works, i.e. reports working hours towards the procurement tasks. The workload follow-up is important from two separate reasons. First, it warns of overload of the personnel, because it shows if tasks take longer than anticipated. Second, workload calculations can be used to estimate the progress of currently active, but unfinished tasks. The workload follow-up was achieved by integrating the procurement flow, scheduling and working hour reporting. The integrated procurement flow has all necessary information for workload follow-up: procurement schedule, planned workloads, actual procurement events and actual working hours.

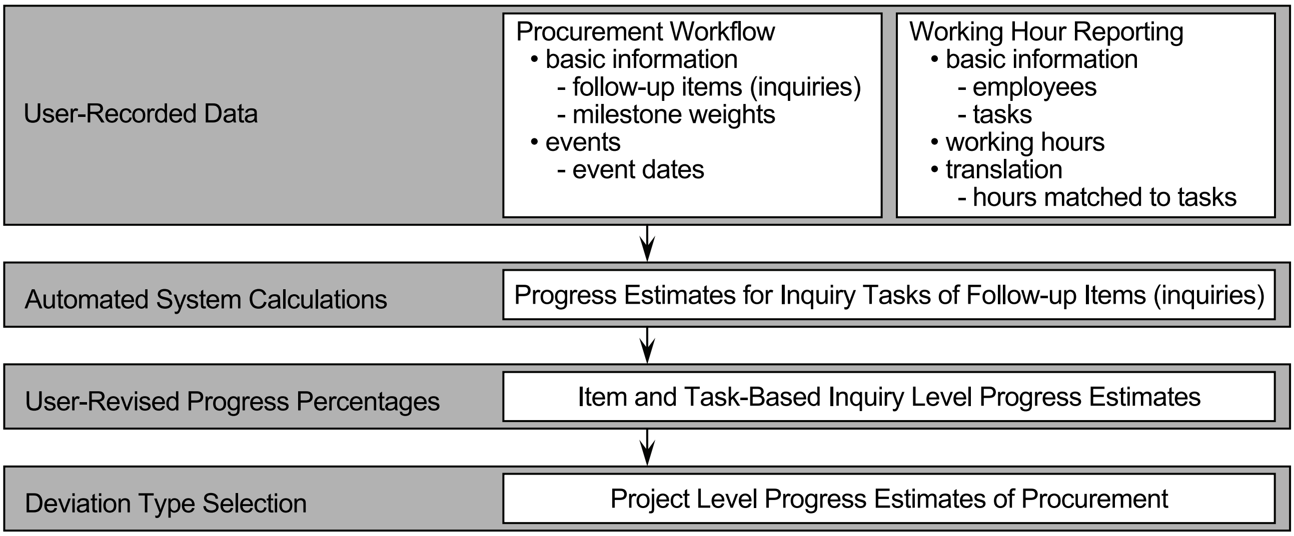
There are three elementary assumptions had to be made in order to develop reliable workload follow-up. The fundamental elements of the procurement status calculations comprised: (1) an appropriate measure for the procurement status, (2) meaningful milestones for the purchasing process, and (3) a calculation method. I had to solve for these three design questions, remembering the over-all target to automate the estimation of the procurement progress.

The measure for the procurement status was a difficult question. I considered using the earned value, but neglected the idea due to the salary - work amount disparity. Finally, I decided that working hours would describe the progress of the procurement best. The EVA might have been an appropriate measure, if procurement had been an outsourced function. However, Pöyry Oyj does not recommend such outsourcing, because it weakens the project management. The company states that managing and controlling procurement inevitably means managing and controlling the project.

Milestones should be unambiguous, exact and discrete events in the procurement flow. Suitable milestones should detect the progress of the purchase without exceptions and recognised in scheduling. They were all dates forming the chain of the procurement events: inquiry issued, tender deadline, comparison and contract signing by the supplier. The latest event (milestone) achieved in the chain points out how far the procurement has advanced in the purchase of the item.

The calculation method was created to provide the best possible picture of the procurement status using the available information. The invented calculation method is three-phased, hierarchical estimation process which chains the estimates hierarchically from bottom to top. The method calculates values of current status, remaining work and total work on task, inquiry and project levels. The method begins with task level estimations of the progress, summing up the task level estimates on inquiry level, and finally summing up the inquiry level estimates on project level. The estimation is automatic, but the users have a possibility to change the system-calculated estimate on the tasks level. The calculation method is illustrated in Figure 64.

Figure 64. Workload-Based Progress Calculations



Before the calculations, the basic data of the procurement flow has to be organised. Each follow-up item has to be recorded with the planned working hours per task and linked to the inquiry they refer to. Then, the actual working hours and procurement events are recorded as they appear. The software combines these pieces of information to deliver the estimates.

In the beginning, the progress of each task is calculated. If no working hours are recorded towards a task, the progress value is 0 %. The progress unfinished tasks, i.e. tasks between the milestones, are estimated by comparing the realised and planned hours of the activity. The tasks, which have achieved the matching milestone, are finished, i.e. the progress is 100 %. This is true despite the ratio between the reported and planned hours. If the reported hours of the task that has not achieved its milestone exceed the planned hours, the system will assume this task to be also finished (the progress is 100 %). Additional hours can be reported to any finished task, but its progress remains 100 %. On this level, the users can adjust these system-calculated estimates as they see appropriate.

Next, the progress estimation is made on the inquiry level to determine the status of the item to be purchased. All inquiries, i.e. purchases, are estimated on their tasks. If no working hours are recorded towards any task of the inquiry, the progress value is 0 %. If the milestone indicating contract signing has been achieved, the progress of the purchase is 100%. Unfinished purchases are estimated by summing up the weighted progresses of its tasks.

The estimation is automatic, but the users have a possibility to select the deviation capsulation method, which can be either item or task-based. The item-based estimation principle follows the idea that progress is going to continue as before. The deviation ratio will stay the same in all the future tasks of the item (i.e. inquiry). The idea is readily supported, if all the purchasing tasks are carried out by the same personnel. This implies that their work will continue with the same deviation percentage compared to the planned work. The task-based estimation principle follows the idea that the deviations in the previous stages were mistakes. Therefore, the deviations so far in the workload do not have any effect on the future. The following tasks will be processed according to the procurement plan. For each item, the capsulation method can be selected independently.

The overall procurement status is calculated by using the selected capsulation method. When the progress of all items is summed up by their weight, the general project status is reached. The minimum, maximum, task-based capsulation and item-based capsulation values of the procurement status values are calculated to support the evaluation of the accuracy of the project status estimate. An example of hierarchical calculations is provided in Figure 65.

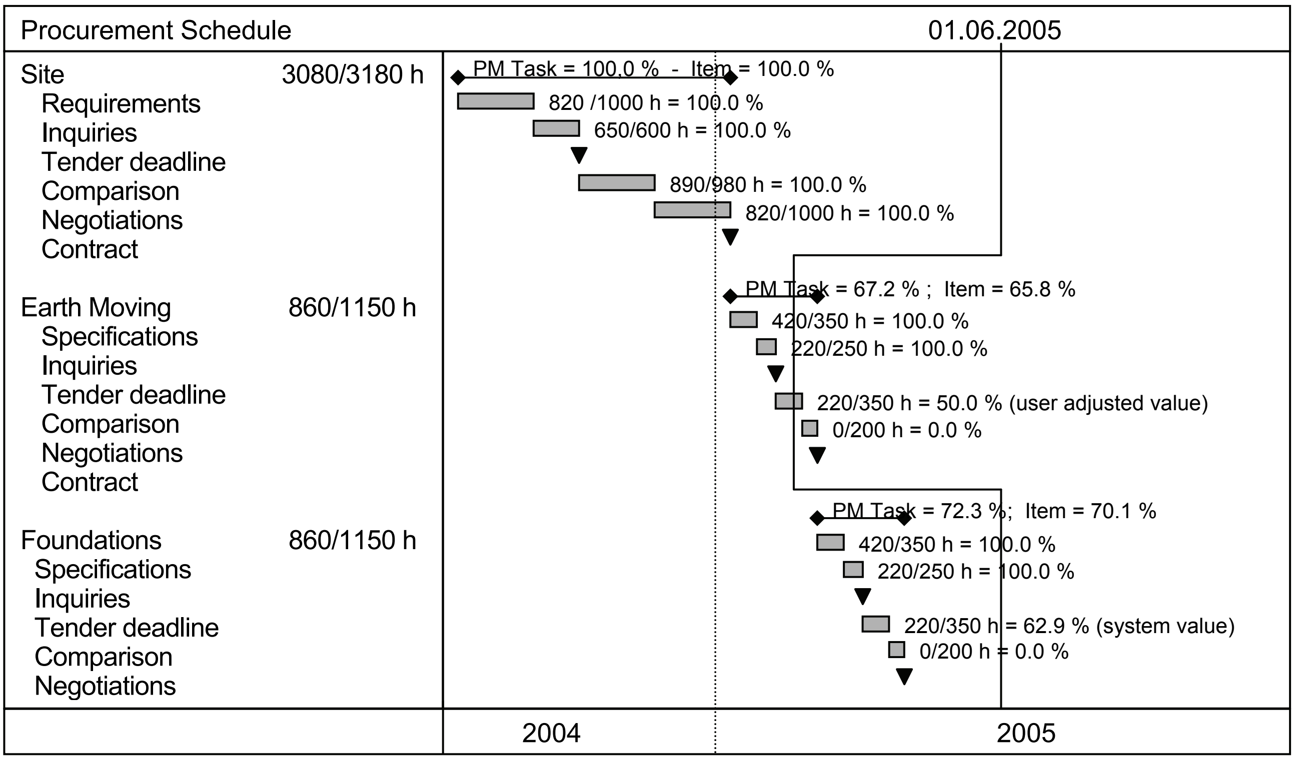
Figure 65. Example of Hierarchical Procurement Status Estimation

Project Level	Procurement Status: 85.9 %	Item: 85.5 % Task: 86.5 % Min: 85.5 % Max: 86.5 %	
Inquiry Level	Site: > Task: 100.0 % Item: 100.0 %	Earth Moving: Task: 67.2 % > Item: 65.8 %	Foundations: > Task: 72.3 % Item: 70.1 %
Task Level	Tasks: - inquiry prep. 100.0 % - tendering 100.0 % - tender comp. 100.0 % - negotiations 100.0 %	Tasks: - inquiry prep. 100.0 % - tendering 100.0 % - tender comp. 50.0 % - negotiations 0.0 %	Tasks: - inquiry prep. 100.0 % - tendering 100.0 % - tender comp. 62.9 % - negotiations 0.0 %

The progress calculations present an estimate only for the progress of the purchasing, not the entire project. E.g. the purchase of an evaporation plant could require 100 hours. This means that the purchasing is assumed to take 100 hours and manufacturing, installation, testing etc. are not included. They are supervised by either separate schedules or different activities in the same schedule.

In order to automate the progress calculations, scheduling and working hour reporting has to be integrated with the procurement flow. The results can be transferred to the preferred scheduling program, which can report the results graphically and use the values as the starting-point for further progress calculations. An example of graphical procurement follow-up is provided in Figure 66.

Figure 66. Procurement Schedule and Workload



8.3.3. REDESIGNING MANAGEMENT OF PROCUREMENT DOCUMENTS

A steady information flow between all the parties is regarded important for fluent project implementation. Before the software development, the procurement documents were managed by paper lists. The paper lists were used to follow the document transfer both between the engineering company and the client and between the engineering company and potential suppliers. Document flow management was organised to streamline document transfer in projects. The focus was on linking the appropriate documents to their events with minimal work.

Document flow management was designed to handle the information of documents (i.e. information of paper documents and electronic files), not the entire documents. A single set of documents could be linked to an event in procurement flow. This set (or group) of documents had to comprise all the documents used in the event. An individual document could be included to several document groups, which is common in project specifications.

The main information of the documents, i.e. the properties of the document were registered. The idea is roughly equal to the Windows file managing system, which appeared a little later and made most features of the document flow management partly obsolete. The management of documents should be sufficient to satisfy quality assurance programs, such as ISO-9000.

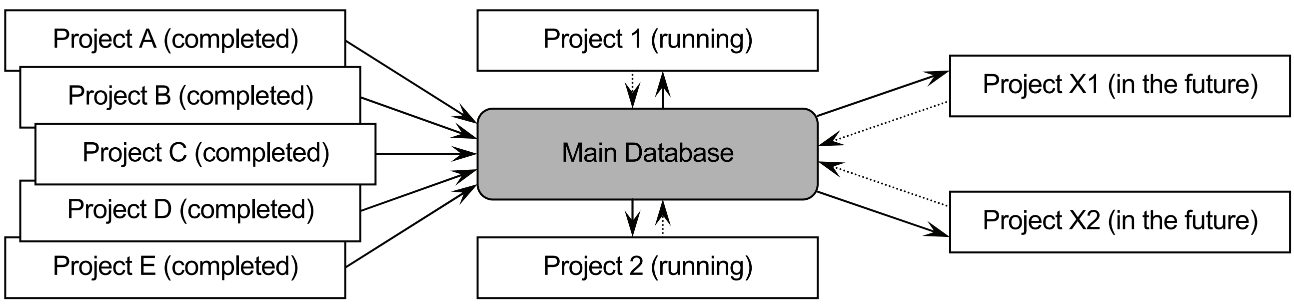
8.3.4. REDESIGNING THE DATA WAREHOUSING

The original data warehousing at Pöyry Oyj divided data storing to the main office and site offices. The main office keeps a separate storage for all the engineering and project management documents. They are stored at least as long as the main engineering target (factory or plant) is operating. Moreover, project offices keep their copies on file as long as they are of any interest to the project. In the end of the project, the sites deliver the remaining documentation to the client.

I realised that data warehousing must be integrated and automated with the procurement flow in order to change data warehousing from archiving to an active support function. The integrated data warehousing saves work, minimises errors, and maximises data search possibilities. I limited data warehousing to cover the most useful procurement information, i.e. cost items, suppliers, contact persons, plants and projects. Whenever a tender or a contract is saved to the software, the cost item is automatically created and all the users have instant access to the cost information.

At the site, the software has full access to its own database including information transferred from other projects. Normally, a project is only interested in some information of the main database, which is worth transferring to the project database. At project completion, the warehoused data items are transferred to the main database. In the office, access to the main database is unlimited. The integrated data warehousing is illustrated in Figure 68.

Figure 67. Organising Data Warehousing

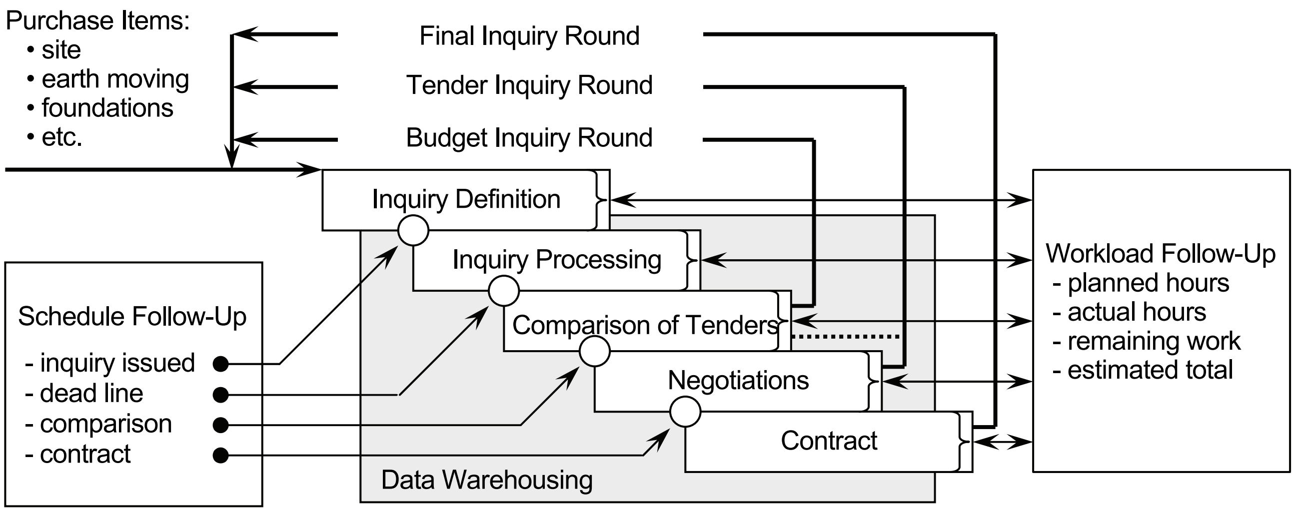


8.3.5. IMPLEMENTED PROCUREMENT PROCESSES

It was a major redesign task to overthrow the linear procurement model and replace it with a cyclical model supporting the successive procurement subprocesses. The executing subprocesses included budget inquiries, tender inquiries and final inquiries. These subprocesses were supported with document flow management, which was an auxiliary executing process. The controlling processes comprise the follow-up of the schedules and the workload. Data warehousing formed a separate management process belonging to over-all project administration.

The redesigned software processes included all three inquiry types, the necessary supplier and client correspondence documents, document flow management and reporting. The implemented procurement software is illustrated in Figure 68. It shows the procurement processes, stages and milestones. Furthermore, the picture presents both schedule and workload follow-up methods and data warehousing.

Figure 68. Implemented Procurement Processes



8.4. REVIEW

This chapter has discussed a “revolutionary approach” of business process redesign and described the redesign of the procurement process and the procurement software. The BPR (or its variation in information technology, the techno-change approach) was needed to achieve far better outcomes than the evolutionary progress would ever deliver. The preceding evolutionary development process was described in Section 3.3. The results of the evolutionary process, the *Project Management Manual* and *Procurement Manual*, were described in Sections 4.3. and 5.3., respectively.

The software redesign was initiated by questioning the structure of the procurement software, which had earlier followed the instructions of the *Procurement Manual* directly. The development of the 4GL tool, DataEase, also pulled the idea of redesigning the software further. After hard rethinking of procurement, the software structure was radically changed. The linear procurement model was scrapped and it was replaced with the cyclical procurement process model. The cyclical model was applied to procurement tasks, follow-up, and data warehousing on a much smaller and compact database. Budget inquiries, tender inquiries and final tender inquiries were implemented on a single set of procurement programs. Each inquiry type was designed to be supported by procurement follow-up, data warehousing and document flow management. The applied cyclical model saved a lot of programming and maintenance work.

The processing of the cost information was redesigned. It resulted in the processing of the cost items, i.e. tenders and contracts are recorded as item structures which present hierarchically the cost information. Whenever a tender or a contract is saved, the cost item is automatically created and all the users have instant access to the cost information. Every priced part of the tender is recorded and the total price is calculated from its components. This cost item approach eases the comparison of tenders and makes it possible to warehouse cost data efficiently.

The procurement follow-up was integrated with the procurement flow. The implemented follow-up comprises schedule and workload follow-up. The schedule follow-up concentrates on the comparison of the planned and actual timing of procurement events. The workload follow-up estimates the current progress, remaining work and total work. The over-all procurement status in a project is estimated by summing-up the progress of the separate inquiries. Particularly the automated workload-based progress estimation method seems to be a radical improvement in procurement follow-up. Although the accuracy of the estimates largely depends on the basic data recorded in the application, the easiness of reporting makes the feature valuable. Alarming progress reports suggest that either the progress of procurement is lagging behind or the planning of procurement has weaknesses; both cases demand immediate actions to correct the situation.

Data warehousing was seen as a part of knowledge management, disseminating the existing information within the company. The reorganised data warehousing changed its position from a minor archiving function to a support function. The data gathered from previous projects improves cost estimation possibilities, speeds up inquiry issuing and helps in the comparison of tenders. The integrated data warehousing saves work, minimises errors and maximises project support.

Finally, the programmed software was designed as compact software. The final design was something unheard of. It provided an efficient procurement solution with adequate features to any industrial plant project.

9. SOFTWARE DEVELOPMENT AFTER THE REDESIGN

This chapter describes the redirected development of the procurement application after redesigning the procurement flow. I carried out four additional development rounds after the redesigning of the procurement software to enhance and upgrade the procurement software. Each round brought improvements and new features to the application. Some improvements increased the functionality and some fixed errors.

During the redesigning of the procurement software, Pöyry Oyj terminated my employment. I had just converted the procurement software (version 3) to use DataEase 4.24 when it happened. The development work did not end there; I programmed the next two versions in order to support Metsä-Serla Chemicals Oy in their CMC-project. The last version was programmed because I needed a tool to report working hours and progress estimates in ERP projects. I used the software as a personal aid to complement the ERP systems of my former employers. Finally, after six development rounds, the final state of the application was achieved.

The application development rounds before the redesigning of the procurement software were discussed in Section 7.3. The redesigning for the procurement software wass described in Section 8.3. This chapter comprises the development work carried out after the redesigning of the procurement flow, the development of the user interface and the characteristics of the software.

9.1. DEVELOPMENT ROUNDS AFTER THE REDESIGN

Information technology has provided new ways to do business; it offers totally new or improved business practices and improves the efficiency of old ones. IT also replaces the old processes with more efficient ones and sometimes removes unnecessary and outdated processes. Each development cycle had been initiated by a discovery of a new need or possibility; either in project management or in software development. The growing user demands and IT development required further developing of the software. I regarded the growing user demands as a pull and the IT development as a push for software development.

Altogether, it took six development rounds, as illustrated in Figure 57, to reach the mature, efficient and powerful procurement software. The four last development rounds are described in this section. The main reasons and results of each development round are explained. The ultimate target stayed the same: improving the procurement software.

Development Round 3 – Conversion to 4.24

The third round was based on the DataEase development. The development was initiated in order to apply new features of DataEase. DataEase 4.24 enabled more powerful data processing than version 2.53 (we had skipped DataEase releases between 2.53 and 4.24.). DataEase 4.24 was capable to use extended memory, allowing much larger programs. It was also capable to operate on a local area network, which provided new possibilities to distribute information.

From the point of the users, the table-view was the most important new feature. It enabled the users to enter data records into a “table”, like a spreadsheet. The old DataEase 2.53 had only a form-view. DataEase 4.24 also allowed instant switching between the form-view (one record) to the table-view (many records presented as lines). Furthermore, I utilised the table-view feature to construct fixed main record–subrecord relations, where father–son related data was shown at one glance. For example, the basic information of one company with its (many) employees could be shown together.

This development round also initiated the redesign of the procurement software. Previously, I had used the linear succession of tables according to the chronological order of the events. My redesigning efforts resulted in a cyclical procurement process with automated procurement follow-up and data warehousing. The redesigning of the procurement software was discussed in Section 8.3.

The alternative would have meant neglecting the new features of the DataEase. It would also have implied that the procurement software had reached its final status as a clumsy, complicated, home-made application with no real future. The upgrading of the 4GL tool and the database engine provided a far better user interface with more powerful data processing, which all suggested that the software was a real choice for any procurement professional.

Development Round 4 – Documentation Integration

The fourth development round was made, again, because of a software interface. Documentation integration was needed to control the documents and the distribution of the documents in the purchasing process. Integration with office programs was also demanded. It was implemented by creating a possibility to switch the procurement software to another programs and back. This feature was welcomed in MS-DOS environments and mostly unnecessary in Windows. The standard selection of complementary office programs consists of Word for text processing, Excel for spreadsheet calculations and Primavera for scheduling.

The integrated documentation process provided a much more advanced solution than a reference to an enclosed list of valid documents. The solution allowed the users to define the documentation for each printout, depending on the needs of an inquiry or a contract. The procurement process was also extended to cover the inquiry specification process.

The alternative would have been keeping the document flow management as it was before: writing and listing documents with a pen or any available word-processing software. The old way based on the employees' skills and hard work in keeping documentation updated and the documents circulating fluently.

Development Round 5 – Conversion to 4.53

The reason for the fifth round was the same as that for the third round; it was based on DataEase development. DataEase 4.53 was published. It was able to operate under Windows, use a mouse as the input device and utilise cut-and-paste functionality in data processing. DataEase 4.53 also provided very stable networking environment for applications and truly offered client-server features.

The alternative would have meant neglecting the new features of the DataEase. In principle, it would have kept the procurement software out of most Windows environments. The upgrade ensured the operationality of the software in Windows environments.

Development Round 6 – Workload Estimation

The purchasing tool would have most likely stayed in oblivion, if I had not had workload estimation problems in implementing ERP projects. As a project manager, I had to be able to follow schedules, workload and remaining work, but I did not have any tool for that. I programmed the last version to follow the workload in ERP projects, because they are notorious for their inaccurate schedules and workload estimations. It is common that ERP projects tend to exceed budgets and project schedules.

Although my employers expected me to report the progress of the project, I did not have a lot of time for project management tasks, because I had also the responsibility of consulting about the use of the software package. Therefore, I sought for a way to automate the schedule and workload estimations. The target was to minimise the project management tasks. The ultimate goal was to automate the project follow-up.

First, I noticed that I already had a solution for schedule follow-up, if I replaced the procurement process with the application development process. In principle, I was using the procurement application in a more generalised manner. I could even use the same database, though the field names and labels matched the procurement process, not the software development process.

I still needed something to estimate workloads and remaining work. I noticed that the “procurement software” had all the necessary information for automated status reporting, because it combined schedules, working hour reporting and workflow (with procurement labels). The workload follow-up required some reprogramming to make the software calculate the estimates on the basis of the recorded procurement events. The estimation method was described more closely in Section 8.3.2.

9.2. DEVELOPMENT OF THE USER INTERFACE

The character user interface improved a lot during the development rounds. The improvements were based on changes in the layout principles and the development in hardware and software. A graphical user interface would be possible after the conversion of the software, but the conversion has not been made yet.

In 1991, colour displays and display cards for PCs were already introduced, but monochrome displays were still quite common. The application was designed to use colours, but a simple change in client settings enabled a workstation to use a monochrome display. The screen resolution dictated the maximum area of one screen, which was nearly always 640x480. It was the basic setting of PC programs and nearly all PC applications used it. This limitation has stayed for MS-DOS environments, although the application generation tool had been upgraded a couple of times. The same limit exists also in Windows environments, if DataEase applications are used in a DOS-window.

This screen limit of 640x480 gives a 24 lines high and 80 characters wide area for DataEase. DataEase itself reserves two lines of the total area for messages and function keys. This results in the situation that developers have 22x80 characters to build one screen. Although DataEase supports scrolling the screen both horizontally and vertically, it was decided that the horizontal scrolling will be never used and the vertical scrolling only if all the other solutions fail.

In the first development round layouts, only 18 lines were used for the fields, and the maximum length of a single field was 60 characters. Currently, the procurement software uses 21 lines for the fields, and the maximum field length 67 characters. Therefore, it is reasonable to say that the layout efficiency has improved remarkably. The layout changes have increased the effective area where all the data entry fields are placed, by 30.3 %. The freed space is used for providing additional program features or lengthening the data fields. The improved efficiency in the data entry program layouts minimised also the need of extension pages in the data entry programs. The improvement can be easily noticed by comparing the original and the current version of the “Inquiries” data entry program. The example screens, Figures 70 and 71, are shown on the next page. It is easily seen that the current version uses the screen much more efficiently.

Figure 69. Original Version of Data entry Program “Inquiries”

```
H3327                            INQUIRIES                              1/1
----------------------------------------------------------------------------
INQUIRY         CMCF-001         Kamyr Continuous Single Vessel Steam Liquor
                                 Plant


SCHEDULED ITEM
DATE                       1ST INQUIRY     FINAL INQUIRY    PLANNED
INQUIRY ISSUED DATE        20/04/90          /  /           11/11/11
TENDER DEADLINE DATE       22/04/90          /  /           12/11/11
COMPARISON OF TENDERS        /  /            /  /           13/11/11
CONTRACT DATE                              01/02/91         15/11/11

 ROUND                           ENQ.ISSUED       DEADLINE          COMPARED
 01 - 0 BUDGET INQUIRY ROUND     20/04/90         21/04/90            /  /
 02 - 1 INQUIRY ROUND            21/04/90         22/04/90            /  /
 03 - 2 FINAL INQUIRY ROUND      22/04/90         24/04/90            /  /

REMARKS
```

Figure 70. Current Version of Data entry Program “Inquiries”

```
Inquiries
Project:    H3227     CMC2000
Inquiry:    CMC2000-001     Continuous Single Vessel Steam Liquor Plant

Follow-Up:  CMC2000-001     Liquor Plant
WL, Sched:          600,0 h Est.Total, Item:      631,7 h = 95,4 %  Use: PM Task
WL, Used:           602,5 h Est.Total, PMT:       624,5 h = 96,5 %
Remarks:


            Customer                     Engineer
Technical:  MMe   Matti Meikeläinen      AIn   Arto Insinööri
Comm:       MMe   Matti Meikeläinen      BIn   Bertil Insinööri
Addressee:  TTe   Teija Teikeläinen      CIn   Cecil Insinööri
Info:       HHe   Heikki Heikeläinen     DIn   David Insinööri

Round                          Docs App  Issued    DL        ESL Sent  Compared
Inquiry Scheduled:                       31/10/98  14/12/98            31/12/98
01 - 0      Budget Inquiry     22/01/99  22/01/99  15/02/99  15/02/99  22/02/99
02 - 1      Inquiry Round      15/03/99  15/03/99  31/03/99  31/03/99  05/04/99
03 - 2      Final Inquiry      18/04/99  22/04/99  12/06/99  14/06/99  07/08/99
                                                   H3227     JUHA      21/03/99
```

9.3. CHARACTERISTICS OF THE PROCUREMENT SOFTWARE

This section describes the final version of the procurement software. Although it is important to outline the design, the actual construct, the procurement software, has also practical and scientific importance. The section comprises the hardware requirements of workstations, servers and networks, the structure of the software, main software features, and software documentation. The written instruction manuals for the software are not enclosed to this study.

The hardware requirements sound nearly ridiculous now, but in 1991 these requirements were placed for a decent system which was supposed to operate nicely in site conditions. The circular procurement process, automated procurement follow-up and data warehousing, and documentation flow management characterise the procurement software. Every program and software feature is documented in the manuals. Therefore, I claim that the software is adequately documented.

9.3.1. HARDWARE REQUIREMENTS

Due to the selected system features (relational data structure and client-server model in networking), the vaguely defined efficiency requirements were fairly easy to meet. The relational data structure allowed record-level-locking for data processing, leaving all the other records free to access for some one else. The client-server model pushed the data processing load to work stations giving faster response times. In any case, already the very first software version performed decently. Later, IT development has guaranteed that efficiency demands have been exceeded many times.

A pleasant surprise was that the application could operate in a very small PC. I was even able to make the software run in an IBM 8088 PC with 640 kB RAM. DataEase 4.53 (the DataEase version used to program the final version of the procurement software) had two executing commands: DEASE and DE16M. DEASE required a minimum of 500K of conventional memory, but did not use any extended memory. On the other hand, DE16M was designed to use extended memory. It needed 384K of extended memory available to operate. In order to load all DataEase system files into extended memory, 800K of extended memory was needed.

Hardware requirements were specified for the work stations, servers and networks. The hardware requirements of 1991 sound nearly ridiculous now, but then the requirements were placed for a system which was supposed to work nicely in site conditions. The recommendations did not specify the minimum hardware assembly which could operate in favourable conditions. They were given to present a fairly decent, efficient and well functioning networked system. I included the hardware requirements for the modern installation as well. They are based on the hardware requirements for the Windows XP application.

Workstation

The workstation recommendation included also a printer. In 1991, it was thought to be either a dedicated or a shared black-and-white laser printer. In 2005, it could also be a colour laser printer. The hardware requirements for the work stations are presented in Table 20.

Table 20. Recommendations for a Work Station PC

Feature	Recommendation in 1991	Recommendation in 2005
Processor	At least 80386, 20 MHz or equal	At least PIII, 500 MHz or equal
RAM	2 MB	256 MB
Hard Disc	80 MB	32 GB
Display	Colour or monochrome, 680x480	Colour, 1024x768
Operating System	MS-DOS 3.1 or higher	Windows XP SP 2
Database System	DataEase 4.24 (individual installations)	DataEase 6.52 (individual installations)

Server

The server recommendation was based entirely on the load of the procurement application in 1991. There were no other applications to be considered in the resource calculations. Today, the situation has changed totally. Other programs cause much more network traffic than the database applications. The server recommendations are shown in Table 21 on the next page.

Table 21. Recommendations for a Server PC

Feature	Recommendation in 1991	Recommendation in 2005
Processor	At least 80486, 50 MHz or equal	At least P5, 1.8 GHz or equal
RAM	32 MB	1024 MB
Hard Disc	500 MB	128 GB
Display	Colour, 640x480	Colour, 1024x768
Operating System	MS-DOS 3.1 or higher	Windows NT, 2000, XP or Novell
Database System	DataEase 4.24 (server installation)	DataEase 6.52 (server installation)

Network

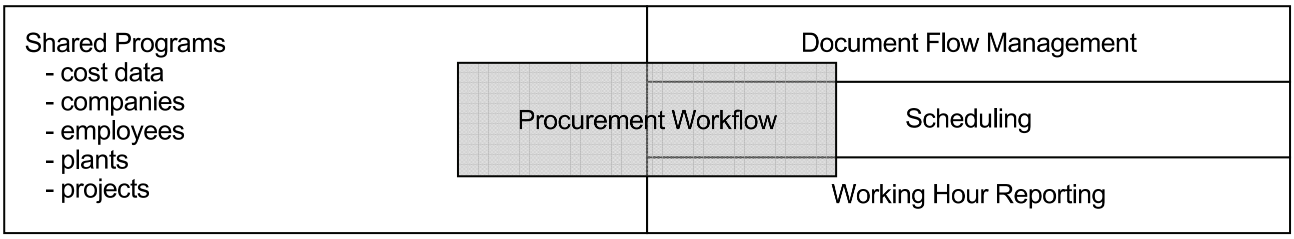
If DataEase is installed as a network installation, for example Novell, DataEase does not perform any caching. This will increase the network traffic since the amount of disk input/output will increase. Any caching that does occur will be performed by the network. Caching will save processing time by reducing the amount of disk input/output that takes place.

In 1991, the network recommendation was Novell 2.1 (or higher). Also any other network operating system with a network interface supported by DOS 3.1 protocol would have been accepted. In 2005, DataEase is network type independent. It uses the standard Windows API calls and does not care whether a Novell or Microsoft workstation or any other network clients and servers are installed.

9.3.2. SOFTWARE STRUCTURE

Procurement tasks, follow-up, and data warehousing are organised on a compact database. The database stores all the data of the procurement software. The recorded data comprises the static data of the each feature, and the data of procurement workflows, documentation flow management, scheduling and working hour reporting. The software uses modular architecture following the idea of the relational data model on a higher level. The modular software architecture is illustrated in Figure 71.

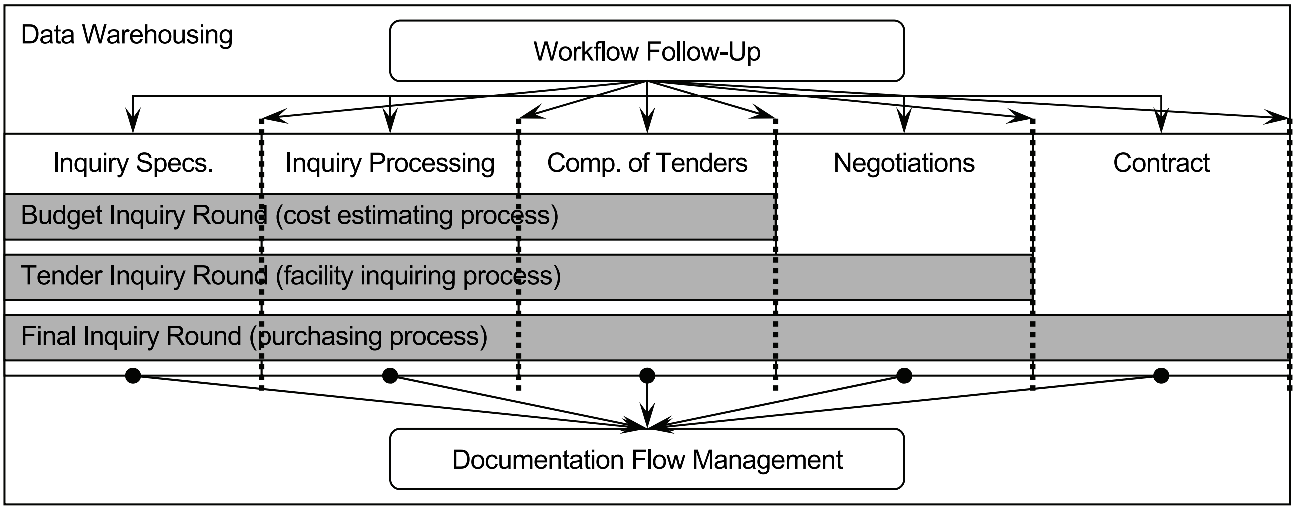
Figure 71. Modular Software Architecture



9.3.3. MAIN SOFTWARE FEATURES

The main features characterise the procurement software. The efficiency and efficacy of the software is based on the adequacy and high-quality of the key functions. The reasoning behind the software was discussed in Sections 4.3., 5.3., 6.3. and 8.3. The main software features comprise procurement workflows, follow-up, documentation flow management and data warehousing, as presented in Figure 72 on the next page. The software maintenance tasks are excluded from this research report.

Figure 72. Supported Main Features



Procurement Workflows

Procurement is, indeed, an iterative process, which is normally carried out at least three times for expensive investment items. First, budget inquiries are sent to ask a tender from several potential suppliers in order to establish the investment estimate. Second, tender inquiries are processed to investigate the suppliers' interest and facilities to participate in the project. Third, a final inquiry round is made with the most successful supplier candidates. The final tenders are used for supplier selection and forming the agreements.

The procurement workflows are implemented on a single database with a single program set for inquiry specifications, inquiry issuing, comparison of tenders, negotiations and contracting stages. The inquiry rounds can be carried out as many times as necessary to reach the contract. The final inquiry rounds advance normally through every stage. The budget inquiry rounds and the tender inquiry rounds apply as many of the early stages as are seen fit for the project needs.

The semi-automated comparison of tenders provides an improved method for the comparison of tenders. The method uses a hierarchical extended product structure to describe the tenders. All parts (equipment, services, documents etc.) of the tenders are placed in the tender structure. The tender structures are adjusted to match the comparison scope before all technical, commercial and other aspects are compared. The received tenders are matched either by excluding the tender parts outside the comparison scope or adding the cost information of missing tender parts. At this point, human intelligence is needed to make reliable comparisons.

Procurement Follow-Up

The automated workload-based progress calculation method helps project management. The progress is calculated from reported working hours without any manual operations. The procurement status data includes the used work hours, progress percentage and estimates of the total and remaining workload. Both aspects of progress estimation, timeline and workload, can be very precisely followed, and deviations could be noticed early. If deviations are noticed, corrective actions are made and the purchasing process is returned back to the right track. The earlier the deviations are found, the easier they are to correct.

Although it is possible to purchase all the needed equipment and services based on a general construction schedule and previous experience, purchasing is normally scheduled and the needed work is estimated. Sometimes only the schedule is established and the resources are arranged, but the workload is not calculated. The idea behind this is very opportunistic: the project personnel is flexible and bending according to project needs and the work force is not arranged and sized to satisfy the timetable. There are three main approaches in using the procurement application to follow the procurement status: (1) typewriter approach, (2) timeline approach, and (3) workload approach.

The typewriter approach is the simplest way to benefit of the application, namely to use it as a very powerful typewriter. In this case, the transactions are recorded during the procurement process and the software provides the needed documentation. Events are reported, as they actually took place and were dated. No comparison towards schedules or workload is performed.

The timeline approach follows the idea of connecting the procurement process to time planning. Either the schedule can be created in the procurement software or scheduling data can be transferred from another application to the procurement software. Schedules are compared to actual procurement events and the follow-up is based on the differences of the planned and actual dates.

The workload approach connects the procurement process with both the scheduling and working hour reporting. In this manner, the progress of the project can be calculated and the total resource usage estimated with reasonable accuracy.

Data Warehousing

The Integrated data warehousing with data transfers from and to the project database is something the project professionals were dreaming of at Pöyry Oyj. It saves work, minimises errors, and maximises data search efficiency. Data warehousing is limited to cover the most useful information for future projects, i.e. cost items, suppliers, contact persons, plants, and projects. If somebody has entered the information in the software, it is available for everyone. Earlier the project professionals had to use the papers of previous projects to find addresses and cost data for the project at hand.

The data transfer programs were programmed to support the updating of the company database from projects and to any project. A database located in the same network has direct data transfer programs for both directions. The databases without direct database access can be updated with another pair of data transfer programs, which imports and export the data through transfer files.

9.3.4. SOFTWARE DOCUMENTATION

The procurement software was intended to be a corporate level solution. It placed strict requirements on the quality and the manner of the documentation. The documentation was decided to be created in English and carry the end-user view. The user interface was documented first, then the software. Later, the marketing material was created. The database was described last. Clarity was striven for, because it makes the documents understandable and easy to use. This makes sense, because clearly written is normally also easy to understand.

Conciseness was needed to keep the documentation to the point. I managed to stay in the topic in the enclosures. The conciseness was considered to have been achieved, if the software had a user interface guide, an application guide, development tool manuals and marketing material. These documents form the core of the software documentation. Although they do not comprise all the desirable documentation, they were considered to be enough.

The manuals were designed to make it possible for users to find information fast. First, each software module has its own manual, because the whole procurement package does not need to be used in all projects. It was a natural extension to the modular system design to document the application modularly. A project might do well with one or two modules, depending on the project. Second, the manual structures follow the software structures. The idea is utilised so far that the paragraph numbering is exactly the same as the menu selections in the software. The titles and paragraph numbers in the manuals match the selections in the software all the way. For example, in the *General Programs*, paragraph number 1.5.2 corresponds with the Exchange Rate -program. The corresponding selections are 1, 5 and 2 to enter the program, as illustrated in Figure 73.

Figure 73. Selections in Procurement Application

1 5 2

→ 1 - Companies (submenu)
→ 5 - Currencies (submenu in Companies submenu)
→ 2 - Exchange Rates (data entry program)

Every program is presented in the manuals. The presentation rules for program screens were designed and rigorously applied. The screen typology was kept unchanged in every manual to make it easier to understand the screen layouts. Six colour combinations are used to point out the field properties in the procurement application. Each colour combination has its own convention in the user documentation. These are described in Table 22.

Table 22. Screen Presentation Rules in Documentation

Field type	**User access**	**Application appearance**	**Manual appearance**
Regular - data processing fields - derived and underived fields	Depending on the security level	White letters, blue background	Single underline
Virtual - virtual fields which are related to another record - key fields determine the values of virtual fields	No access	White letters, red background	Dotted underline
Summary - calculated from other related record(s) or fields	No access	Red letters, black background	***Bold, Italics***
Header - header of the 2nd screen - displays the key information of the record	No access	White letters, green background	Dotdash underline
System - relative field names - message fields of the application	No access	Yellow letters, black background	Normal
Hidden - system-derived fields	No access	Black letters, black background	Not shown

User Documentation

The user documentation consists of on-line help, an introduction presentation (also used as basic marketing material, as discussed below) and software manuals. The field and table helps are not delivered with this research report. The software manuals were designed to support the training and use of the procurement software. Three software manuals are provided: (1) the *User Interface Guide*[292], (2) the *General Programs*[293], and (3) the *Purchasing Manager*[294]. Each of them covers its own area of the software.

The *User Interface Guide* describes the user interface of the software. The main purpose is to advise the readers to use the applications efficiently. It introduces the editing keys, function keys, fields and records. The user interface is programmed to have a similar appearance in analogous cases. The similar combinations of drawn borders, messages, designed field lengths, field colours, layouts of fields etc. are used in analogous situations.

The *General Programs* describes the shared programs of the procurement application package. The shared programs are a vital part of the procurement application, although they can be used independently without the procurement application. The real task of the sub-application is to share the common data across the database, like companies, employees and cost data. This manual also describes the collaboration with commonly used office applications, like Windows Word and Windows Excel. Furthermore, the database maintenance programs are discussed in this manual. The provided maintenance features cover most of the needs in database administration. On the other hand, database administrators have more advanced features available in DataEase system maintenance.

The *Purchasing Manager* describes the functions of the procurement software. The manual guides the procurement tasks with integrated procurement follow-up and data warehousing. This manual also describes the interface towards planning programs, like Primavera, Artemis, or MS Project. The interface is designed to match the procurement software. The most suitable file format for the procurement software is used in data transfers. The scheduling software is supposed to be able to create corresponding ASCII files.

Developer Documentation

The developer documentation of the procurement application consists of code and architecture documentation. It was thought that the developer documentation should be kept simple and condensed. This was based on the advantage of self-made applications: the actual developer would be available for problem situations in all office hours without extra costs. For obvious reasons, none of the developer documentation is enclosed in this research report.

DataEase applications are not compiled, so the source code for forms, fields, procedures and menus is available all the time. It gives everybody with adequate user rights an access to the source code and comments included in the source code. The comments were used to show the main information of the current program (program purpose, version, date and programmer), to explain complex program parts, and to keep the previous version of the modified program part. Removing the complex code might not be a wise decision, because the new version might be worse and the previous version should be restored.

[292] Vehviläinen, Pöyry Oyj: User Interface Guide (1990, re-edited in 2005), 32 p.
[293] Vehviläinen, Pöyry Oyj: General Programs (1991, re-edited in 2005), 36 p.
[294] Vehviläinen, Pöyry Oyj: Purchasing Manager (1991, re-edited in 2005), 55 p.

Architecture documentation was created to show the general structure of the software. I made an E-R diagram[295] to illustrate the database and the relationships between the tables. In the beginning, it was used to plan the overall design, which was kept updated to match the structure changes of the software. Later, the diagram was used to describe the software.

Marketing Material

Marketing material[296] was provided to support project service marketing. The aim was to convince potential customers that Pöyry Oyj used highly developed, flexible and cost-efficient procurement tools. The marketing material was normally modified to match the special features of a prospective project. The material was adapted according to the conception of the marketing people and the implied desires of prospective customers. The basic material was created and it was changed to meet the situation.

The marketing material describes the general features of the procurement software and the 4GL tool. It emphasises the benefits, quality and usefulness of the software. In the marketing material, special attention has been paid to demonstrating potential savings in project management.

9.4. REVIEW

The redirected software development after the redesigning went through four development rounds: (1) database engine conversion from DataEase 2.53 to DataEase 4.24, (2) document flow management integration, (3) database engine conversion from DataEase 4.24 to DataEase 4.53, and (4) development of workload-based follow-up. The third and fifth versions were programmed to utilise new features of the database engine. The forth version brought document flow management to the software. Finally, the sixth version solved the problem of the procurement status estimation. After the workload-based follow-up, the final version of the procurement software was reached.

The procurement software has a large set of documentation. The documentation comprises user manuals, marketing material and developer document. Every program and feature of the software is documented in the manuals. Altogether, the software is adequately documented.

The final version of the procurement software is a mature product. I think that it is reasonable to say that the operational features of the application are adequate for the purposes of the application. Originally separate budget inquiries, tender inquiries and final tender inquiries are combined into a single procurement process. The single procurement process is integrated with procurement follow-up and data warehousing. The whole procurement software is organised on a small and compact database. Some additional benefits are achieved through software development in operating systems, databases and programming tools. Finally, some of advantages are realised through hardware development, such as extended memory management, a mouse and laser printers.

The procurement software exceeds the original requirements by a very great margin. The benefits of the software (savings compared to the previous manual methods) indicate that the procurement software is a viable product. The final version of the software is a much more efficient, versatile, flexible and capable solution than the original plans required. The actual outcome is far better than the requirements demanded and the software is a valid choice for procurement software in industrial plant projects.

[295] Vehviläinen, Pöyry Oyj: Project Management Database and Programs (1990), chart
[296] Vehviläinen, Pöyry Oyj: Marketing Material (1990, re-edited in 2004), slideshow

10. EVALUATION

In science, the achieved results are not the only evaluation subject. The research method and the use of the method are also evaluated. A well-applied research method with no results can be valid scientific research, because it tells the others that there are no results available with the applied method. It is sometimes also a very valuable result to prove something untrue. Thus, a method and the way to use the method are highly regarded and they matter in science.

Because of the dual scientific nature, I have evaluated results in the views of business science and Information Systems. I have also evaluated my research towards my own general success criteria and made a practical software evaluation. Finally, the evaluation is discussed in four ways, each having a dedicated section: (1) evaluation according to business science, (2) evaluation according to Information Systems, (3) evaluation towards my personal criteria of the research success, and (4) practical software evaluation.

The target of this chapter is to evaluate the research. The evaluation includes the research process and all the created artefacts, i.e. procurement framework, project manuals and procurement software. Evaluation according to business science is carried out using the market tests (see Subsection 1.6.1.). The general evaluation guidelines of the design science approach (see Subsection 1.6.2.) are used in Information Systems. In personal research evaluation, I compare my success criteria (presented in Subsection 1.7.2.) with the realised research. The software-specific evaluation focused on the practical evaluation of the software.

10.1. EVALUATION ACCORDING TO BUSINESS SCIENCE

I am confident that the previous chapters describe my research process in enough detailed manner. I regard that my research matches closely enough the features of the constructive method[297] as it is pursued in business science. These characteristics include: (1) a step by step procedure, so that the nature of the steps is specified in the framework, within the applied method, (2) possibility to check every step, or every phase, in the construction process, and (3) the research procedure as a whole serves a definite purpose, making the construct building a goal-directed activity.

The research results are evaluated by measuring the quality and extent of the user experience (discussed in Subsection 1.6.1). In principle, the use of the software proves that it works. Kasanen et al.[298] have advocated market-based validation, which originates from the concept of innovation diffusion, i.e. constructs are competing in the markets. It tests the business appeal of the construct, but it does not take into account the understanding generated in the building process. The strength of the market testing lies in the simplicity of the test method and unbiased results it provides. Kasanen et al. state that the actual usefulness of a construct is never proved before a practical test is passed.

Market Tests of Procurement Framework

The demonstrated utility of the software proves that the procurement framework behind the software is valid. The framework parts before redesigning the procurement flow are included in the project manuals. I claim that those parts of procurement framework are globally accepted and pass all the market tests. The redesigned framework parts are under study after my presentation in Pöyry Oyj[299].

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[297] Kasanen, Lukka and Siitonen: The Constructive Approach in Management Accounting Research (1993) Journal of Management Accounting Research, Vol. 5, No. 3-4 (Fall 1993), p. 258

[298] Kasanen, Lukka and Siitonen: The Constructive Approach in Management Accounting Research (1993) Journal of Management Accounting Research, Vol. 5, No. 3-4 (Fall 1993), p. 253

[299] Halmepuro, Pöyry Oyj: Discussions of circular procurement process (2006)

Market Tests of Project Manuals

The *Project Management Manual* and *Procurement Manual* are in general use in Pöyry Oyj and have been used regularly after their publication. The project manuals comprise the project management knowledge accumulated at Pöyry Oyj during the decades. The manuals are based on the experience gathered from hundreds of industrial projects. The instructions peak the evolutionary development of the project management in the company. Both manuals are widely considered to present industry level best practices in industrial plant projects. I claim that the project manuals are globally accepted and survive all the market tests.

Market Tests of Procurement Software

I also conducted the market tests for the procurement software, but the results were rather poor. Each version of the construct survived the weak market test, because each version has been in use. I regard that the second software version might fulfil the criteria of the semi-strong market test, but not the other versions. Every version failed in the strong market test. I think the situation will not change, because the character user interface makes the software uninviting and gives the impression of an obsolete product. There have been no attempts to modernise the software, either.

The first version of the procurement software was used already in the early 1990s in some cost estimating projects. The scheduling features of the second version increased the popularity of the application. The whole procurement flow was used in some large-scale industrial projects both in Finland (Enocell, Joutseno) and abroad (for example, Celbi in Portugal, Golbey in France, and Saillat also in France). It proved that the procurement process worked. The software was also included in Pöyry Oyj's project management tools for the fifth nuclear power plant project in 1991. After the redesign of the procurement software, the software was upgraded by database conversion resulting in the third version of the software, which was used in 1992-93 in the CMC project in Äänekoski. After the CMC project I have not followed the history of the early procurement software versions. I have heard rumours that the software has been used in Russian projects, but I can not confirm this. Altogether, dozens of project professionals have used the three first versions of the software.

The fourth and fifth versions were programmed for the documentation needs of Metsä-Serla Chemicals Oy. The fourth version added document flow management to the converted software. This additional feature was used in 1992-94 in the CMC project, in which a four-person project group used the software. The fifth version upgraded the data processing of document flow management. I have no knowledge of other cases where the document flow management may have been used.

The last major enhancement of the procurement software comprised the workload based procurement follow-up. I designed it for project status reporting in ERP projects. I have used the calculation model in some projects and I have noticed that the model gives a fairly accurate picture of the project status. The clear understanding of project status makes it easier to focus on the most important tasks at that moment.

10.2. EVALUATION ACCORDING TO INFORMATION SYSTEMS

In Information Systems, evaluation should be carried out to determine the quality of the building process and the created artefact. Järvinen[300] proposes that the researcher should describe the building process in detailed manner so that the reader is persuaded that the best possible solution

[300] Järvinen: On Research Methods (2004) p. 98-127

was created. I hope that my presentation of harnessing best practices via software to support knowledge management has been interesting and justified. I have used a lot of energy in describing the planning and implementation, but I claim that the building process has been described with sufficient accuracy.

Evaluation of the Artefacts

Hevner et al. state that the usefulness, originality, quality and efficacy of a designed artefact must be demonstrated via observational, analytical, experimental, testing, or descriptive evaluation methods[301]. The business environment establishes the requirements which the artefact is expected to answer. Evaluation includes the integration of the artefact to the technical infrastructure in the business environment. Performance evaluations are not required for totally new research outcomes, as discussed in Subsection 1.6.2., because the outcome itself can be seen as a merit. However, the potential importance of the new artefact is expected to be evaluated.

The necessary condition of the constructive method has been fulfilled; I have developed, or at least participated to development of, viable artefacts, the procurement framework, project manuals and procurement software. Together they describe a working, logical consistent and effective solution for procurement in project implementation. I am confident that I have fulfilled the scientific requirements in building the artefact. I have evaluated my research via observational case studies, in which I have studied the artefacts in depth in their business environment. I also state that the evaluation has been carried out as a field study, where I have monitored the use of the artefacts in multiple projects.

Because the major part of the procurement framework and particularly the project manuals are generally accepted, I expect them to fulfil the requirements of usefulness, originality, quality and efficacy easily. Therefore, I decided to focus on evaluating the procurement software according to Information Systems.

The usefulness of the software will be discussed in detail in the procurement software section in Chapter 11. It emphasises that the software is useful and suitable for procurement tasks. It has helped in project implementation, minimised workload at projects, and produced direct savings in procurement costs. On the other hand, the indirect savings can be much more important. The usefulness can be regarded proven, because Pöyry Oyj has used the software in its projects. Thus, the software (and research) is validated in its business environment.

The originality of the software was discussed in Section 1.2. Based on the literature study, it seems unlikely that any similar software exists. Neither my former colleagues at Pöyry Oyj, nor the professionals of Proha Oyj know any software whose functionality would match the software. So far, ProcuMent from Proha Oyj resembles the procurement software most. ProcuMent is designed for the planning and execution of purchasing for construction projects. The main differences are that ProcuMent is not designed to handle evolving inquiry specifications, nor is it able to handle individual tenders, which are crucial for comparisons of tenders, negotiations, and data warehousing of cost information. Therefore, I claim that the procurement software is a novelty.

The quality of the software can be demonstrated by comparing the construct towards existing solutions. Before the procurement software, Pöyry Oyj used Word Perfect for text processing in company correspondence and reporting, Lotus 1-2-3 for spreadsheet calculations in the follow-up of procurement flow and cost estimations, and Primavera for scheduling and for graphical representations of the schedules. In 2005, the corresponding office programs were MS Word, MS

[301] Hevner, March, Park and Ram: Design Science in Information Systems Research (2004)
MIS Quarterly, Vol. 28, No. 1, pp. 85-87

Excel and MS Project, respectively. Before the procurement software, the data transfers were made by typing them manually. In 2005, Windows provides elementary co-working features making procurement tasks a lot easier. Compared to the combined use of general office programs, I firmly believe that my procurement software is a superior solution. It supports procurement tasks in ways general programs would never be able to.

The efficacy of the software is proven by the user experiences. I did not get complaints of transaction processing or reporting speed, nor did I receive remarks of insufficient calculation accuracy. So, I regarded that the software operated with adequate efficacy. Minimised data entries, selections instead of typing and predefined printouts saved work in procurement tasks. Furthermore, the software made workload-based progress calculations automatically. In principle, no work was needed to check the current procurement status in a project assuming that all the basic data had been recorded and all the events registered. There might be applications which are capable to report the procurement status with equal (= 0 hours/project) work, but not with less work.

10.3. PERSONAL EVALUATION OF THE RESEARCH

All the seven success criteria (presented in Table 5), which I placed on my research, have been fulfilled. These general success criteria cover the whole research, i.e. the research process and the realised constructs.

The first of all, the project instructions were rewritten and used and the software with adequate features was programmed and documented (criterion 1, design as an artefact). Second, the research problem is relevant: procurement and its follow-up is a vital part of any industrial plant project (criterion 2, problem relevance). Third, the project instructions and the software have been used in several projects and the users have been satisfied with them. Market testing, or field testing according to Information Systems, was applied for the artefacts, which implies that the design evaluation was carried out as a field study (criterion 3, design evaluation).

Fourth, the research provides an enhanced framework for procurement, upgraded project instructions, and new software for procurement which operates along the principles presented in the project manuals. Furthermore, the software enabled reorganising of the procurement function, and the software produces savings in project implementation (criterion 4, research contribution). Fifth, the manuals were rewritten and the software programmed along the revised Pöyry project methods. Market tests, or field tests according to Information Systems, were used to evaluate and validate the framework, the manuals and the software. The potential usefulness and importance of the artefacts were studied (criterion 5, research rigor).

Sixth, the designing of the artefacts followed, more or less development spiral. The rewriting of the project manuals implies continuous search for better solutions. The development of the procurement software (see Figure 57) took six development rounds (criterion 6, design as search process). Seventh, the *Project Management Manual* and the *Procurement Manual* were published and several supplementary presentations of project instructions were been produced. The software has both user and system documentation. Moreover, the procurement software has several introduction and marketing presentations. Besides this dissertation, project manuals and software documentation, I have made a presentation slideshow[302] of the research and an executive summary[303] of the research (criterion 7, communication of research).

[302] Vehviläinen, Lappeenranta University of Technology: Presentation of Research (2005)
[303] Vehviläinen, Lappeenranta University of Technology: Procurement in Project Management: Summary (2005)

10.4. PRACTICAL SOFTWARE EVALUATION

The software-specific evaluation was carried out, because in business the development tasks have no value of their own; they are only a source of costs, and only achieved results matter. Therefore, companies seek ways to increase the efficiency of the development process. The efficiency of the development process is measured by the incomes of the developed products or savings in the producing process. This inevitably leads to emphasising the results, and the methods are of secondary importance.

I have used two practical ways to justify the programming efforts of the procurement: (1) savings expected to be achieved by using the software, and (2) comparing the requirements of the software with the implemented software. Both evaluation principles justify the programming efforts, which indicate that the software is a commercially viable product.

Expected Savings

The use of the software was expected to produce savings in project costs. Savings were thought to be achieved both in project management and procurement costs. The costs were supposed to be reduced in direct and indirect ways. Originally, the expected direct savings were enough to justify the initiation of the software development. Later, the indirect savings were regarded more important than the direct savings. The expected savings are illustrated in Figure 74.

Figure 74. Available Savings

Direct Savings

1) automated and minimised work
   - data entries, searches, printouts, reporting, data warehousing, and progress follow-up
2) minimised errors
   - data formats, self-evident data processing, pre-entered basic data, previous project examples
3) maximising event processing speed
   - selections, batch processing, adequate basic data

Indirect Savings

Knowledge	Reaction Possibilities	Personnel Utilisation
- wider range of possibilities - more detailed analysis	- opportunity utilisation - faster error corrections - avoiding idle time	- automated routine tasks - experts concentrate on guidance and problem solving

Lengthening Service Time of Legacy Systems

The direct savings were assumed to be achieved by more efficient procurement work compared to the previous manual procurement methods. The efficiency of the procurement was supposed to be increased by (1) minimising (and automating) work, (2) minimising errors, and (3) maximising the event processing speed. The work was planned to be minimised by minimal data entries, predefined printouts and reports, and automating everything possible, like data warehousing and procurement follow-up. Errors were minimised by using appropriate data formats, self-evident labelling and field locations, use of pre-entered basic data, and using data from previous projects. The event processing speed was maximised by field value derivations, using selections instead of typing, utilising batch processes instead of separate event processing, and supporting event processing with adequate basic data.

Indirect savings were expected to be achieved by reducing project management and procurement costs through improved knowledge. The application enabled wider analysis range, more detailed analysis and increased number of analyses. Savings were achieved through improved reaction possibilities, giving changes to utilise opportunities, faster error corrections and minimising idle time. Also, the utilisation of the personnel was expected to improve via automated routine tasks, giving the experts the possibility to concentrate on guidance and problem solving. The last possible indirect source of savings was seen in the possibility to continue using legacy systems by making the procurement software co-operate with them.

Requirements Compared to the Actual Software

Requirements compared to the actual software showed that the software fulfils its requirements. The fulfilment of requirements can be estimated by three important aspects: (1) matching of the target state and the final solution, (2) quality comparison between the target state and the final solution, and (3) the realised costs and timing compared with the implementation plan.

The procurement software was constructed to operate the way project professionals required at Pöyry Oyj. The original idea was to program software according to the *Procurement Manual*. This implied that the software would carry out the procurement process and produce defined documents (Inquiry Covering Page, Inquiry Summary Letter, Final Tender Request, Letter to Unsuccessful Tenderers, Tender Comparison Summary, Request for Purchase, Letter of Intent and Main Page of Contract). The procurement flow was programmed so that the flow gathered the information needed for the procurement documents. This fairly simple target was moved at least five times during the software development. It is no wonder that the procurement software does not match to the original requirements closely. On the other hand, the last target state and the final software version are quite close to each other.

The second aspect concerns the quality of the final solution compared to the target state. Again, the final solution is a much more efficient, versatile, flexible and capable procurement application than the original plans require. Even the plans of the final version were exceeded by the actual outcome. I am convinced that the procurement software exceeds with considerable margin the requirements.

I admit that costs and schedules were exceeded due to multiple workloads. The moving target made it impossible to achieve (and later, exceed) the requirements in time and within the budget. I have to say that I feel the cost and schedule comparisons irrelevant, because I have worked years to develop the application without any financial compensation.

11. RESULTS

The results of the research include the procurement framework, rewritten project manuals and the procurement software. The results of the procurement framework come from the describing and guiding power of the created framework. The results of the rewritten project manuals realised after the publication of these manuals. The manuals have aided and supported the implementation of several hundred projects. The programmed procurement software has resulted in minimising the procurement costs in project implementation.

These results are chained. The rewritten project manuals enabled the new procurement framework, which in turn made it possible to program the last versions of the procurement software. The artefacts are also and partly iterative, because the procurement software caused changes in the procurement function in project environments. Therefore, the procurement instructions had to be upgraded to take into account the software.

Procurement Framework

The procurement framework provides an enhanced view towards procurement in large industrial plant projects. The concurrent engineering approach is incorporated into procurement. The framework gives a process view towards procurement and competence to understand and overcome the uncertainty of item specifications in procurement. The demonstrated utility of the software proves that the procurement framework (its theoretical background) is valid.

The procurement framework introduced the business environment; projects and project management (see Section 4.3.). The framework was developed further in Section 5.3., which described the procurement function operating without supporting software. Last, the redesign of the procurement function revised the procurement framework, and resulted in the redesigned procurement software, which is discussed in Section 8.3.

Rewritten Project Manuals

The rewritten project manuals, the *Project Management Manual* and the *Procurement Manual*, I consider as intermediate results of the research. My role in rewriting these manuals was supportive and I state that I merely participated in the rewriting project. I made some minor adjustments in these manuals, but Halmepuro organised and managed the rewriting project. Finally, he made most of the rewriting of these manuals.

The rewritten project manuals have been in general use at Pöyry Oyj for years. The manuals were an important step in harnessing the company knowledge of Pöyry Oyj. Since their introduction, they have guided and supported project management in numerous projects and sustained the competitive advantage of the company.

Procurement Software

The most important practical result of constructive research is naturally the well-documented software. The procurement software has been designed to meet the best practices used in project management. The purpose of the procurement application is to provide a flexible and efficient, but nevertheless easy tool for purchasing and follow-up in project environments. The software supports procurement process and follows the procurement status from the scheduling stage to contracting. Furthermore, the application provides on-line reporting facilities and data warehousing.

The procurement software minimises the need of project professionals and supports the use of less-educated employees. The software gives possibilities for better procurement decisions in automating routine tasks, which would otherwise have to be prioritised in order to keep the project running. The software makes easy to concentrate on the most important procurement tasks: unfinished, current and soon-to-be-started tasks. The software is expected to help in enriching and disseminating information, which in turn would support the planning and implementing of new industrial plants.

The procurement software supports the main target of project management: successful implementation of a project. In order to achieve this main target, the beneficial application features are truly needed: 1) proven standard workflows, 2) total control of procurement, and 3) minimising errors. Some of the benefits are not necessarily measurable in money, for example the quality of the selected equipment might be higher due to the improved technical analysis.

1) Proven standard workflows include
    - consistent results
    - easy transition from a project to another
    - easy knowledge transfer
    - predefined printouts and reports
    - easy personnel utilisation
2) Total control of procurement comprises
    - the whole process from scheduling and documentation to contracting
    - all the reporting directly from the database (no calculation gap)
    - a more accurate estimate of the project status and earlier notification of problems
3) Less errors means less trouble in project management through
    - less procurement method errors
    - less data errors
    - less calculation and evaluation errors
    - more time to focus on actual management tasks

As a result, the procurement software is expected to save work in procurement tasks. The financial effect[304] of the procurement software is estimated to be a 25-40 % decrease in the direct procurement workload in large industrial projects. Indirect savings, how significant they might be, have not been estimated, because they cannot be reliably calculated. I have used a speculative example to illustrate the potential indirect savings. Because procurement activities establish all or nearly all of project costs, this means that the procurement software handles large amounts of money. For example, a green field pulp mill could cost 500 M€, depending the site and necessary facilities. A small percentage saved of the project costs would justify the software. If it would save 0.01 % of total costs, this would mean 50 000 € in a 500 M€ project.

[304] Halmepuro, Pöyry Oyj: Statement of Financial Impact of Procurement Software (2006)

12. DISCUSSION AND CONCLUSIONS

The target of this chapter is to discuss the value of the dissertation and its contribution to science. The general position of the research and the materialisation of the guidelines of design science research are discussed. Later, the research contribution, applicability and limitations of the research will be pointed out. Last, I will make some recommendations both regarding the use of the created procurement software and future research.

I have written this dissertation believing that a holistic approach to procurement in project environments would provide the best results. I consider that there is enough contribution to science in each part of the work to be included in this work. Otherwise, I would have focused on one of the topics. I made this study from the viewpoint of an engineering and consultancy company. This implies that practical values are highly appreciated and the research is carried out in a pragmatic manner. Moreover, the research has dual scientific nature; it belongs partly to business science (procurement and project management) and partly to Information Systems (development of procurement software and the software itself). The dual nature of the research has lengthened this study.

The revising of Pöyry project manuals (*Project Management Manual* and *Procurement Manual*, see subsections 4.3. and 5.3., respectively) started the actual research. I was appointed to the task as a secretary, mostly responsible for graphical illustrations. I was supposed to acquire the necessary background information of procurement tasks in the revising of the project instructions. It was a very efficient way to make me learn the company practices and get to know the people.

A little later, I was appointed to program procurement software based on procurement instructions. The heavily-emphasised cost-effectiveness in software development explains some features of my research. Although, the design science approach in Information Systems[305] assumes that the software is developed by producing alternative solutions and selecting the best among them, I had no possibility to do so.

The cost-aware managers at Pöyry Oyj did not allow me to program alternatives, only to reject unsuccessful attempts. In the rewriting of the project manuals I was not in a position to even suggest something like that. I was an apprentice, who had to do the tasks my supervisors appointed to me. In the programming of the procurement software, I might have had a possibility to program alternatives, but the amount of the work and the pressure to introduce new versions ruled out the alternative solutions. My supervisors at Pöyry Oyj pointed out several times that a good, working solution today is much more valuable than the best possible solution in the next year. I admit that the lack of alternative designs or programs might be a shortcoming in my research, even though this kind of development method is not required in business science[306].

The design of the software continued until a working solution was found. At that moment, all the other possibilities were abandoned and the actual programming started. After the selection, the other possibilities were neglected and they were not documented, likewise software errors. It kept the documentation at minimum and saved time and money. The scarcity of time and money demanded that any working satisfying the software requirements was acceptable as long as it provided a better solution than the manual work processes at that time. Therefore, I did not have alternative programs or alternative designs to report and I have only documented the programmed software.

[305] Järvinen: Written instructions to enhance this doctoral dissertation (2006)

[306] Kasanen, Lukka and Siitonen: The Constructive Approach in Management Accounting Research (1993) Journal of Management Accounting Research, Vol. 5, No. 3-4 (Fall 1993), pp. 243-264

It was decided beforehand that the project manuals and procurement software would be developed further in the future. Pöyry Oyj had done it before with the project manuals and the company is determined to continue keeping the manuals updated. The approach towards the procurement software was similar. The end-users were told that the software would be developed further and the end-user experience would be used to develop the next software version (the development rounds of the procurement software are illustrated in Figure 57). The satisfaction of the end-users would decide the maturity of each feature in the software. Therefore, I claim that the development process of project manuals and the procurement software was iterative.

In business science, the research approach is called the constructive research method and its goal is to build a solution to an explicit problem. In Information Systems, building and evaluating processes can applied and evaluated separately, or they can be entwined and belong to the same process, when the combined research process is called action research[307]. Both disciplines (business science and Information Systems) are striven with usefulness aspects. Hevner[308] et al. have proposed seven guidelines for design science research (see Table. 4), from which I have derived success criteria for this research (presented in Table 5). These guidelines for design science research are compared with the realised research in Table 23.

Table 23. Design Science Guidelines Realised in the Research

Design Science Guideline	**Realisation in the Research**
1. Design as an artefact • a viable construct	The rewritten project manuals and the programmed procurement software.
2. Problem relevance • solutions to relevant business problems	Procurement and its follow-up is a vital part of any industrial plant project.
3. Design evaluation • utility, quality, and efficacy of a design artefact must be rigorously demonstrated	The rewritten project manuals have been in use for 15 years in Pöyry Oyj guiding project implementation. The software has been used in several industrial plant projects, supporting the procurement function. Market testing was applied for both artefacts, which implies that the design evaluation was carried out as a field study.
4. Research contributions • clear and verifiable in design, design foundations and/or design methodologies.	The research produced enhanced project manuals and a novelty, procurement software. The development of the software was preceded by the development of a procurement framework, which guides procurement in project environments. The use of the software has resulted in savings in project management. Furthermore, the software has enabled reorganising of the procurement function in project environments.
5. Research rigor • both in construction and evaluation	The construction of the project instructions and the software are described in detail in this report. Evaluation is also presented in this report.
6. Design as a search process • utilising available means to reach desired ends while satisfying laws in the problem environment	The rewriting of the project manuals implies continuous search for better solutions. The development of the procurement software took six development rounds. Each of them was targeted to improve the software.
7. Communication of research • both to technology-oriented and management-oriented audiences	Besides this dissertation, project manuals and software documentation, I have made a presentation slideshow[309] of the research and an executive summary[310] of the research.

[307] Järvinen: On Research Methods (2004) pp. 98-127
[308] Hevner, March, Park and Ram: Design Science in Information Systems Research (2004) MIS Quarterly, Vol. 28, No. 1, pp. 80-90
[309] Vehviläinen, Lappeenranta University of Technology: Presentation of Research (2005)
[310] Vehviläinen, Lappeenranta University of Technology: Procurement in Project Management: Summary (2005)

12.1. RESEARCH CONTRIBUTION

Constructive research[311] requires the creation of an innovative, purposeful construct for a specified problem. The construct must yield utility for the specified problem, and making thorough evaluation of the construct is crucial. Novelty is similarly crucial since the construct must be innovative, solving a previously unsolved problem or proving a better solution for a known problem. Research contributions can be divided to three separate classes: (1) totally new results, (2) supportive or enhanced results, and (3) inferior results or results falsifying earlier research.

The totally new result is the procurement software; the software is a novelty. It is a new construct, an integrated solution to procurement, procurement follow-up and data warehousing. The novelty and originality have been established with a literature and commercial research (described in Section 1.2.). It increases the efficiency of the procurement function compared to the combined use of office programs. The use of the software provides direct and indirect savings, as described in Section 10.4 and in the subsection "Procurement Software" in Chapter 11.

The enhanced results comprise the developed procurement framework and project manuals. The enhanced procurement framework gives a more precise picture of the procurement function and follow-up of procurement in project environments. It supports findings in EPC projects, particularly in managing the uncertainty of item specifications. The rewriting of the project manuals updated the *Project Management Manual* and the *Procurement Manual* on the current level. These manuals widely considered to describe industry level best practices in project management and procurement in project environments.

No falsifying results were noticed. I did not find any inferior or falsifying results, although the software building process woke up my interest. Because of the differences of software development according to design science approach in the literature and my own 20-year industrial experience, I will make a proposition for future research (Section 12.3.)

12.2. APPLICABILITY AND LIMITATIONS

The applicability of the research results should be considered and the limitations should be studied. This would show the usefulness and importance of the results. Wider applicability would indicate more important research. The applicability and the limitations of the research results can be studied at least on two possible levels: general and construct-specific level.

General Applicability and Limitations

The topic is studied from the viewpoint of an engineering and consultancy company at Pöyry Oyj. This means that the research is heavily based on one company and their experience. This could be a severe shortcoming in the research, but the unit of the analysis was not a company, it was a project. Pöyry Oyj has implemented hundreds of industrial plant projects with many customers in every inhabited continent. Therefore, I suggest that the findings can be applied in any company in the same business.

The studied projects were all large-scale industrial plant projects, i.e. pulp mills, paper machines, power plants etc. All these projects involved a large amount of engineering and technical expertise in their implementation. The projects were carried out by fast tracking the project activities and

[311] Hevner, March, Park and Ram: Design Science in Information Systems Research (2004) MIS Quarterly, Vol. 28, No. 1, p. 82

involved concurrent engineering, which makes project management and procurement more complex. I assume that the project management and procurement in these projects is more difficult than in average projects. It must be remembered that an average pulp mill costs ca. 500 M€ (2005 estimate) and employs thousands of men and women during the project. Even the sheer sizes of the projects make them difficult to implement and manage. However, I assume that some parts of the procurement framework can be generalised to any large project which involves purchasing.

Construct-Specific Applicability and Limitations

The construct-specific applicability and limitation concerns the project manuals and the procurement software. They have quite similar applicability area and limitations, although it seems that the project manuals have a little stricter applicability area. The enhanced project manuals with their project methodologies are aimed to guide and support large industrial plant projects. I claim that they can be applied in any company in the same business; some parts, I suppose, can be utilised in any EPC – project, i.e. involving engineering, procurement and construction.

Because the software has in-built flexibility to match varying project environments, I regard that it is a relatively safe generalisation to assume that it could be used in other engineering and consultancy companies for procurement. Particularly, I regard that companies managing large industrial plant projects could use the procurement software. These companies would also be able to understand and manage procurement in project environments.

The procurement software is designed for industrial plant projects. It might operate outside its original environment but considerable data flow would be needed to justify the use of the software. For small projects, a pen and a telephone would form quite an adequate information system for procurement. In other words, large data flow is a prerequisite for the benefits of the procurement software.

The software has limitations, but it could be used in some cases outside its original scope of procurement. As a workflow-specific application, it is able to handle the procurement flow, but nothing more. The procurement, document flow management and schedule follow-up cannot be used in any other way than designed. The other severe limitation is that there is no automated schedule comparison towards anything else than the procurement process. Although it is possible to use the schedule comparison features manually, it is not recommended. The use of any scheduling program will be much more efficient and convenient.

The workload-based progress estimation (feature of the software) is designed for the procurement workflow. The calculation method could be generalised and used for any process, whose progress is estimated by working hours. Even the created application is capable to do so, although some names of programs and fields would be very misleading. The software could estimate the total workload and needed hours to finish tasks. The estimation method is automated only if the working hours are reported and coded according to procurement tasks. If the data structures of working hour software and procurement flow differ, it is difficult to match the workload towards the procurement tasks. The provided interfaces were designed to solve some matching problems; the interfaces are able to target (1) several procurement tasks towards a single hour code, (2) an hour code towards many procurement tasks, and (3) several hour codes towards a single procurement task.

Comparison of tenders (feature of the software) is based on priced item structures. The calculation method could be used in any environment. It could be used manually with or without spread-sheet software. There are numerous applications able to use priced item structures, but they are used for different purposes and/or environments.

Data warehousing (feature of the software) is automated with procurement flow. Every tender and contract is automatically saved in the data warehouse. Data warehousing could be used manually to register company and cost information, if somebody is willing to do the work.

12.3. RECOMMENDATIONS

I would also like to give some recommendations based on my research. These recommendations can be divided roughly two groups: general recommendations and recommendations related to my research. The research-related recommendations comprise recommendations for practitioners and suggestions for further research, both discussed in their own subsection.

My only general recommendation is to motivate students to carry out their research swiftly, if nothing forces to interrupt the research. I made the mistake of suspending this work for several years. It was difficult and time-consuming to restart my research.

Recommendations to Practitioners

The procurement software and its follow-up can be used as they are. If somebody is planning to rebuild the procurement application, I recommend him to use modern application development tools with a graphical user interface, client/server networking, internet capabilities etc. I do not recommend direct copying of the data structure, only using it as a starting-point for the development of the new application.

Also, I would recommend preparing proper user documentation before the introduction of the software. Before beginning to use the software, I strongly recommend that the users be trained to use the software. The users have to be trained to utilise the software with the intended hardware in the right environment. Procurement tasks are not so simple that anyone can use the software efficiently without any training.

Suggestions for Further Research

In my research, I noticed a distinct difference between my empirical findings and the theoretical views towards software development. Design science research expects that software is developed by making selections between alternatives. In my entire 20-year IT career, I did not notice significant support to this view. The normal routine was that software requirements were discussed and decided with a customer, the software designer made the design for the software, and the software was programmed and tested by the IT company. Finally, the software was delivered to and accepted by the customer.

It is possible that my previous employers in ERP business (Tietonauha Oy, TietoEnator Oyj and Sentera Oyj) operate with an inferior business model, but it would be interesting to investigate if any software company or any branch of software business follows the approach suggested by design science research. It might be that the software development methods differ from branch to branch in IT business. I know that several development models are used in software business. It would be interesting to survey their distribution and applicability in the IT branches. It would also be challenge to attempt to figure out reasons behind the popularity of the development models.

ACKNOWLEDGMENTS

First, I would like to thank my former instructor, Professor Seppo Pitkänen. He guided my first steps in this research. He made me consider scientific research more carefully. He pointed out that research ought to be something else than a demanding engineering task.

I am indebted to my former employer, Pöyry Oyj, which gave a young employee the challenging task of programming procurement software. That task turned out to be the cornerstone for my research; my doctoral dissertation focuses on procurement in project environments, along with the knowledge I gained in programming the software. Particularly, I would like to thank my former supervisors Jorma Halmepuro and Veijo Vartiainen, who tried to guide their subordinate to the secrets of project management. I would also like to mention the help of Proha Oyj in my business survey. The discussions with Martti Aatola of Proha Oyj convinced me that the procurement software is still a novelty in 2006 and it does not have rivals in commercial project management software packages.

I am also deeply grateful to my instructor, Professor Tuomo Kässi. He encouraged me to improve my scientific skills. He emphasised especially the meaning of the research methods and the need of verification and validation in scientific research. Due to his project management background, most of the business processes and project management concepts were familiar to him and it was relatively easy to form common understanding in project management issues.

I acknowledge particularly the support of Professor Emeritus Pertti Järvinen. I think of him as the second instructor in my research and I am grateful of his invaluable support. He has provided advices, comments, and constructive criticism to improve this work. His insight and ideas were very helpful when I struggled to improve my dissertation. I highly appreciated his fast responses to my enhancements in the dissertation and his determination in guiding the writing process towards the publication. I would also like to mention his excellent book, *On Research Methods*. The book illustrates research methods and gives some first hand advice in conducting constructive research.

I would also like to thank my previewers, Professor Esa Jutila, Professor Emeritus Pentti Kerola and Professor Pekka Kess, who have guided my research. Thanks are particularly due to Professor Jutila for his support in developing this dissertation through its various versions.

Furthermore, I would like to thank my family. Without their support, I would not have been able to finish this doctoral dissertation. The work proved to be much larger and demanding than I had anticipated. I admit that my previous goal was more modest – my plan was to graduate as a Licentiate of Science. Sometimes it is beneficial to pursue top level goals, but most of the time the whole man suffers from the consequences.

Last, I would like to thank my son, Riku Vehviläinen. He has been my best source of motivation. With his understanding and the confidence of the two-year-old boy, he once declared to his grandmother: “Isästä tulee tohtoli.” I have not needed more motivation since.

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