Process oriented information management in construction

– Information systems supporting the work processes of project managers and project groups

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A thesis submitted in partial fulfilment of the requirements for the Degree of Doctor of Technology to be presented with due permission for public examination and criticism in the Kollegiesalen at the Royal Institute of Technology on the 14th of November, at 10.00 am.
Thanks Helena – my love – for all the support you have given me!
The construction industry is often accused of being fragmented and inefficient in nature due to the lack of continuity and repetitive behaviour in projects. For many years information technology has been put forward as a solution. But, despite the potentials, little gains have been harvested by the development of computerised information systems (IS). The overall aim of this research is to determine if a more accessible and clearly described housing development process could be enabled by an information system, which in itself, could improve both individual and project (group) performance. Two research questions are being put forward; first, will a process-oriented IS positively impact on the performance of project managers and in particular on the performance of project groups? Second, how important is a process-oriented information management process for the success of the IS? To answer these questions an action research approach with large influences of survey research has been adopted. The research consists of two phases; a process orientation within a large Swedish housing development company and a survey of project managers’ attitudes towards a new process-oriented IS also including a study of dependencies found among variables of information system success (ISS). To enable a verification of the success of the IS an assessment instrument – hypothesis model – for evaluating ISS was developed. The assessment instrument was built on DeLone and McLean’s (1992) ISS model and extended to include measures of information management process quality (process quality). The hypothesis model was then tested empirically with a questionnaire survey. A statistical test was also performed to test the hypothesised relationships of the augmented ISS model. In summarising the findings of the data analysis, it is evident that the new IS received unexpected support from the respondents. The findings also indicate that the collected and analysed data show support for numerous of the hypothesised relationships of ISS. Conclusions are drawn that confirm the presence of a process quality measure for assessing ISS. From a practitioner’s perspective, this research suggests a course of action for process oriented organisational development. It also indicates beneficiary use of a process focus in IS development.

**Abstract**

The construction industry is often accused of being fragmented and inefficient in nature due to the lack of continuity and repetitive behaviour in projects. For many years information technology has been put forward as a solution. But, despite the potentials, little gains have been harvested by the development of computerised information systems (IS). The overall aim of this research is to determine if a more accessible and clearly described housing development process could be enabled by an information system, which in itself, could improve both individual and project (group) performance. Two research questions are being put forward; first, will a process-oriented IS positively impact on the performance of project managers and in particular on the performance of project groups? Second, how important is a process-oriented information management process for the success of the IS? To answer these questions an action research approach with large influences of survey research has been adopted. The research consists of two phases; a process orientation within a large Swedish housing development company and a survey of project managers’ attitudes towards a new process-oriented IS also including a study of dependencies found among variables of information system success (ISS). To enable a verification of the success of the IS an assessment instrument – hypothesis model – for evaluating ISS was developed. The assessment instrument was built on DeLone and McLean’s (1992) ISS model and extended to include measures of information management process quality (process quality). The hypothesis model was then tested empirically with a questionnaire survey. A statistical test was also performed to test the hypothesised relationships of the augmented ISS model. In summarising the findings of the data analysis, it is evident that the new IS received unexpected support from the respondents. The findings also indicate that the collected and analysed data show support for numerous of the hypothesised relationships of ISS. Conclusions are drawn that confirm the presence of a process quality measure for assessing ISS. From a practitioner’s perspective, this research suggests a course of action for process oriented organisational development. It also indicates beneficiary use of a process focus in IS development.

**Keywords:** Process orientation, information system, information system success, information management, project management
The writing of this thesis has been a difficult, but a rewarding task. Especially difficult was having to change supervisors as a result of my first professor leaving his position at the Royal Institute of Technology in 2001. Regardless of this, the thesis work has given me a greater understanding of the importance of performing proper research as well as a deeper understanding of the complexities of housing development as a business process. This knowledge will hopefully help others in their future research and hopefully my own career years ahead.

There are many people who have supported me and contributed to the writing of this thesis, some directly, most of them indirectly. First, I would like to gratefully acknowledge the financial support of the Foundation for Strategic Research (SSF) and NCC AB, as co-sponsor, for this doctoral research project, which forms part of the Swedish national graduate school and research programme, Competitive Building. I wish also to acknowledge Örjan Wikforss, Professor in Construction IT, and Brian Atkin, former Professor in Construction Management and Economics, at the Royal Institute of Technology in Stockholm, for the supervision of this research project.

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Stockholm, May 2003

Christian Lindfors
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## Abbreviations and definitions

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<tr>
<td>BPR</td>
<td>Business Process Reengineering</td>
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<tr>
<td>Building cost</td>
<td>The cost for construction work including: connection costs for electricity and district heating; costs for landscaping and lot fitting; costs for basic preparations and basic planning; costs for streets, roads and civil works on the block grounds; and construction management costs that can be related to these posts (SCB 2002a).</td>
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<td>CPI</td>
<td>The Consumer Price Index is compiled monthly and covers the consumption of the entire population of the Swedish country. The weights and the sample of items are updated at the beginning of each year. The weights for the major groups are based on the Swedish National Accounts statistics (SCB 2002b).</td>
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<td>DSM</td>
<td>Dependency Structure Matrix</td>
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<td>IDEF</td>
<td>ICAM (Integrated Computer-Aided Manufacturing) Definition Method or Integrated Definition Method</td>
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<td>IS</td>
<td>Information System</td>
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<td>ISO</td>
<td>International Organization for Standardization</td>
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<td>ISS</td>
<td>Information System Success</td>
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<td>ISSM</td>
<td>Information System Success Model</td>
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<td>IT</td>
<td>Information Technology</td>
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<td>ITC</td>
<td>Information Technology in Construction</td>
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<td>KM</td>
<td>Knowledge Management</td>
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<td>OSTN</td>
<td>Object State Transition Network</td>
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<td>PDS</td>
<td>The developers name for the new process oriented IS</td>
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<td>PM</td>
<td>Project Manager</td>
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<tr>
<td>Process</td>
<td>In this work, the term process is any activity or structured</td>
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set of activities that takes one or more inputs and together with additional resources creates a specific and valuable output to a customer or stakeholder.

**Process orientation**

In this work, the term process orientation is not used to describe the work of streamlining cost estimation activities, or purchasing activities, but the overall housing development process. Thus, a process orientated organisation, as described in this thesis, emphasises a process oriented way of thinking by focusing on its core processes as opposed to hierarchies.

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<td>QFD</td>
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<td>SCM</td>
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<td>TPC</td>
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1. Background to the research

The construction sector is experiencing major and radical changes. These have been forced upon it by external factors such as shifting social patterns, internationalisation, growing environmental awareness, rapid development of the information technology (IT) sector, increasing national as well as international competition and more knowledgeable and demanding customers. In response to these circumstances, national governments, industry bodies and individual companies are looking for ways of raising quality and long-term performance of the completed product, lowering costs and shortening project times (DETR 1998; BKD 2000). Much has been written and said about the fragmented and inefficient nature of the sector and concern prevails that it is cost driven. Moreover, too many decisions are taken on the basis of lowest cost instead of quality, safety, the environment and the intended use of the built product. The research and business communities lay some of the blame on the sector’s actors, who are seen to adopt a short-term interest in buildings they create, and are agreed upon a lack of integration in the building value chain\(^1\). Furthermore, it is said that the construction sector fails to understand the needs of its customers and how to translate their needs effectively into products.

Even so, it is not unusual for overall success to be achieved on individual projects, though too few results seem capable of being reproduced elsewhere on a continuous basis. It has been claimed that construction project processes usually present non-routine features that do not easily lend themselves to systematic repetition (Gann and Salter 2000). Whilst there is little point in stating that construction has

\(^1\) A firm’s value chain is a collection of activities that are performed to design, produce, market, deliver and support its products (Porter 1985).
its own specific challenges – since this applies for all industries – it is still important to bear in mind that the sector has its particular characteristics. Models created to achieve improvements in other industrial sectors are not likely to be successfully applied to construction without a certain degree of modification. However, the prevailing confusion between the process of delivery and the end product could be seen as one of the key failings of the construction sector. Even though the nature of construction makes it anything but a trivial affair, creating unique architecture and engineering solutions does not necessarily have to be accompanied by unique procedures to achieve it.

One proposed solution – and the one investigated in this thesis – is the implementation of a process orientation in housing development. By using the term ‘process orientation’ it is implied that a company is managing\(^2\) (controlling, directing and handling) work along the entire value chain of a building project, with the participation of different actors and trades. In this work, the term process orientation is not used to describe the work of streamlining cost estimation activities, or purchasing activities, but the overall housing development process. Thus, a process oriented organisation, as described in this thesis, emphasises a process oriented way of thinking by focusing on its core processes as opposed to hierarchies.

The belief that the construction sector might have something to learn from technological advancement and innovative management practices taken from manufacturing industry has gained currency during the past few years. In particular, the philosophy of process orientation has been recognised as solution to the problems of the sector by advocates of a modern and customer-focused sector. Although calls for the sector to adopt practices from manufacturing are hardly new, the last decade has seen a growing academic interest in the implementation of process principles to construction (Koskela 1992; Akintoye 1995; Barlow 1996; Kagioglou et al. 1998; Koskela 2000). A common belief is also that IT is best used in specialist fields such as architectural drawing, cost estimating, purchasing, scheduling and so on. Until recently, IT has been seen as a driver for the development of many construction organisations and operational processes (Aouad et al. 1999). This has, in many cases, led to a backlash against information issues in general, largely from an over-confidence in the technologies themselves rather than as enablers of major improvement.

Problems tend to arise when introducing new IT solutions, resulting in rising costs instead of cost reductions. Without process knowledge the use of information

\(^2\) More about the concept of management can be found in Lindfors (2001b).
systems (IS) to improve efficiency will continue to fail. However, this may be about to change as business and work processes are seen as offering competitive advantage, with the focus shifting to how IT can support business and work processes (ODell and Grayson 1998; Aouad et al. 1999; Maguire 2000). A focus on processes, or collections of tasks and activities that together transform inputs to outputs, is important for organisations wishing to view and manage materials, information, and people in a more integrated way (Garvin 1998). As a consequence of this desire, information and communication flows become all the more important from a control perspective. Delivering or collecting the right information at the right place and at the right time can increase organisational efficiency. These new demands and needs necessitate an improved, more clearly defined, transparent and accessible building process in order to improve knowledge management and to stimulate development within and between organisations. Being able to perform these changes and stay one step ahead of the competition is necessary in order to remain profitable and take care of customer demands.

In connection with this growing interest in process principles and ISs, which are focused in support of actual work processes, NCC Housing (a large Swedish housing developer) launched an initiative aimed at mapping its internal work processes. This thesis describes the actions taken within the company and reports on the findings. The underlying study adopted had the aim of determining whether or not even a modest attempt to make the housing development process (from idea to occupation) more accessible and better defined could bring real and immediate benefits for the company, as well as increasing the understanding of process issues in the sector and scientific community. More specifically, the study describes the definition, implementation and development of processes along with the development of a collaborative IS, or rather, the development of an assessment instrument enabling an evaluation of IS success.

1.2 Research problem/question and hypothesis

As mentioned earlier the fragmented and inefficient nature of the building process is a common concern within and outside the construction sector. Yet, little effort has been put into improving the situation. Consequently, an area that should be addressed is that of ensuring continuity in the building process through the establishment of a coherent representation of the entire process. Furthermore, an aim

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3) NCC Housing is a business unit within NCC Construction Sweden AB. NCC Construction Sweden AB is the umbrella organisation for the NCC Group’s Swedish operations. The NCC Group is an € multi-billion construction corporation, primarily located in the Nordic region.
should be to explore how IT can be utilised to improve the information process along the entire building value chain. These two areas have been recognised as primary research areas within the IT in construction (ITC) community (Björk 1999). An area of special interest within this context is proper hypothesis testing concerning the effects of a process orientation on particular categories of IT tools (Ibid.).

When it comes to evaluating the benefits of such research both ISs and processes have repeatedly been considered as independent processes without any apparent connections (Aouad et al. 1999). Seltsikas (2001) states that when consulting the literature the lack of in-depth examples of the relationship between ISs and holistic process approaches are predominant. Alter (1999) also points out what he calls the Siamese twin problem, that is, the lack of integration between work systems and ISs (see figure 1).

Figure 1: The relationships between work system, IS and information management process

The research problem, in a narrower context, is that there is a lack of continuity (repetitive behaviour) in housing development. From this stated research problem two related research questions are put forward. The comprehensive research questions for this study are formulated as:

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4) The work system is the physical system supporting the work process.
5) This particular problem has also been claimed by research in organisational development, information systems research as well as in ITC research (Björk 1999; Aouad et al. 1999, Alter 1999; Seltsikas 2001).
1. Will a process oriented information system positively impact on the performance of project managers and in particular on the performance of project groups?

2. How important is a process oriented information management process for the success of the information system?

In reading these two research questions, seven words or expressions have to be discussed to clarify the intended meanings of the questions overall. First, there is the process, which is defined as \(\text{any activity or structured set of activities that takes one or more inputs and together with additional resources creates a specific and valuable output to a customer or stakeholder.}\) More precisely, the process under study in this research is the housing development process\(^6\). Second, there is process orientation, which is a generic concept of management philosophies using a comprehensive process view for improving organisational performance. A major issue in process orientation is a high interoperability between individuals in the value chain of a product or service.

Third, we have information system, which Samuelsson et al. (1977) define as “…that combination of human and computer-based capital resources which results in the collection, storage, retrieval, communication, and use of data for the purpose of efficient management (planning, decision-making, reporting and control) of operations in organisations.” Thus, a system is made up of a combination of technology, information, process and individuals. The fourth expression is project manager\(^7\) performance, which deals with issues concerning how the use of the IS impacts on a project manager’s (PM’s) individual performance. The fifth term is project group performance, which deals with issues concerning how the use of the IS impacts on the project group’s performance. The penultimate term is information management process, which is defined by Abecker et al. (1998) as the process of developing, acquiring, identifying, preserving, utilising and disseminating information.

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\(^6\) The process being studied is performed according to NCC Housing’s total package concept (TPC). The housing developer’s TPC covers the process from project idea and acquisition of landed property to product delivery and post occupational commitments and services. Thus, it covers the whole work (information) process including many different professionals such as surveying, design, cost estimation, purchasing, sales, project management and so forth.

\(^7\) A Project Manager at NCC Housing is financially responsible for the development and execution of housing development projects. For the execution, specialists such as project engineers, surveyors, sales representatives, cost estimators, purchasers and consultants support the Project Manager.

\(^8\) Performance is defined as: \text{“the act of performing; executing, accomplishment, fulfilment, etc. (WN-WCD 1997).”}
Finally, the term information system success is mentioned, which refers to a set of interdependent dimensions of ISs, which contribute to information systems success. This research particularly claims a positive relationship between measures of information management process qualities (process quality) and user satisfaction/system use in ISs. From this it is hypothesised that, based on DeLone and McLean’s (1992) information system success model⁹ (ISSM), system quality, process quality and information quality singularly and jointly affect both system use and user satisfaction. Also, the amount of system use, positively or negatively, affects the degree of user satisfaction and vice versa. System use and user satisfaction directly affect individual impact, which in turn is expected to have a positive impact on the project (workgroup)¹⁰. From these definitions and explanations the following chapters will try to answer the above-stated research questions and try to find support for the hypothesised relationships.

1.3 Justification of research from an industrial perspective

The lack of repetitive behaviour and the lack of interoperability in projects, as mentioned in the earlier sections, are huge problems for the sector. The construction sector is a project-based industry meaning that its core business is in managing projects. The profitability for construction companies is therefore solely dependent on how well projects are performing. Thus, ways of improving the project performance ultimately lead to large improvements in the sector in terms of cost, time and quality. In recent years alarming news has come in the form of large increases in construction defects, individuals suffering from stress and increased building costs. Today, approximately 5% of the cost of building is related to construction defects and poorly performed work (BKD 2000). This directly increases building costs and decreases quality. Since 1996, building costs (total production cost minus land cost) for multi-dwelling buildings has increased by 65% (CPI= 1.4% /inflation rate = 7%)¹¹ and for single-family homes by 53%. Only in the last year has building cost increased by 9% for multi-dwelling buildings and 7% for single-family homes (SCB 2002a). This alarming increase in building costs has forced companies to adopt new strategies in attempts to cut costs. Work-related stress among PMs has also increased by approximately 20%, from already high averages, over the past two years (NCC 2002c).

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⁹ For further reading see chapter 6.

¹⁰ See chapter 2, for more detail.

¹¹ The Consumer Price Index during the same time period increased with 1.4% and the inflation rate increased with 7% during the same time period (SCB 2002b).
Two ways of tackling these industrial problems are a process orientation for housing development and the implementation of supporting ISs. An efficient information process, together with an efficient information management process, will decrease work-related stress for PMs as well as coordinating and improving interoperability in housing development projects. This will ultimately lead to decreased defects and time, and will thus reduce building cost. In the U.S., according to Strassmann (1999), the average cost of information management is 21% of a company’s total revenue. Strassmann defines the cost of information management as the sum of sales, general, administrative plus research and development expenses, i.e. expenses in the process of managing, planning, promoting and coordinating organisations for the purpose of effective delivery of goods and services. In the case of the housing developer under study, with an overall information management cost of approximately 25% of the total revenue, this would equate to approximately €59 million on its €235 million revenue (€1 = SEK 9.35 is used). There is clearly the potential for significant improvement. If it were possible to reduce the annual information management cost by 12-13% this would mean a profit increase for the housing developer of €7-7.6 million – more than double its present profit level. For the construction sector it is not a question of why, it is more a question of how for survival. The application of tools and techniques such as process modelling has large potential for the sector; that is, showing how the process can be better understood and how it can be better organised and managed. Even a marginal improvement in the activities that constitute the building process justifies the research, whose results could have dramatic impact on productivity, profitability and the economic vitality of the sector.

1.4 Aim and objectives
The overall aim of this research is to determine if a more accessible and clearly described housing development process could be enabled by an IS, which in itself, could improve both individual and project (group) performance. More specifically, the research aims to identify, define and recommend improved processes for a housing development organisation through a novel IS. It also aims to explore the concept of process orientation and information system success (ISS) and the different categories of research being conducted in the subject areas. Dependencies among objectives within the research are shown in figure 2. The relationships between these objectives and the different research stages are also shown. The different research stages shown in figure 2 are more thoroughly described in chapter 2.
There are five objectives for the research:

1. To identify and define activities and events that constitute the housing development process, so that deficiencies in the flow of information and resources can be highlighted and excluded.
2. To propose an improved housing development process and instantiate it in every day work, by developing an information system that visualises correct work procedures in a process-oriented manner.
3. To establish measures, in an assessment instrument, that will reveal the various dimensions of information system success, including qualities of the information management process.
4. To evaluate how project managers using the information system perceive information system success.
5. To explore the relationships, based on the evaluation, between the derived process qualities and the dimensions of information system success enabling a validation and enhancement of the assessment instrument.

Figure 2: Schema of dependencies among the research objectives

1.5 Methodological overview
This section provides an overview of the research methodology: chapter 2 describes and justifies this methodology in more detail. The research uses both a qualitative and a quantitative approach in an attempt to grasp as many perspectives of the research problem/questions as possible. Action research was adopted, due to the researcher’s close collaboration and high involvement with the subject company. This allowed an agile research process to be utilised, applying parts of survey or case study research techniques when required. The early (planning) parts of the research included a review of company specific documentation,
unstructured and semi-structured interviews and focus group sessions with key individuals, a questionnaire survey and model building. The result of the combined actions was an *as-is* process model of the housing development process.

Actions were then taken to improve the *as-is* conditions\(^{12}\) including an extensive literature review, focus group sessions, workshops and the development of a supporting IS. With the knowledge collected from the literature review an extensive development effort was designed and performed, resulting in an improved housing development process. Whilst the IS was being implemented in the organisation a complementary literature review was undertaken. The literature review was generally aimed at gathering information on how to evaluate the success of the newly created IS and process. This review resulted in the development of a testable research hypothesis\(^{13}\) and an assessment instrument based on the existing ISSM (DeLone and McLean 1992). Hypothesis testing was chosen as it has been declared an area of special interest in the ITC community as a consequence of too many self-evaluated (i.e. researcher-evaluated) prototypes (Björk 1999).

The later part of the research followed a survey course of action and included an assessment of whether the IS was perceived useful by its users. A statistical test was also performed to test the hypothesised relationships of the augmented ISSM. A questionnaire was developed to test the hypothesis model empirically. The choice of a questionnaire was also to allow a comparative analysis with other surveys conducted to test empirically the relationships in the ISSM (Seddon and Kiew 1996; McGill et al. 2000a; McGill et al. 2000b; DeLone and McLean 2001). The sample was chosen to reflect a homogenous group of individuals inside a company, namely PMs. A Likert-scale was used as this has been found to communicate interval properties of attitude patterns, thereby enabling valuable hypothesis testing (Oppenheim 1992). Before distributing the questionnaire to the intended recipients a pilot test of the questionnaire was performed focusing on the issues of instrument clarity and question wording. This in turn led to a number of important enhancements being built-in into the final version of the questionnaire.

Finally, data were collected using the questionnaire. This stage adopted a more quantitative approach, using statistical analysis, to test the hypothesised relationships and the reliability of the questionnaire. In order to test the internal reliability

\(^{12}\) Creating a *to-be* housing development process.

\(^{13}\) The augmented information system success model, aside from the relationships in DeLone and McLean’s (1992) information system success model, claims positive relationships between process quality and user satisfaction/system use in information systems, and between individual impact and project (group) impact.
of the questionnaire, Cronbach’s alpha method was applied. As the number of
respondents was limited to fifteen PMs it was decided to test the results using a
correlation coefficient analysis. In summarising the findings of the data analysis, it
was evident that the new IS showed unexpected support from the respondents.
Also, the data indicate that the process quality measure has a large impact on both
user satisfaction and individual impact as well as on project (workgroup) impact.
Thus, the result is an evaluation of PM attitudes against a process-oriented IS and
an augmented ISSM.

1.6 Delimitations of scope and key assumptions

The scope of this research includes the concepts of process orientation and ISs in
the construction sector in order to improve project performance. The process un-
der study is that of a housing developer. A key feature of the research is the focus on
the whole works system (information process) for housing development projects.
Thus, when using the term ‘process’ in the thesis, it implies the whole information
process, i.e. activities transforming information, communication and documentation.
The questionnaire survey is restricted to investigating PMs’ opinions. A limitation is
the use of the word information\(^\text{14}\). Since respondents are not able to distinguish easily
between information and data, the word information, which is well established in the
construction sector, is used in dialogue and discussion. Information is therefore used
both for data and information in the questionnaire, whereas knowledge is distinctly
understood as learned information.

1.7 Thesis structure

The thesis is structured into nine chapters, which relate to the several research
objectives and the adopted research design. This first chapter laid the founda-
tions and summarised the key achievements of this thesis. It included an intro-
duction, which, in addition to listing five research objectives, has also described the
background, research problem and research questions. This chapter also included
a justification of the research from an industrial perspective and a brief description
of the methodology. Finally, limitations in scope and key assumptions were
outlined.

chapter 2 provides a wider theoretical explanation of the proposed methodolo-
y with reference to the different parent disciplines, research strategies and re-
search methods. The research design is described and the techniques used are jus-

\(^{14}\) For more about this issue see chapter 6 in which the matter regarding the use of the terms
data, information and knowledge within the construction sector is clarified.
CHAPTER 3 describes the identification and definition of the housing development process at NCC Housing. Different process modelling techniques are reviewed for the purpose of identifying and describing the housing development process. A cognitive process is described where the researcher takes part in the identification and capture of the different perspectives of the process using different forms of interactions with process participants. The result is presented as an as-is process model of the housing development process from project idea and acquisition of landed property to product delivery and post occupational commitments and services.

CHAPTER 4 evaluates the current understanding of the concept of process orientation and highlights different philosophies found in the management field using a process approach to organisational development. The eight management principles of the ISO family are then used to describe the key activities for a successful implementation of a process orientation. In the light of the described key activities, and the earlier described as-is housing development process, the cognitive process of developing the to-be housing development process at NCC Housing is described.

CHAPTER 5 discusses the importance of IT as an enabler in the instantiation of a process description. Based on this knowledge, and the to-be process, the development of a process-oriented IS is described and, finally, the IS itself.

CHAPTER 6 draws from the wide literature on operational research, construction IT research and ISs research in order to propose an assessment instrument for measuring IS success. Consideration is given to the information process, the entities of data, information, knowledge and ISs in general. Particular attention is given to DeLone and McLean’s ISSM, which is extended by a seventh measure of information management process quality.

CHAPTER 7 presents the final design and performance of a questionnaire survey, using the extended ISSM, evaluating the success of the developed process-oriented IS. Consideration is given to the sample population, attitudes, scales and question formulation. Particular attention is given to the pilot-study, data collection, statistical analysis and presentation of the results.

CHAPTER 8 discusses the main findings arising from the questionnaire survey with reference to the hypotheses established for the research. The discussion covers the descriptive statistics and the testing of 11 hypotheses. Special attention is given to supported relationships provided by correlation analysis.
CHAPTER 9 presents the key conclusions and implications of the results of the research. Particular attention is given to conclusions about the research problem, research questions, fulfilment of the research objectives and hypotheses, implications for theory and implications for policy and practice. Finally, limitations in the research are discussed and recommendations are made for future work.
2. Research design and methodology

2.1 Introduction
Research is the methodological procedure for satisfying human curiosity (Beach and Alvager 1992). Research is considered as a voyage of discovery, contributing to knowledge and evoking new learning, which depends on the methods and techniques chosen and the subjects being studied. Simply finding out what one does not already know is far from real research. It is about systematic enquiry, looking for relationships, comparisons, predictions and generalisations (Wing et al. 1998). A prerequisite for performing research is methodology. The objectives of methodology – ‘the study of scientific methods’ – are to improve the procedures and approaches employed in the conduct of scientific research (Ackoff et al. 1962). Here, scientific method refers to the procedure of selecting appropriate techniques for a research project, that is, to evaluate alternative courses of scientific action (Ibid.). This chapter will briefly deal with some of the aspects of research disciplines, research strategies and research methods. Finally, an applied research design will be described and some conclusions made on methodological issues.

2.2 Parent research disciplines/fields
The parent research discipline covered by this thesis is that of construction management. The idea of construction management as a discipline of its own based on a theory or a science, or a grouping of already established disciplines, has been discussed in the construction management community (see for example Seymour et al. 1997; Raftery et al. 1997; Runeson 1997; Wing et al. 1998; Harriss 1998, Love et al. 2002). According to Love et al. (2001) construction management is a multi-disciplinary field of research, which draws heavily on already established theories that have been developed in other disciplines. The majority of the academics, involved in the debate, also take this stance. The discussion has been
concerned with appropriate research strategies when conducting construction management research.

One side advocates the abandonment of 'rationalistic' quantitative research (Seymour et al. 1997) and argues in favour of 'interpretive' qualitative research. The other side however advocates a more pragmatic approach by defining the problem and then applying the most appropriate design of the research method (Raftery et al. 1997; Runeson 1997; Wing et al. 1998, Love et al. 2001). Wing et al. 1998 suggest that “the way forward for the construction management field is through methodological pluralism and paradigm diversity which can be characterised by a range of researchers choosing to investigate problems from a range of paradigms using strategies (qualitative or quantitative) designed to investigate those problems.” This thesis tends to support the view that it is difficult to accept a single research method and a single research discipline to all problems in construction management research. Most of the substance in this thesis therefore originates outside the field of construction management. A special focus is applied to operations management research, ITC research and information systems research.

2.3 Research strategies

Instead of examining theory and data, the two different research strategies (qualitative and quantitative) mentioned earlier, focus on collection of data (Fellows and Liu 1997). Simply stated, a qualitative researcher works with few variables and many cases, whereas a qualitative researcher relies on a few cases and many variables (Creswell 1998). This study makes use of a combination of the two. The following paragraphs briefly explain the difference between qualitative and quantitative research.

2.3.1 Qualitative research

Some established characteristics of qualitative research are that it is performed in a natural setting (field focused), the analysis of data is performed inductively with attention to particulars and that it focuses on participants’ perspectives, i.e. their meaning (Creswell 1998). The qualitative approach seeks to gain insight and understanding of people’s perceptions of their surrounding environments (Fellows and Liu 1997). Creswell (1998) states “qualitative research is an inquiry process of understanding based on methodological traditions of inquiry that explore a social or human problem.” Qualitative research often starts with the research question of how or what to a certain topic describing what is going on (Ibid.) The information gathered in qualitative research can be divided into exploratory and attitudinal research (Naoum 1998). Exploratory research is used when you have limited
amount of knowledge about a topic, i.e. diagnosing a situation, screening alternatives and discovering new ideas (Naoum 1998). One typical feature for exploratory research is that you find a research question and not a hypothesis (Creswell 1998). The results from these are a description of what people have said or what has been observed. Attitudinal research however is subjectively used to evaluate perceptions and attitudes of a person or a group towards a particular item (Naoum 1998). The objective of qualitative research is thus, without prior formulation, to collect information and data to gain understanding so that explanation can be made and theories created. Thus, qualitative research can be a precursor to quantitative research (Fellows and Liu 1997).

2.3.2 Quantitative research
Creswell (1998) defines quantitative research as an enquiry into a social or human problem, based on testing a hypothesis or a theory composed of variables, measured with numbers, and analysed with statistical procedures, in order to determine whether the hypothesis or the theory holds true. Thus, the approach is to gather factual data and to study relationships between facts and look for relationships according with theories and previously published findings (Fellows and Liu 1997), making it suitable for a researcher wanting to find facts about concepts and their relationships. Grady (1998) defines quantitative research as a set of methods that are used to answer questions that ask ‘why?’ In contrast to qualitative research, quantitative research tends to look for comparisons of groups or relationships between variables trying to establish cause and effect (Ibid). In quantitative research, the hypothesis, research question and objectives can be better understood when they are grounded in a theoretical framework (Naoum 1998). Quantitative research is often chosen when a researcher wants to test a particular theory or hypothesis.

2.4 Research method(s)
Applying an appropriate research method(s) for a particular research project is dependent on the problem being solved or the questions being answered. What method to use, depends on the nature of the investigation and the type of information that is available or required (Naoum 1998). Wing et al. (1998) argue that “the research method used should be appropriate to the objectives of the research and the needs of the particular stage reached and hence the type of knowledge to be discovered.” When these choices have been made it is appropriate to think seriously about the techniques for collecting the data (Naoum 1998). The research community does not however always approve of the use of a particular method, even if the method is appropriate for the intended study. Approved methods are rooted in the philosophical supremacy of researchers. Philosophical supremacy refers to the
refusal of scientists to accept any knowledge founded in any alternative philosophy or science other than their own (Baskerville and Wood-Harper 1996). The reason why philosophical supremacy is brought up is the need to keep this in mind when choosing a particular research method or research design. The previously stated research questions and research objectives of this study indirectly point towards more specific methods for data collection. Derived from this are a number of research methods, which are evaluated for the appropriateness to the objectives of the research.

2.4.1 Evaluated research methods

The most commonly used research methods in construction research are surveys, cases studies, ethnographic research, experiments and action research (Fellows and Liu 1997). The choice of deciding on a governing research method is more thoroughly described in the following two paragraphs. The following is a brief description of these different research methods evaluated for the purpose of this research.

SURVEYS

Survey research is a method of collecting information from individuals, about themselves or about their social units, using various techniques from highly structured questionnaires to unstructured interviews (Forza 2002). Surveys are often used to gather data from a relatively large number of respondents within a limited time frame (Naoum 1998). This is perhaps one of the dominant forms of data collection in the social sciences. Within survey research a distinction is often made between descriptive, analytical and exploratory survey research. Exploratory research means, just as it implies, to explore a new phenomenon in the early stages of the research process. Analytical research however (or theory testing) takes place when knowledge of phenomena has been articulated in a theoretical form using well-defined concepts, models and propositions (Forza 2002). An analytical survey is appropriate for quantifiable data requiring statistical interpretation to gain its meaning (Beach and Alvager 1992). A descriptive survey is aimed at understanding the relevance of a particular occurrence and describing the distribution of the result in a population (Forza 2002). Survey research asks questions and is a method, which forces individuals to formulate opinions about these questions. Survey research was found appropriate for some parts of this research as it intends to measure attitudes of PMs based on a number of research questions.

CASE STUDIES

A case study is a traditional research method and one of several ways of performing research in social science and management. Yin (1994) defines a case study as “an
empirical inquiry that investigates a contemporary occurrence within real life context, especially when the boundaries between phenomenon and context are not clearly evident.” Thus, the objective is to immerse oneself in the situation and gain a holistic understanding of a phenomenon in its natural setting (a person, a group of people, and organisation or a particular project). Normally, only a few cases are studied and due to this the case researcher will typically try to uncover more variables of interest than data points (richness of detail). This may be considered as a strength of case study research, making it possible to uncover causal relationships.

Case studies can be divided into three types of categories, i.e. exploratory, descriptive and explanatory. Case studies employ a variety of data collection methods, but usually they employ interviews of key actors in the subject of the study (Fellows and Liu 1997). Descriptive and explanatory cases studies relate to the corresponding survey approaches except that they are applied on detailed case(s). The exploratory case studies however try to explain causality (proposition testing) and to show relationships among studied items (Naoum 1998). Case studies can be performed in combination with both ethnographic research and action research (Fellows and Liu 1997). A case study was also found appropriate for this research as it intends to investigate a group of people based on a number of questions.

**ETHNOGRAPHIC RESEARCH**

Ethnographic research originates from the social sciences by cultural anthropology through early 20th century anthropologists and their studies of comparative cultures (Creswell 1998). Ethnography is a form of research focusing on applying insights from social and cultural anthropology to the direct observations of socio-cultural phenomena. The term ethnography originates from the term ‘ethnocentrism’ that refers to the tendency of people in most cultures to think of their own culture as the most sensible (Harvey and Myers 1995). Good ethnographic research makes sense of beliefs, values and practices of natives in a closed society that were considered as absurd in other societies. Thus, a goal of ethnographic research is to improve understanding of human thought and action through interpretation of human actions in context. During the study the researcher ‘goes native’ by becoming part of the community under study to observe behaviour and statements in order to gain insight into what, how and why the patterns occur. Ethnography is a research method well suited to providing researchers with rich insights into the beliefs and values of human, social and organisational aspects of a socio-cultural phenomenon (Harvey and Myers 1995). The result of the method is, however, difficult to determine due to the uncertainty of the influence caused by the presence of the researcher and existence of the research project (Fellows and Liu 1997). For reasons of the uncertainties mentioned above and the need for the researcher in this study to interact and influence the community under study – more similar to action research – an ethnographic approach was rejected.
EXPERIMENTAL RESEARCH

Experimental research is the only method that can claim true ‘cause-and-effect’ and is associated with the traditional ‘scientific method’ (Ackoff et al. 1962). An experiment intentionally discovers a phenomenon from its context, so that attention can be focused on a few variables only. Typically, the context is ‘controlled’ by a laboratory environment (Yin 1994). In experimental research, the researcher deliberately manipulates an independent variable (cause) to see if it creates a change in the dependent variable (effect). Experiments are best suited to bound problems or issues in which the variables involved are known, or at least hypothesised with some confidence (Fellows And Liu 1997). Experimental research is divided into true experiments, quasi-experiments and pre-experimental design. True experiments are those that use a random assignment of subjects, whereas those that do not are called quasi-experiments (applied when using human subjects). Pre-experimental design is used when little control of the factors that could affect the outcome of a study is possible (no use of another group for comparison). Isaac and Michael (1981) identified the purpose of experimental research as investigating “possible cause-and-effect relationships by exposing one or more experimental groups to one or more treatment conditions and comparing the results to one or more control groups not receiving the treatment.” When these experiments are conducted in dynamic social environments and not in an isolated laboratory environment it becomes increasingly difficult to claim causality. A well-known example is the Hawthorne Experiment, which intended to investigate the relationship between illumination and productivity at the Western Electric Hawthorne Works (Mayo 1949). The Hawthorne Experiment showed how difficult it is to claim causality in dynamic environments. Due to this known limitation and also the consequence of the broad and comprehensive research questions, which preclude the use of a controlled, ‘bound’ study to examine the effect of changes in a dependent variable, the choice of an experimental approach was rejected.

ACTION RESEARCH

Action research is a research method that attempts to achieve both research and practical objectives by linking the concepts of theory and practice but also thinking and doing (Baskerville and Wood-Harper 1996). One distinguishing feature, unlike the methods of objectivist science, therefore is the active and deliberate self-involvement of the researcher in the context of the investigation (Altrichter et al. 2002). Argyris and Schön (1989) state that action research “builds descriptions and theories within the practice context itself, and tests them there through intervention experiments – that is, through experiments that bear the double burden of testing hypothesis and effecting some (putatively) desirable change in the situation.” Action research has dual aims, which are highly interlinked. One is to bring improvements through making changes in a problematic situation inside an organ-
isation and the other is to generate new knowledge and new insights as a result of those activities (Altrichter et al. 2002). "In action research the researcher reviews the current situation, identifies the problem, gets involved in introducing some changes to improve the situation and, in contrast to survey and case study research where the researcher tends not to interfere with that which is being studied, possibly, evaluates the effect of the changes (Naoum 1998)." Action research receives critique, which requires "action researchers to defend their method against the challenge that 'this is nothing but consultancy!' (Baskerville and Wood-Harper 1996)." This critique is considered in the following paragraphs, which brings up choices of method, considerations and critique of the chosen method.

2.4.2 **Research conditions and the researcher’s frame of reference**

The study was conducted at NCC Housing\(^\text{15}\), a large Swedish housing developer, a subsidiary in the NCC Group. Before joining the housing developer the researcher had acquired experience of the construction of multi-dwelling buildings, single-family homes, warehouses, schools and roads. While this study was ongoing, NCC Housing employed me (the researcher) as an industrial Ph.D. student\(^\text{16}\), assigned to coordinate the process orientation work being performed within the organisation. This new type of research arrangement in the construction sector, with the researcher occupying two positions, has raised some questions about objectivity and research quality in the academic community. However, this arrangement is becoming more frequently adopted for research that has a strong industrial relevance. During the study, the researcher was highly involved in the development work and could be viewed as a key participant in the improvement process, working closely together with others in the organisation to bring about change. At many points during this work, the researcher took on the role of moderator, directing and eliciting the participants’ different opinions towards one common goal.

2.4.3 **Choice of research method**

Based on the earlier sections of this chapter an appropriate research method was chosen. The choice of method depends on a judgement as to which method or technique(s) will best obtain the information needed in order to achieve the objectives of the study (Naoum 1998). The research method should be appropriate to the objectives of the research and the needs of the particular stage reached and, hence, the type of knowledge to be discovered. In this study the researcher’s high

\(^{15}\) NCC Housing is more thoroughly described in chapter 3.

\(^{16}\) An industrial Ph.D. student works at a company, whilst at the same time engaging in doctoral studies a university.
involvement with the studied organisation and the high pace of the development work made it difficult to choose a particular approach. Different approaches serve different functions in the knowledge discovery process (Wing et al. 1998). Therefore, consideration of both a qualitative and a quantitative approach was perceived to be equally useful for this research project.

Each research method described in the earlier section has its benefits and three out of five are applicable to some extent to the stated objectives. An analytical survey is very much appropriate when quantifiable data requires statistical interpretation to gain its meaning (Beach and Alvager 1992). For example, a descriptive survey is appropriate when trying to understand the relevance of a particular occurrence and describing the distribution of the result in a population (Forza 2002). Descriptive and analytical cases studies relate to the corresponding survey approaches except that they are applied on detailed case(s). But none of these methods, by themselves, cover the different needs for this entire study. Indeed, a combination of methods is often appropriate to make use of their different strengths (Moser and Kalton 1979). Action research is, however, a more general research method enabling a combination of the other two. “Action research therefore attempts to link theory and practice, thinking and doing, achieving both practical and research objectives” (Baskerville and Wood-Harper 1996).

The determining factor in choosing action research, as the principal research method for this study, was the researcher’s organisational commitments and conditions. The active and deliberate self-involvement of the researcher in the context of the study made an action research approach favourable. Naoum (1998) states that action research “is more attractive to practitioners, industrialists and students from professional backgrounds who have identified a problem during the course of their work to investigate and propose a change to improve the situation.” A problem arising from the use of a traditional research method would have been the unpredictability of the studied organisation (dynamic environment), demanding a flexible research process and the involvement of the people in the organisation being studied. Thus, action research allows the researcher to develop knowledge or understanding as a part of practice (Dick 1997). Action research is committed to seeking solutions to real-life problems, producing new knowledge and a discourse of theoretical insight (Altrichter et al. 2002).

ISs research plays an important role in this research, since an IS is being developed, used and then evaluated by users. Action research is a widely used research method in the ISs research community and is recognised as a suitable method among the collection of methods accepted by the discipline (McKay and Marshall 2001). It is
especially powerful as an instrument for researchers who are interested in finding out about the interplay between humans, technology, information and socio-cultural contexts (Ibid.). Baskerville and Wood-Harper (1996) state, “Action research is widely cited as an exemplar of post-positivist social scientific research method, ideally suited to the study of technology in its human context.” Thus, action research is well suited to gaining understanding of whether technology is perceived useful in a process context.

2.4.4 Critique and considerations of the chosen method

As mentioned earlier, action research is not excluded from weaknesses as a research method, nor is it without its critics. Consultancy and action research are easily confused, because of the researchers active involvement in the research process, making differentiation between the two somewhat difficult. To cover for any misunderstanding the action researcher has to apply dual perspectives of the work, one of the research problem being solved (consultancy) and the other of the research questions being answered (action research). These perspectives are easier displayed by the two cycles of action research described by McKay and Marshall (2001) (see figure 3).

Figure 3: The dual cycles of action research (McKay and Marshall 2001)

The criticisms that action research lacks scientific rigour and discipline, validity of data and that it is difficulty to generalise the results “have lead to it falling into disfavour in those academic circles which evaluate research according to scientific criteria” (McKay and Marshall 2001). Rapoport (1970) identified three dilemmas in action research: personal over-involvement with the research; the two taskmasters in social research (subject and science); and the practical pressures that interfere with the conduct of ‘a disinterested pursuit of knowledge’.
Baskerville and Wood-Harper (1996) states, "scientists, who employ other methods, even survey research, also know these three dilemmas. These are not peculiar to action research." Therefore, for credibility it is crucial that the action researcher rigorously plans methodological data collection methods and is able to claim validity of the data (Baskerville and Wood-Harper 1996). Adopting the dual perspectives of action research (see figure 4), deals with the criticism that action research is just like consultancy, as the second cycle looks at the research interest instead of the problem definition. This arguably facilitates the researcher in being more explicit about the reflection and learning process of action research and the results will show a high degree of scientific rigour, validity and support for generalisation. By thinking of both the problem-solving interest and the research interest, it is believed that much greater clarity will be ensured for both the researcher and the consumer of the research output (McKay and Marshall 2001).

![Figure 4: The action research framework (McKay and Marshall 2001)](image)

### 2.5 Applied research design

Deciding to use an action research approach makes the choices of techniques used of particular importance for the validity/generalisation of the result. A scientific technique refers to the way of accomplishing a scientific objective, a scientific course of action (Ackoff et al. 1962). The applied research design in this study takes its origin from the research questions and the defined research objectives.

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17) MPS and MR refer to the two methods (problem-solving and research) being employed, A refers to a real-world problem situation, P refers to the problem situation and F refers to the theoretical framework.
Previous sections in this chapter suggest that a multi-method action research approach is suitable for this kind of research. The following section will therefore follow the different stages (plan, action, implement, evaluate and reflect) of the action research cycle, describing the techniques used to achieve the stated objectives.

2.5.1 Planning the action to improve the as-is conditions (1999)

The first objective states: “to identify and define activities and events that constitute the housing development process, so that deficiencies in the flow of information and resources can be highlighted and excluded.” To accomplish this first objective, a definition and description of the as-is housing development process had to be created. The planning stage started with a review of descriptive company specific system documentation, which was performed to identify the generally accepted activities of the housing development process. The review was also performed to clarify the different existing control and support systems available within the organisation. This stage made beneficial use of individual views expressed by interviewees to capture as-is conditions and increase the researchers understanding of the process context. Understanding that a process model is less complicated than reality, and hence easier to use for research purposes (Ackoff et al. 1962), it was decided to formalise the process in a model. A review of process modelling techniques was then conducted and appropriate techniques chosen. To gather the information needed to support the formalisation of the process model, two matrices were developed, based on the earlier review of descriptive company specific system documentation. The matrices were then sent out to process actors and collected through a postal questionnaire. Based on the empirical data captured in the interviews and surveys an as-is process model of the housing development process was created.

2.5.2 Action taken to improve the as-is conditions (2000-2001)

The second objective states: “to propose an improved housing development process and instantiate it in everyday work, by developing an information system that visualises correct work procedures in a process-oriented manner.” To achieve this objective a thorough literature review was performed and an extensive development effort was carried out to improve the housing development process and a new, supporting, IS. As little was known about the concept of process orientation the researcher chose an exploratory approach. The literature review was summarised under the

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18) See chapter 3 for more details.
19) See chapter 4-5 for more details.
eight management principles of the ISO family to highlight similarities and to focus on the essentials of a process orientation task. The first effort was an eight-day workshop with cross-functional participation to clarify the essential dependencies between activities in the process. The workshop was also performed to clarify external and internal resources in the process activities. The result from the workshops was then simulated using a DSM algorithm to help the researcher generate a proper sequence of process activities.

With this in mind an extensive development effort was initiated within the subject company to develop a to-be housing development process. People in the organisation were assigned to focus groups and a development organisation structure was established. Over a period of 12 months of frequent focus group sessions a new process structure emerged. The result was a description of a work system describing the processes, inputs, outputs (record documents), control/support documentation (procedures, knowledge documents, checklists and templates) and resources (people and IT). Based on the process context an IS was developed, including the dimensions of activities, process phases, documentation, information, communication and participation by all project members. The IS was developed to serve as a process-oriented perspective of a single project for information and people. Thus, each project has its own temporary IS, which consists of its own information and is available for every one involved in the project. The natural owners of each of these are the PMs who control who is to be invited and for how long.

2.5.3 Implementation of the information system and constructing an assessment instrument for evaluating the information system success (2001-2002)

The third objective states: “to establish measures, in an assessment instrument, that will reveal the various dimensions of information system success, including qualities of the information management process.” To achieve this objective a thorough complementary literature review was performed, aimed at gathering information on how to evaluate the newly created IS and housing development process. Simultaneous with the literature review, the IS was implemented in the organisation. The implementation of the newly developed IS was preceded by a three-hour training course for employees. The training course provided a comprehensive description of the main functions and procedures of the IS. After completing the course, project accounts were opened in the IS for all new projects. Since little was known about

20) See chapter 5 for more details.
21) An account in the IS serves as a process-oriented perspective for information and people in a single project.
how successful the applied IS was and how it impacted on both individual and project performance, it was decided to adopt a theoretical framework to investigate the research interest. The need to combine both measures of ISs and process was also apparent, as in-depth examples of the relationship between ISs and holistic process approaches are predominantly lacking (Aouad et al. 1999; Alter 1999; Seltsikas 2001). It has also been recognised as primary research area within the ITC community (Björk 1999).

Consequently, a thorough literature review was performed, aimed at gathering information on how to evaluate the success of the newly created IS and process. After completing the review of literature, previous work relating to the proposed research interest was identified. The literature review revealed existing theoretical frameworks and clarified issues of importance. It was found that the ISSM developed by DeLone and McLean (1992) was the most cited, acknowledged and widely used assessment model within the ISs research community (Kennerly and Neely 1998; Garrity and Sanders 1998). The ISSM claim that system quality and information quality singularly and jointly affect both system use and user satisfaction. Also, the amount of system use – positively or negatively – affects the degree of user satisfaction and vice versa. System use and user satisfaction directly affect individual impact, which in turn should have some impact on the organisation.

Following a closer look at the model it became apparent that it lacked a measure to assess the qualities of the information management process and how it impacted on the project (group). The project impact variable is important from a construction perspective, because the construction sector is a project-based industry. Since the objective states the establishment of measures that will reveal the various qualities of the information management process, this variable had to be developed and added to the existing ISSM. Based on the literature review the dimension of process quality was developed, organising the measures according to an information (knowledge) management process framework Abecker et al. (1998). These two extensive literature reviews resulted in the development of a testable research hypothesis and assessment instrument based on the existing ISSM. DeLone and McLean’s ISSM was consequently augmented and updated to include the dimensions of process quality and project (group) impact (see figure 5).

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22) Integration between work systems and information systems.
23) Measures of information management process qualities.
24) Development, acquisition, identification, preservation, utilisation and dissemination of information (knowledge).
Hypothesis testing plays a central role in evaluating a theory (Ackoff et al. 1962). The hypotheses model, in this research, was developed to confirm or reject the specific statements, based on theory and predicted by the researcher, that constitutes IS success. Beach and Alvager (1992) state that “the principal advantage of a well thought out set of hypotheses is that it places clear and specific goals before the researcher and provides a basis for selecting research procedures to meet these goals.” As mentioned earlier, proper hypothesis testing was chosen as it has been declared as an area of special interest in the ITC community. The following relationships were stated and tested on 15 PMs within the subject company. It was hypothesised that:

\[ h_1 \]: Increases in system quality will lead to increases in system use.
\[ h_2 \]: Increases in system quality will lead to increases in user satisfaction.
\[ h_3 \]: Increases in process quality will lead to increases in system use.
\[ h_4 \]: Increases in process quality will lead to increases in user satisfaction.
\[ h_5 \]: Increases in information quality will lead to increases in system use.
\[ h_6 \]: Increases in information quality will lead to increases in user satisfaction.

In these hypotheses there are five variables: system quality includes measures of the information processing system itself; process quality includes measures of the information management process; information quality includes measures of IS output; system use includes measures of user consumption of the output of an IS; and user satisfaction includes measures of user response to the use of the output of an IS. These are, based on the order in the hypothesis model (figure 5), followed by four more hypotheses, which all correspond to the DeLone and McLean (1992) model, which are:
H7-H8: Increases in system use will lead to increases in user satisfaction (and vice versa).

H9: Increases in system use will lead to increases in individual impact.

H10: Increases in user satisfaction will lead to increases in individual impact.

In these four hypotheses there are three variables involved of which one is new. The variable individual impact measures the effect of information on the behaviour of the user. The last hypothesis slightly deviates from the DeLone and McLean (1992) model and states that:

H11: Increases in individual impact will lead to increases in project (group) impact.

In this last hypothesis there are two variables of which one is new. The variable of project (group) impact includes measures the effect of information on project (group) performance. The variable of organisational impact from the DeLone and McLean model has been renamed to project (group) impact in the new construct, to reflect the impact on the project organisation, which is of importance in a construction context. Thus, the augmented ISSM claims that the variables of system quality, process quality and information quality singularly and jointly affect both system use and user satisfaction. Also, the amount of system use – positively or negatively – affects the degree of user satisfaction and vice versa. System use and user satisfaction directly affect individual impact, which in turn should have some impact on the project (group).

2.5.4 Evaluating whether or not the information system is perceived as successful by the users in a process context (2002)

The fourth objective states: “to evaluate how project managers using the information system perceive information system success.” To achieve this objective a survey had to be designed and performed to evaluate whether or not the IS was perceived as successful by the users. Therefore, it was appropriate to adopt a research technique such as the use of questionnaires, interviews, attitude scales or rating scales (Oppenheim 1992). The choice of a questionnaire survey, to measure the attitudes of the PMs, was made because of the extensive use of questionnaires for measuring IS success (Lewis 1995; Seddon and Kiew 1996; Saarinen 1996; Ishman 1998; Coombs et al. 1999; McGill et al. 2000a(b); Leonard and Cronan 2001; Staples et al. 2002). The most widely used method in the field of ISs research is survey

25) The variables include 64 measures including totally 167 detailed questions (see chapter 6).
Consequently, a questionnaire survey was designed and carried out to measure the attitudes of the housing developer’s PMs towards the new IS and to test the research hypotheses’ model empirically. It was decided to investigate only PMs’ attitudes and to exclude other professionals for the purpose of homogeneity. The focus on obtaining data from one part of the total population, selecting human subjects from a narrow subculture\textsuperscript{26}, enabled the researcher to receive the best homogeneous results (capable of generalisation) possible from such a small sample (Tweney et al. 1981; Fellows and Liu 1997). The questionnaire was based on the previously developed hypotheses model, and whenever possible, pre-validated questions by other established instruments were adopted.

As it was attitudes that were going to be measured it was suitable to use attitude scaling, which is a well-established method in survey research (Oppenheim 1992). For this particular exercise, it was decided to adopt the Likert scaling method. A number of reasons account for the use of a Likert scale. First, it is one of the most common scales for obtaining attitudes from respondents’ giving them the opportunity to position their attitudes towards a statement on a scale (Fellows and Liu 1997). Second, this scale is probably the most relevant if one wishes to study attitude patterns or explore relationships of attitudes (Oppenheim 1992). The Likert scale used for this particular instrument rates the responses from strongly agree (7) to neither (4) to strongly disagree (1) with no verbal labels for scale points 2-3 and 5-6 (see figure 6). Five numerical rating scale questions were also included to capture quantitative measures for actual usage and perceived benefits in time and cost by using the IS.

\begin{table}[h]
\centering
\begin{tabular}{|l|l|l|l|l|l|}
\hline
Strongly agree & Neither & Strongly disagree \\
\hline
7 & 6 & 5 & 4 & 3 & 2 & 1 \\
\hline
\end{tabular}
\caption{The Likert-scale used in the research}
\end{table}

\textsuperscript{26} A prerequisite, to be included in the questionnaire survey, was for the project managers to have approximately one year of experience in using the information system (see chapter 7).
Question formulation\textsuperscript{27}, based on the choice of using the Likert scaling method, was then performed to create uniform, consistent and reliable questions. For validity reasons, as many questions as possible were derived from already established measurement instruments (Oppenheim 1992). The questions were also formulated not to provoke the respondents to switch on the autopilot, when filling out the questionnaire, by wording roughly one third of the questions negatively (Moser and Kalton 1979; Parasuraman et al. 1988). Before the final data collection a pilot study was performed on five staff members, focusing on the issues of construct clarity and question wording. The feedback from the pilot study led to a number of important enhancements to the final version of the questionnaire. The feedback also suggested including the housing developer’s annual system satisfaction index (SSI) measure, enabling a comparison between pre-implementation and post-implementation.

After the pilot work was completed, the adjusted questionnaire was distributed to the intended respondents. The pilot work also highlighted the problems of gaining a high response rate because of the large number of questions included in the questionnaire. It was therefore suggested that the researcher sat in when the respondent answered the questionnaire as a guard against not receiving any answers. The researcher, however, did not interact, intervene or influence the respondents’ answers in any way to secure objective results. After a brief introduction of the purpose of the questionnaire survey and some definitions of word use, the respondents were asked to indicate to what extent they agreed or disagreed with each statement (question). Thus, a subjective self-report of perceived job performance related to the IS was generated. The answers were then summarised and the data were entered into an SPSS database for analysis.

\textbf{2.5.5 Reflection on the evaluation results and hypotheses’ testing (2002)}

The fifth and final objective states: “to explore the relationships, based on the evaluation, between the derived process qualities and the dimensions of information system success enabling a validation and enhancement of the assessment instrument.” To achieve this objective and as a consequence of the duly performed questionnaire survey, a statistical analysis of the collected data was performed\textsuperscript{28}. The analysis was performed to reflect on the results of the evaluation and on the whole action research process. In action research the reflection phase is where new problems and

\textsuperscript{27} Questions extracted from theory and literature in support of the augmented information system success model (see chapter 6).

\textsuperscript{28} See Chapter 7 and 8 for more details.
questions may be identified and raised, hence instigating a new cycle of planning, acting, implementing, evaluating and reflecting (Swann 2002).

The descriptive analysis, from the questionnaire results, was presented as mean value (Mean) and standard deviation (S.D.). The need to present the number of responses for each question was rejected as the respondents left out no answers. In order to verify the internal reliability, of each of the IS success dimensions, a statistical reliability analysis was conducted using Cronbach’s $\alpha$ (internal consistency method). A questionnaire’s reliability is its ability to give a similar result when filled out by a homogenous group of people with similar values and attitudes (Kirakowski 1997) and an adequate reliability is a prerequisite to secure validity (Oppenheim 1992). Reliability relates to how well an instrument measures the content domain it is supposed or intended to measure, which makes reliability an essential condition (Liu and Fellows 1997). The reliability is theoretically expressed on a numerical scale between the minimum of 0 and the maximum of 1. The most agreed upon acceptance level is that of 0.70 and above (Staples et al. 2002; McGill et al. 2000b; McCormack 1999b), though in social and behavioural sciences reliabilities above 0.90 are very rare (Oppenheim 1992). An instrument, which is unreliable, cannot attain a sufficient degree of validity. To assure sufficient validity (content validity, concurrent validity and construct validity) a number of important considerations were taken during the development of this research.

When a hypothesis is involved, among the more commonly used statistical tests are mean or variance and correlation coefficients (Ackoff et al. 1962). Moser and Kalton (1979) also acknowledge correlation analysis as a proper approach when one wishes to establish the degree of association between pairs of variables in a sample from a population. Therefore, after making sure that the instrument’s internal reliability was acceptable, a statistical correlation test was performed, enabling the researcher either to confirm or reject the hypothesised relationships. A correlation is a quantitative relationship between two variables measured on an ordinal scale. In a correlation analysis, one generally wants to determine whether or not two variables are interdependent, i.e. if they vary together. The small sample population made many other statistical methods unfit for use. For example, factor analysis was rejected due to a rule of thumb saying that sample size needs to be larger than the amount of questions (Chen et al. 2000).

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29) The attitudinal responses on the individual questions were statistically analysed and tested using a Kendall’s $\tau$ correlation analysis (two-tailed). Kendall’s $\tau$ was chosen to avoid undesired effects, which can occur when using the Pearson’s $r$ to measure correlation between linear variables (Sverlinger 2000).
The test in this research was performed to determine whether or not the collected data sample was consistent with the hypothesised relationships of the augmented ISSM enabling a validation and enhancement of the model. Even though the hypotheses were directional a two-tailed significance test was performed to ensure a higher probability for the correlation result (Beach and Alvager 1992). Probability measures above 5%, which is the conventional level (Naoum 1998), were rejected and dismissed as not supporting the hypothesised relationships. Thus, a lower probability measure indicating that there is a significant relationship applicable to the collected data.

2.6 Conclusions

This chapter has considered a variety of issues concerning research design and methodology. Various strategies and methods have been considered, including qualitative and quantitative, survey research, case studies, ethnographic research, experimental research and action research. Then the applied research design was discussed and applied tests and techniques described. As this study falls under the discipline of construction management, which is not an agreed discipline of its own by the construction research community, most of the substance in this thesis is applied from other disciplines such as ITC, operations management and ISs research.

The emergence of industrial Ph.D. students has raised some questions about objectivity and research quality in the academic community. Concerns are directed towards the often practical and organisation directed focus of this kind of research. This makes it crucial for credibility, for this category of researchers, to plan methodological data collection methods rigorously in order to be able to claim validity of the data. This applies especially when an action research approach is taken. But this can provide useful insights, as problems do not often arise without opportunities being present.

An action research approach was selected, due to the parent research discipline, research questions, research conditions and the researcher’s frame of reference. This enabled the researcher to merge research and practice. Hence, it was important for the researcher to have dual aims, bringing improvement through making changes in a problematic situation and also by generating new knowledge and new insights as a result of research activities. The research method, techniques and tests were thus being chosen on the basis of appropriateness, i.e. to answer the research questions and to meet the objectives of the research. In the following chapters the

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30) Probability of a result being due to chance.
applied research design is described in more detail to explain their purpose and application to the study.
3. Identifying and defining the housing development process

3.1 Introduction
This study started in 1999 as a collaborative effort between NCC Housing, a large Swedish housing developer, and the Royal Institute of Technology. At the time of initiating the research, NCC Housing was a business unit within the NCC Group, a €multi-billion construction corporation located primarily in the Nordic region. The business unit is organised with a head office in Stockholm and four local regional offices (See figure 7). In 2001 the developer’s total revenue was approximately €235 million with a total number of 170 employees. A large reorganisation early in 2000s led to their internal production capability being fully outsourced to the internal contractor of the NCC Group.

Figure 7: The organisational chart of NCC Housing Sweden

In 1997, the housing developer was the first Swedish construction organisation to be awarded an ISO 9001 certificate. The same year the housing developer was ac-

\footnote{In 2002 NCC Housing was incorporated in NCC Construction Sweden AB. NCC Construction Sweden AB is the umbrella organisation for the NCC Group’s Swedish operations.}
quired by the NCC Group and consequently forced to use NCC’s operational control system. Before this, in 1996, the managers of the housing developer had decided to process-orient their operations and between 1996-1997 they introduced the total package concept\(^{32}\) (TPC), which was a first attempt to identify and define the housing development process. This work lost most of its momentum as a consequence of the merger with NCC. In the years between 1997 and 2000 multiple development efforts were performed simultaneously within the NCC Group as a consequence of the following vision:

NCC shall be the leading construction company in the Nordic region and the Baltic region when it comes to profitability and market share, and from this base develop strong international project organisations. NCC shall stand out as the leading construction and real estate company with respect to quality management, environmental management, efficiency/effectiveness and development capability on all markets where we operate. NCC shall be regarded as the young and exiting company where every ones fresh ideas, participation and competences are in focus.

The vision and the following strategy focused on quality management and environmental management and internal effectiveness/efficiency. Actions were thus taken to realise the strategy and after a period of two years the entire Swedish operations had been awarded with both an ISO 9001 (Quality Management) certificate and ISO 14001 (Environmental Management) certificate. NCC Housing was also the first unit within the NCC group to receive an ISO 14001 certificate. Even though large efforts had been taken to improve quality and environmental issues, the company was not harvesting large productivity gains. Instead of improving their operations the multiple attempts to create control systems and the later attempts to obtain ISO certifications had only made their operations even more bureaucratic. The vast number of initiatives had lost focus of simplicity, just adding new procedures instead of improving those existing. The numerous control and support systems inherited from the several improvement efforts and mergers were drowning the organisation in paperwork. The following sections will describe the initial actions to improve these conditions. Starting with the process identification and definition work within the subject company, starting with the aim and objectives followed by a thorough review of different modelling techniques. Finally, process modelling work is described and the conclusions that can be drawn from it.

\(^{32}\) Project development, product development, detailed design, production management, sales product delivery, customer commitments and customer services are the main phases of the total package concept.
This also highlights choices that had to be made and the difficulties that had to be overcome.

3.2 Process modelling aims and objectives

When the opportunity came in 1999 to start a research project the housing developer agreed to participate with resources. The research proposal was intended to pick up the thread of earlier process identification work and address the problems facing the sector by indicating how even a modest investment, in making the housing development process (from idea to occupation) more clearly described and more easily accessible, could bring real and immediate benefits. In this connection, the stress was on establishing a comprehensive view of processes that ordinarily are described and presented in fragments and manifest in a multiplicity of user domains. As a condition for the process orientation work to be carried through in an effective manner the management of the housing developer included it as an issue of strategic importance in its strategic plan. From this plan the following reasoning could be discerned as an answer to the need of more cost effective design and production.

The possibility to decrease lead time and at the same time increase quality is seen as a huge potential result from a process orientation. By a process orientation of the operations, possibilities are created to cut cost and at the same time decrease time consumption. A process orientation may create crucial advantages to us when it comes to project effectiveness/efficiency, i.e. increased customer focus, increased comprehensive view, increased value focus, more clear and rational flows, increased individual commitment from the personnel and an improved management of the whole organisation. The implementation of a supporting IS for projects (TPC) may also increase process understanding. The ability to access the right information, at the right place, at the right time creates a large potential for improved efficiency. An analysis of our core processes, may contribute to the efficiency, optimisation and development of our operations.

With this clearly stated view on the importance of process orientation, the aims and objectives of the process identification and definition had to be made explicit. The aims and objectives were clarified early to focus effort and resources. Issues such as aims, delimitations and objectives were established to make the implementation strategy clear. The aim was to reduce documentation by integrating the numerous control systems into one operation and management system. It was decided that the first objective, forming the study, was to identify and define the activities and events that constitute the housing development process, so that deficiencies in the
flow of information and resources could be highlighted and subsequently rectified. The initial identification was decided to concentrate on clarifying process activities, activity dependencies (inputs and outputs), process-related resources (personnel and IT-applications) and process related control and support documentation (procedures, knowledge documents, checklists, and templates). The developer’s preliminary total package concept (TPC) documentation was used as the starting point for this work.

3.3 A review of process modelling techniques

Before starting the identification and definition process a review was carried out to decide what modelling technique to use for systemising the gathered information. Using a modelling method was determined by the knowledge that using graphical modelling techniques for the creation of a process definition increases understanding and insight for the developer (Abeyesinghe and Urand 1999). “The simplicity of models, compared with reality, lies in the fact that only the relevant properties of reality are represented” (Ackoff et al. 1962). It was therefore important that the model was easy to understand, easy to change, easy to correct and above all represented the process correctly, unlike most process modelling methods, which tend to break the processes into its different parts using one primary dimension for analysis (Malone et al. 1999). The following section describes the different techniques that were considered to support the researcher in defining and structuring the housing development process, i.e. IDEF0, IDEF3, ActionWorkflow™, QFD, DSM and Stage gate.

3.3.1 IDEF0

Integrated Definition Method (IDEF0) was designed as a function modelling method. IDEF0 is a standardised method for developing structured graphical representations of a system or business (NIST 1993). It is designed to model decisions, actions, and activities of an organisation or system. The IDEF0 method was originally developed by the United States Air Force as the Structured Analysis and Design Technique (SADT), which was intended to be a function modelling method for the analysis and communication of a system from a functional perspective (Anon 2002). The IDEF0 box and arrow graphics show the activity as a box and the interfaces to or from the activity as arrows entering or exiting the box (see figure 8). The controls specify conditions required for the activity to produce the correct outputs. The mechanisms specify resources that support the execution of the activity, e.g. personnel and computer systems. Inputs are transformed by the activity to outputs, which are the result produced by the activity (Lindfors and Leiringer 2002).
IDEFO models are often created as one of the first tasks in an enterprise development effort. The primary strength of IDEFØ is that the method has proven effective in describing activities, enabling gradual decomposition down to the detail level necessary for decision-making to take place (Anon 2002). The hierarchical nature of IDEFØ facilitates the ability to develop as-is models that have a top-down depiction, but which are analysed in a bottom-up manner. The primary weakness of IDEFØ models is that they often are so complex that they are comprehensible only if the reader has participated in the model development. For individuals not familiar with the method it is easy to misinterpret the models believing it represents a sequence of activities in a timely manner from left to right, i.e. by embedding activity sequencing in the model (Ibid.).

Identification typically begins with interviews of subjects or domain experts and studies of existing documentation. Prior to the modelling the purpose and viewpoint of the new model has to be stated, clarifying the intended perspective of the model and why it was built. Hence, the modeller starts grouping together activities that are closely related or that belong to the same process phase. When an existing enterprise is being analysed, IDEFØ assists the modeller in identifying what activities are performed, what is needed to perform those activities, what is currently performed correctly, and what is currently performed wrong (Anon 2002). Thus, the requirement to model the process in a formalised manner in order to be able to compare and refine the process can be supported directly by the IDEFØ technique (Malmström et al. 1998). Applying the IDEFO technique results in an organised representation of activities, a full understanding of the relationships between activities, conditions required for the activity to produce the correct outputs and means that support the execution of the activity (Anon 2002).
3.3.2 IDEF3

IDEF3 was designed as a process description capture method. It enables collection and documentation of processes, and supports the capture of precedence and causality interaction between situations and events. In this way, it provides a structured method for communicating system, process or organisation knowledge (Anon 2002). The IDEF3 method builds structured descriptions that capture information and process knowledge about the actual or intended situation of a system. The method uses two description modes, i.e. the process flow (see figure 9) and the object state transition network (OSTN) (see figure 10). The process flow describes processes and interactions that exist between processes, i.e. how things work in an organisation. The resulting diagrams and text constitutes a description as opposed to a model, which is produced by other IDEF methods (Anon 2002).

Figure 9: IDEF3 process flow description diagram

The OSTN description, as opposed to the process flow description, illustrates the evolution of an object throughout a particular process. Each object state transition is performed by a ‘unit of behaviour’ (UOB), which helps the object to evolve. The UOBs can be decomposed enabling a closer look with a more fine-grained IDEF3 representation of that particular UOB. IDEF3 provides this opportunity to capture different views of the same activity by allowing multiple decomposition of the same UOB (Anon 2002). In an OSTN, the circles represent object states and the arrows connecting the objects represent transitions (see figure 10).
An object state is defined in terms of the facts and constraints that need to be true for the continued existence of the object in that state and is characterised by entry and exit conditions (Anon 2002). The entry and exit conditions characterise the conditions under which an object can transition into and out of a state. The conditions specify the requirements that need to be met before an object can transition into a state (Ibid.).

3.2.3 ActionWorkflow™

The Action Workflow™ method is an example of a communication-based modelling method. The method focuses on showing structures of agreements between people to produce customer satisfaction (Medina-Mora et al. 1993). The method is built around workflow units with an identified performer who is doing work for a customer. Each workflow is illustrated as a graphical loop (see figure 11). “Processes can be modelled as a series of workflows, with different participants assigned the roles of customer, performer, and observers within each workflow” (Ibid.). The method is characterised by systematically displaying actions communication and coordination among people.

Figure 10: IDEF3 object state transition network diagram

Figure 11: The basic syntax for an ActionWorkflow™ model
Each workflow is divided into the four phases: preparation; agreement; performance and acceptance. The four phases display the process of the interrelationship between a performer and a customer in a wider sense. Generally, processes are made up of many connected workflows. Medina-Mora et al. (1993) represent the workflow relationships by putting all process workflows on a map, and drawing links between them indicating what phase in a parent workflow initiates a sub-workflow (see figure 12). These maps are an integral part of the ActionWorkflow™ method.

Figure 12: Simple ActionWorkflow™ business process map

### 3.3.4 Quality Function Deployment

The main objective of the Quality function deployment (QFD) method is to assure the customer’s needs (quality) during the design process as well as supporting communication between engineering, manufacturing, and marketing. The QFD method supports the design process relying heavily on a series of matrices (see figure 13) to create desired product characteristics. "QFD is a formal structure for improving the system development process using charts like a QFD matrix" (Brady 1995). QFD is an integrated set of tools used for capturing customer requirements and from them developing a product to fit. The complex mapping from customer needs to product expectations can be handled in the house of quality – see figure 13 – (Malmqvist and Svensson 1999).

QFD has been reported to be the most appropriate method, when it comes to incremental change and when attributes can be easily quantified. Benefits recognised are clarity in product specifications, reducing waste and rework, more rational decision-making, improved workflows, and means for solidifying design early and welding teams together (Brady 1995). Davenport (1993) states that the QFD method is "a rigorous if somewhat unimaginative approach that has come out of
the quality movement that can be applied to issues at the interface between engineering, manufacturing, and marketing". Brady (1995) sites the works of others noticing that out of 200 corporations in the U.S. investigating the QFD method only a handful of these organisations where successful – less than ten were able to realise its full potential. One reason for the meagre results might lay in the difficulties of implementing the method (Ibid.).

![Figure 13: The QFD house of quality matrix](image)

### 3.3.5 Design Structure Matrix

The Design Structure Matrix (DSM) (also known as the Dependency Structure Matrix, the Problem Solving Matrix (PSM) and the Design Precedence Matrix) is a compact matrix representation of a process/product/system. Donald V. Steward originally developed DSM in the 1970s, but was later improved and applied to industrial project planning and assessment in the early 1990s by Steven D. Eppinger at MIT (Ulrich and Eppinger 1995). The DSM method uses a matrix notation to partition and correlate activity relationships in an appropriate manner, making it an effective tool for demonstrating and analysing activity dependencies. When using the DSM method for process development it provides a compact and clear representation of a complex process and a capture method for the information dependencies between activities.

In a DSM, a process activity is appointed a row in a perceived information flow and a corresponding column. Thus, all activities are ordered identically on rows and columns. An activity (row) is annotated with marks indicating the existence and directions of information flows and dependencies with other activities (columns).
Reading across a row shows all activities (columns) whose output is essential for carrying out the activity corresponding to the row (Anon 2000; Ulrich and Eppinger 1995). Thus, the required information exchange and dependency patterns are visualised in the DSM (see figure 14). For example, consider activity E in the left matrix in figure 14. Activity E relies on information from activities B, C and I and delivers information to activity I. Activity I appearing above the diagonal indicates that an earlier activity (activity E) is dependent on a later activity. Tools supporting the method are powered by a mathematical algorithm (often a macro to an MS Excel spreadsheet) that performs the partitioning of activities. Changing the order of activities to correlate to the dependencies is called partitioning. As a result of the partitioning, activities are ordered according to the sequential dependencies of activities. An inspection of a partitioned DSM reveals which activities are sequential, which are parallel and which are coupled and require a concurrent execution (Ulrich and Eppinger 1995; Browning 1998).

Figure 14: (left) A DSM with marked dependencies (right) A partitioned DSM

After running the mathematical dependency algorithm a more accurate representation of the process is visualised. This is displayed as a list of the best possible information flow under current circumstances. The bottlenecks in the process are also visualised in the models by clusters of dependencies (see figure 14 (right)). The DSM method approach of localising bottlenecks in the processes can be useful when analysing complex processes. Benefits recognised from the use of the DSM are the possibility to visualise information flows and activity dependencies, structured process modelling (matrix format) and helping to discover unknown process patterns (Anon 2000). DSM also allows the user to identify leverage points in the process showing the optimal way to improve process performance (Carrascosa et al. 1998).
3.3.6 Stage gate

The Stage gate method is an unsophisticated, but useful, visualisation method of processes developed in the early 1990s by Robert G. Cooper. The Stage gate approach applies a consistent planning and review procedure throughout the process (Kagioglou 1999). The formal representation of a Stage gate model corresponds to the name of the method. The Stage gate method breaks the process into discrete and identifiable stages, each consisting of a set of prescribed cross-functional and parallel activities. At the entrance to each stage is a gate, shown as a diamond in figure 15, which controls the process and serves as a decision point and review point for process advancement. Gates have a common format, including inputs, decision criteria and outputs (Cooper 1996).

![Figure 15: The basic concept of Stage gate modelling](image)

Cooper (1996) states that each stage is designed to gather information needed for the advancement of the project to the next gate or decision point. When the information is gathered it has to pass through the gate where the decision is made to pass the project forward or not. Senior managers from different functions, who own the resources required by the project leader and team for the next stage, usually staff the gate function (Ibid.). The Stage gate method has been widely used in all types of industries. An example of an application in the construction sector is the Process protocol, which combines the Stage gate model with a cross-functional flow chart (Aouad et al. 1999). Davenport (1993) states that the method is a good way "to ensure that resources are focused on the most promising project and that new products meet business needs."

3.4 Identifying and describing the as-is housing development processes

Based on the review of modelling techniques, three techniques were selected for the purpose of defining the housing development process. These were IDEF0, DSM and Stage gate modelling. The other alternative techniques described in the previous section, i.e. IDEF3, ActivityWorkflow™, and QFD were found to be either too simplistic or too complex for the intended purpose (Karhu 2000; Malmström et al. 1998; Pikosz and Malmqvist 1998). For the IDEF3 and the Ac-
tionWorkflow™ techniques, rejection was made on the grounds that they did not cover enough perspectives of the process within a single model. QFD on the other hand covers a plethora of perspectives, but with an increasing complexity that makes the method cumbersome to use. The three selected techniques complement each other and are useful when modelling the information process. The IDEFØ is good at modelling processes in a formalised manner and covers a range of process perspectives. The decision to use the IDEFØ method was based on the method’s superiority in displaying a process from multiple perspectives at the same time. IDEFØ models often become very complex with enormous amounts of boxes and arrows, but the syntax of the technique captures four very pertinent perspectives of a process. IDEFØ is not considered, as mentioned above, to be the ideal modelling method, but despite some deficiencies and limitations the method is easy to understand for the modeller and it is supported by a number of available computer-based modelling tools (Björk 1999).

The DSM on the other hand is good at structuring duplicate dependencies and analysing them accordingly. Finally, the Stage gate method is an easy to understand presentational technique for a process that leaves out the complex relationships inherent in IDEFØ and DSM models. Malmström et al. (1998) agrees with this choice and comments favourably on the combination of the IDEFØ and DSM to compensate for the deficiencies and limitations of the techniques by themselves. The later provides a better overview than IDEFØ, since the complexity of DSMs does not grow as fast as that of IDEFØ models and provides useful insights with little additional work. The Stage gate method was used for display purposes and interaction with company personnel, because of the difficulty of working with the complexity of IDEFØ and DSM models.

3.4.1 Studying existing systems for the purpose of creating an initial process structure

After deciding on modelling techniques, a review of descriptive company specific system documentation was performed. Among the systems being studied were the housing developer’s management system, quality management system, environmental management system, TPC system and operation control system. This review provided the researcher with an improved understanding of the generally accepted activities in the housing development process and how the different existing control and support systems overlapped. The review contributed to the creation of an activity list containing approximately 350 activities claimed to be performing in the housing development process. Company specific control and support documentation such as procedure documents, knowledge documents, checklists and templates were also gathered from this review. The strategy for col-
lecting the remaining information to identify and define the housing development process followed the logic shown in figure 16.

**Figure 16: The identification and definition process used in the initial work**

### 3.4.2 Gathering information from company personnel

Following the document review, an information retrieval process began including elements of both extensive interviews and more structured surveys. During this phase the researcher spent a considerable amount of time discussing the processes with personnel, making beneficial use of individual views to capture as-is conditions. The discussions with the individuals emanated from the material gathered during the document review trying to capture perspectives not described by the existing systems. This contributed a great deal to increasing the researcher’s understanding of the process context. This was followed by the development of two
matrices, based on the document review, to gather the remaining information in order to create the process model, i.e. inputs, controls/supports, outputs and resources (see figure 17). The two matrices were founded on the activity list generated in the document review. The main objective for creating the matrices was to capture the remaining ICOMs (input-control-output-mechanism) besides controls/supports enabling the creation of the process model. The first matrix, the activity and resource matrix, was aimed at capturing the participation of process actors (resources) in activities. The second matrix, the DSM, was aimed at mapping dependencies between activities (input-output/relationships). When finished, the two matrices were subsequently distributed, through a postal questionnaire, to all personnel directly engaged in the housing development process, who were asked to fill out the matrices. Together with the postal questionnaire a letter was sent:

My work with mapping NCC Housing’s TPC has now reached Phase 2. The first phase comprised a mapping purely based on the information gathered in company specific system documentation and from interviews. Phase 2 will include a complementary addition to this result by the distribution and collection of these two matrices. To be able to make this addition, I would be grateful if you, in your position, could contribute with your knowledge as a specialist. I have put together one matrix for measuring the relationship between resources and activities and another for measuring dependencies among activities. These two matrices are distributed to all personnel within NCC Housing enabling a mapping of the actual appearance of the TPC. I should be pleased if you would fill out these two matrices, even if the work entailed seems to be a lot, as it is crucial for the continuation of my work.

The recipients were given freedom to describe how their job situation tended to work. The results were then collected and compiled. The results from the activity-personnel matrix generated a clear picture of personnel participation in activities. The dependency structure matrix generated a full understanding of the present activity relationships in the process.

![Figure 17: Actual use of the different ICOMs in the IDEFØ model](image)
During this retrieval process it was noticed that the numerous control and support systems inherited from several past improvement efforts and mergers were drowning the organisation in paperwork. This had made information search and information retrieval both difficult and time consuming. The absence of an active knowledge model and the lack of structure had led to fragmented internal project (value chain) processes.

3.4.3 Creating an as-is process model of the housing development process

Based on the empirical data captured in the interviews and surveys, an as-is process model was created, displaying activities, inputs, outputs, dependencies, resources, support and control systems (see the comprehensive first level in figure 18). The final product was a process model displaying the entire housing development process and including over 350 main activities. The mapping stopped at this level of decomposition, because the modelling objectives were reached. The IDEFØ model was created using a computer-based tool (Platinum BPWin), which simplified the compilation procedure. The result is presented as an IDEFØ as-is process model of the housing development process from project idea and acquisition of landed property to product delivery and post occupational commitments and services. The final result was an as-is model of the housing development process with inputs and outputs explaining changes in the information exchange, controls covering company specific control and support documentation and the mechanisms explaining the company’s process actors and IT-applications.

3.4.4 Insufficiencies encountered in the as-is process

The modelling work provided the researcher with a sound understanding of the housing development process. Additionally, the modelling helped the organisation to find a shared view of the details in the process, enabling an improvement project to start. Especially noticeable was the lack of clear decision-points, where potential inadequacies in the process could be detected. The lack of a systematic behaviour in the early phases of the housing development process (project development and product development) was also found to be insufficient. For this reason, the early activities of land acquisition, product formulation and managing the work through the development plan process were solved in an ad-hoc manner in every project. Noticeable was that these most crucial phases, where most of the product value is created, were left to be solved on an ad hoc basis. Activities supporting customers were also vaguely acknowledged. Finally, at this comprehensive level, it was found that the definition of who was doing what was non-existent.
Figure 18: The 1st level process diagram view of the housing development process
3.5 Conclusions

This chapter has described the identification and definition of the housing development process within NCC Housing. A number of modelling techniques have been considered, such as IDEF0, IDEF3, ActivityWorkflow™, QFD, DSM and Stage gate. A selection of modelling techniques was made. Following their selection, a cognitive process was initiated where the researcher undertook extensive interviews and discussions with personnel: this contributed to an increased understanding of the process context. It was noticed that the processes of the organisation were not living up to their full potential as a result of a lack of holistic understanding of operations. The need for structure was evident to enable communication and information to flow smoothly within the organisation. The identification and definition work can be summarised as follows:

- Establish aims and objectives.
- Review system documentation.
- Create an activity list and compile existing control/support documents.
- Create an activity-resource matrix and a DSM matrix.
- Distribute the matrices to relevant key personnel together with user-instructions.
- Collect completed matrices and compile the results.
- Create a process model based on the information gathered.

Based on this initial part of the study it can be concluded that an accurate representation of the housing development process creates a good foundation for further improvement of the housing development process. The representation of a process, in any form, can be of immense help for a company wishing to improve its performance. In this particular case, the study has helped the subject company to improve its understanding of its processes. The use of process models, as described in this chapter, is invaluable for the purpose of structuring information about processes, but often considered to be too complex for non-technical personnel. Complex models such as those based on IDEF0 are best suited for researchers and process developers. The result from this chapter, together with a literature review of the process orientation field, forms the foundation for the improvement work described in the following chapter.
4. Understanding the concept of process orientation and developing the housing development process

4.1 Introduction
The result of the identification and definition work laid the foundation for an extensive development effort to start on improving the housing development process. As little was known about the phenomenon of process orientation this work started with a comprehensive literature review. The main purpose of the literature review was to establish a foundation for the planned improvement work of creating/developing a to-be process. The effort was concentrated on the generic concept of process orientation, which includes a wealth of philosophies ranging from TQM to learning organisations. The three first sections in this chapter present the concept of process orientation, some of the most commonly associated research philosophies and a comparative summary of their features under various key principles of management. The following sections then describe the to-be process development work at NCC Housing and the resultant to-be process. Finally, conclusions are drawn.

4.2 Process orientation
Process orientation is not recognised as a distinct research discipline, but rather a generic concept of management philosophies using a process perspective for improving organisational performance. The word process comes from the Latin word *processus* that roughly means *move forward*. Since then the word has come to represent different aspects or events and has developed over time (Bergman and Klefjö 1995). The present literature provides several definitions of a process (Davenport 1993; Hammer and Champy 1993; Georgakopoulos et al. 1993; Garvin 1998). Three of the most commonly quoted in the literature are those by Harrington (1991), Hammer and Champy (1993) and Davenport (1993). Their respective definitions are:
... any activity or group of activities that takes an input, adds value to it, and provides an output to an internal or external customer. Processes use an organisation’s resources to provide definitive results.

... a collection of activities that takes one or more kinds of input and creates an output that is of value to the customer.

... a structured, measured set of activities designed to produce a specific output for a particular customer or market.

Looking at the definitions it is difficult to avoid the similarities between them. It also becomes apparent that almost everything is a process and that business processes play a crucial role in the economic survival of organisations (Harrington 1991). Looking more closely at the definitions, some similarity can be seen between activities, inputs, outputs, value and customers. A combination of the similarities and a clarification of the process term would create the following definition:

A process is any activity or structured set of activities that takes one or more inputs and together with additional resources creates a specific and valuable output to a customer or stakeholder.

The inputs and outputs are usually as varied as materials, information and human resources (Garvin 1998). Michael Porter highlighted Process Orientation as a concept in the early 1980s. Michael Porter (1985) introduced the concept of interoperability across the value chain as a major issue for firms. Among the management philosophies developed over the last twenty years associated with the process orientation context are total quality management, business process reengineering, process innovation, value chain management, supply chain management, knowledge management, learning organisation and lean enterprise. What all these philosophies have in common is the concept of processes and the need to improve both organisational performance and design (Zairi and Sinclair 1995). McCormack (1999a) states that business process orientation is a novel way of working because it gets at the core of activities and the corporate mindsets that occur in a firm as it satisfies the customer. McCormack (1999b) defines an organisation that applies the concept as:

... an organization that emphasizes processes, a process oriented way of thinking, outcomes and customers as opposed to hierarchies.

Thus, the word process orientation is used to describe an organisation, which emphasises holistic processes to managing the complete value chain of a product and
service. To make the similarities clear, the following section will describe the major management philosophies using a process approach for organisational development, followed by a more detailed description of the process orientation concept using the eight declared management principles of quality management (SIS 2000) in order to combine the manifestos.

4.3 Process approaches to organisational development

There are many advocates proclaiming that the process-based organisation is ‘the’ emerging new organisational form with the business process as the basic organisational construct (Harrington 1991; Womack and Jones 1994; Rummier and Brache 1995; Davenport 1996; Hammer 1996; Garvin 1998; Hammer and Stanton 1999; Aouad et al. 1999; McCormack 1999a). It has been claimed that a focus on processes, or collections of tasks and activities that together transform inputs to outputs, allows organisations to view and manage materials, information and people in a more integrated way (Garvin 1998). Mapping processes clarifies dependencies between activities, laying a foundation for organisational development and strategic management decisions. Any process orientation would thereby include elements of structure, focus, measurement, ownership and customers (Davenport 1993).

Seltsikas (2001) claims that broad horizontal product development processes and order-fulfilment processes have become the new organisational building blocks, replacing more familiar and narrowly focused departments and functions. Applying this new perspective to organisations is claimed to decrease difficult functional handovers and improve co-ordination capabilities along the product value chain. This, in turn, enables a more lean approach to product development, production and services. However, this requires that an organisation’s different workflows and processes are identified and modelled. Systematically identifying processes within an organisation and particularly the interaction between them is therefore essential. A key characteristic of a process is that it is a repetitive standardised flow, i.e. it is performed multiple times. Hence, process orientation deals with designing and improving the standardised flow, which also makes it easier to measure (Nilsson 1998). The concept is often described as easily accessible often forgetting to mention that it deals with changing the way organisations work, which is both time and resource consuming (Forsberg et al. 1999).

As mentioned earlier the literature includes many different terms relating to the management and improvement of processes, including such broad concepts as total quality management, business process reengineering, process innovation, value chain management, supply chain management, knowledge management,
learning organisation and lean enterprise. These philosophies cover a continuum of activities ranging from continuous improvement of processes to the complete reengineering of organisations (Zairi and Sinclair 1995). The remaining part of this section will describe the different philosophies from a process perspective.

4.3.1 TQM and ISO 9000:2000

Total quality management (TQM) is often associated with the quality management movement and the ISO 9000 standard. Not until the revised ISO 9000:2000 standard (SIS 2000) was published were Deming’s (1982) original thoughts about TQM finally incorporated. TQM is described as an approach concerned with improving organisational effectiveness and also as a philosophy that continually strives to fulfil customer demands and needs for the lowest price through continuous improvements in which everyone are involved (Zairi and Sinclair 1995; Bergman and Klefsjö 1995). Pike and Barnes (1993) define TQM as:

… a process which ensures maximum effectiveness and efficiency within a business and secures commercial leadership by putting in place processes and system which will promote excellence, prevent errors and ensure that every aspect of business is aligned to customer needs and advancement of business goals without duplication or waste of effort.

Thus, “the aim is to continuously improve process performance in order to satisfy customer requirements” (Zairi and Sinclair 1995). A large emphasis is put on planning, organising and understanding of activities in an organisational, individual, customer and supplier context and in the centre of this is the concept of management of processes. In conformity with other process approaches, categories such as, time, cost, quality and productivity are also stressed placing the customer as a central point of operations. A shared vision and purpose is seen as a good beginning in finding real increases in productivity and efficiency. In TQM, a process orientation is often seen as a way of getting closer to customers while at the same time improving the internal ability of managing the organisation. “Process improvement is seen as a pervasive set of renovation activities that form the life-blood of a company’s regenerating profit potential” (Prasad 1999). TQM seeks steady incremental improvements to process performance and the elimination of defects. Deming (1982) comments that it costs as much to correct a defect as to make it in the first place, pointing out that defects are not free, i.e. somebody makes them and gets paid for making them. TQM also focuses on team environments to reduce inter-functional conflicts and increase interdepartmental connectedness, both of which impact long-term and short-term performance (McCormack 1999a).
4.3.2 BPR and process innovation

The concept of business process reengineering (BPR) or process innovation as it is also called was developed in the early 1990s by Hammer and Champy (1993) and Davenport (1993). Hammer and Champy (1993) defines BPR as:

... a fundamental rethinking and radical design of business processes to achieve improvements in critical, contemporary measures of performance, such as cost, quality, service, and speed.

The approach combines the adoption of a process view of the business with the application of innovation to key processes (Davenport 1993). The focus on broad and inclusive processes is an essential aspect of the approach. The aim of BPR is to reengineer processes from a customer perspective for the purpose of improving organisational performance, not through incremental improvement but through quantum leaps, i.e. having a fresh start, seeking breakthroughs and disregarding the old systems. Hammer and Champy (1993) even goes as far as to claim that BPR is fundamentally about reversing the industrial revolution, i.e. rejecting the industrial paradigm of Adam Smith. Putting the emphasis on the ‘team’ instead of the individual eliminates the inconvenience and inefficiencies of coordinating individuals with complex processes.

For a business, a BPR effort also implies a relatively heavy emphasis on improving how work is done, by asking the fundamental questions of ‘why do we do what we do, why do we do it the way we do?’ (Davenport 1993; Hammer and Champy 1993). To be able to answer these questions the organisation has to adopt a process oriented structure. “Adopting a process-oriented structure generally means de-emphasising the functional structure of the business” (Davenport 1993). The goal of a process innovation is to improve or eliminate interface problems between functions and the line organisation. Even though BPR put a strong emphasis on the fact that it distinguishes itself from the quality field (Hammer and Champy 1993; Davenport 1993) there is a strong link with process improvement methodologies, in some cases even the terminology is almost identical to that used by quality practitioners (Zairi and Sinclair 1995). Similarities are that they both recognise processes as an important entity and that the process starts and ends with the customer.

4.3.3 Value chain management and supply chain management

Michael Porter, who drew up the picture of the firm’s value chain, created the concept of value chain management in the mid 1980s. The term value chain was used as a synonym for process and was displayed as a map of the firm (see figure 19).
Porter (1985) stated that every firm is a collection of activities that are performed to design, produce, market, deliver and support its products. The building blocks of the firm are the value activities that form the organisational infrastructure and facilitate its competitive advantage. Porter (1985) also states that the key source of competitive advantage is difference among competitor value chains. Within the value chain, the activities are interrelated by linkages and reconfiguring those often leads to opportunities of achieving dramatic levels of differentiation, assuming that differentiation is good from a competitive standpoint. The value chain is therefore best described as a collection of interdependent activities that instantiates the firms strategy and its way to achieve the overall result.

The activities within a value chain are divided into primary activities and support activities, very similar to the core activities and support activities of more modern process approaches. Core activities are those involved in product development, production and sales, assisted by the support activities providing purchased inputs, human resources, and various organisation-wide functions (Ibid.). Value chain management thus proclaims that the best way for improving performance is to analyse and examine the value chain, rather than the single activities ordering the activities according to the process flows, enabling an increased clarity of the value chain to managers. Porter (1985) states the ability to optimise and coordinate linkages often is the best way to reduce cost or enhance differentiation.

In the early 1990s the term supply chain started to appear describing a synonymous concept to the value chain. Christopher (1992) defines the supply chain as “the network of organisations that are involved, through upstream and downstream linkages, in the different processes and activities that produce value in the form of products and services in the hands of the ultimate customer.” As a consequence, the supply chain movement started to talk about an integration of business.

Figure 19: The generic value chain (adopted from Porter 1985).

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processes across the supply chain forming the new management philosophy of supply chain management (SCM). The literature provides several definitions of what SCM is (Christopher 1992; Cooper et al. 1997; Lambert et al. 1998; Paulson et al. 2000). The most recent and commonly quoted in the literature is that by Lambert et al. (1998) who define SCM as follows.

Supply chain management is the integration of key business processes from end user through original suppliers that provides products, services, and information that add value for customers and other stakeholders.

Thus, SCM includes integration of processes and functions within organisations and across the value chain, from initial source to the final customer, evolving through several stages of increasing intra- and inter-organisational integration and coordination (Cooper et al. 1997). Based on this fundamental view a SCM framework (see figure 20) has been developed, consisting of three major and closely related elements: business processes, management components and the structure of the supply chain (Ibid.).

![Figure 20: Elements in the framework of supply chain management (Cooper et al. 1997)](image)

As for most other management philosophies the objective of SCM is to lower the total amount of resources required to provide the necessary level of customer service and that the major difference with traditional management is the focus on processes in meeting the customer’s requirements and that the firm is organised around these processes.
4.3.4 Knowledge management and learning organisations

Knowledge management (KM) is a more recent name for what was earlier called organisational learning (Sverlinger 2000). Research in computer science and ISs research prefers to use the term knowledge management. Senge (1990) describes the learning organisation as an organisation "where people continually expand their capacity to create the results they truly desire, where new and expansive - patterns of thinking are nurtured, where collective aspiration is set free, and where people are continually learning how to learn together." Garvin (1993) goes as far as to define the concept of the learning organisation as:

... an organisation skilled at creating, acquiring, and transferring knowledge, and at modifying its behaviour to reflect new knowledge and insights.

KM and learning organisation are not often compared to other process approaches but the similarities are plentiful. Two of the main goals of KM, for example improvement of customer satisfaction and productivity, are also typical for BPR, TQM, etc. (Maier and Remus 2001). Activities like problem solving, lesson learned handling, experimental design, benchmarking, and quick and efficient knowledge transfer are the cornerstones of the learning organisation. All these activities require seeing the world from a new perspective and taking the appropriate action (Garvin 1993).

Liebowitz and Beckman (1998) observe that the only way for KM to realise its potential for enhancing organisational performance is if it is integrated with the strategic goals of the organisation. Garvin (1993) states that there must be left room for reflection, to think about strategic goals, dissect customer needs, assess current work systems and invent new products. A more resent approach to implementing KM is to integrate it with process orientation (Maier and Remus 2001). It is suggested that operative business processes instead of knowledge processes are defined, because of the abstract and inapplicable nature of the isolated definition of knowledge processes (Ibid.). Rubenstein-Montano et al. (2001) stress the need for holistic methodologies and processes that emphasise the organisational and cultural aspects of knowledge management to be developed. The concept of KM and learning organisations requires a new way of thinking which is justified by the following statements of Garvin (1993):

Learning organisations are not built overnight. Most successful examples are the products of carefully cultivated attitudes, commitments, and management processes that have accrued slowly and steadily over time. In the absence of learning, companies – and individuals – simply repeat old practices. Change remains cosmetic, and improvements are either fortuitous or short-lived.
4.3.5 Lean enterprises

The lean enterprise was conceptualised by Womack et al. (1990) in the late 1980s based on practices in the Japanese automobile industry. The concept of lean is that, in contrast to mass production, it uses less of everything, i.e. man-hours, equipment, time needed for product development and overall expenses (Womack et al. 1990). Womack and Jones (1994) describe the concept of lean thinking in the following way:

Lean Thinking enables companies to find the best way to specify value for the customer, to identify the value stream for each product, to cause the product to flow smoothly from concept to customer, to permit the customer to pull value as needed from the producer, and to make a lean leap toward perfection.

The notion of the value stream defines the lean enterprise, using the word value stream as a synonym of process. The concept put high emphasis, from a customer perspective, on eliminating waste through getting rid of non-value adding activities and by doing so reducing time and cost. The concept is often associated with techniques like just-in-time (JIT), Kaizen and the Kanban system. Stressing a focus on processes, when creating a lean enterprise, requires tight integration between sales, manufacturing and logistics into a smoothly functioning process. It also requires a high degree of cross-functional collaboration (Davenport 1993; Womack and Jones 1994). Lean enterprises continually strive for improvement through assigning knowledge workers into cross-functional teams dedicated to pursue perfection in their daily work. By eliminating unnecessary steps, aligning all steps in an activity in a continuous flow, companies can become vastly more flexible and responsive to customer desires. The lean enterprise strives to overcome conflicts between functions and to continuously improve its performance through teamwork along the entire value stream by “permanently assigning members of functions to multi-functional teams as the solution to this conflict between function and process” (Womack and Jones 1994).

4.4 Key principles to process orientation

This research does not try to endorse any one of the previously described philosophies above any another. Instead the course of action has been to identify the common principles constantly reappearing in almost all the literature on the subject today (Bergman and Klefsjö 1995; DETR 1998; SIS 2000; Paulson et al. 2000). In order to enable a comparison of the different philosophies, the eight identified management principles of the ISO 9000 family were used since these are a compilation of best practice behaviour from several industries (SIS 2002). Table
shows a comparison between the different philosophies that indicates a number of highly noticeable intersections and a better understanding of the process orientation concept.

Table 1: Approaches using a process perspective to organisational development

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<tr>
<td><strong>Customer focus</strong></td>
<td>Customer needs, requirements and expectations</td>
<td>Customer satisfaction and value</td>
<td>Customer values</td>
<td>Customer co-Capraison</td>
<td>Customer relations</td>
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<tr>
<td><strong>Leadership</strong></td>
<td>Purpose and direction</td>
<td>Vision, mission, process ownership</td>
<td>Goal, strategy</td>
<td>Vision, motivation</td>
<td>Direction</td>
</tr>
<tr>
<td><strong>Involvement &amp; commitment of people</strong></td>
<td>All levels, full involvement</td>
<td>Process teams, steering committees</td>
<td>Temporary taskforces</td>
<td>All levels, teamwork</td>
<td>Directed teamwork</td>
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<tr>
<td><strong>Process approach</strong></td>
<td>Activities managed as a process</td>
<td>Organisation is managed as processes</td>
<td>Focus on flows of activities</td>
<td>Process structure</td>
<td>Product value streams are identified and co-ordinated</td>
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<td><strong>System approach to management</strong></td>
<td>Managing processes as a system</td>
<td>Process teams replace institutions</td>
<td>Holistic view on activities, chain integration</td>
<td>Teamwork management</td>
<td>Managing processes as a system</td>
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<td><strong>Continual improvement</strong></td>
<td>Permanent objective</td>
<td>Redesign/improvement instead of improvement</td>
<td>Ad-hoc procedure</td>
<td>Commitment to learning</td>
<td>Pursue perfection Kaizen</td>
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<tr>
<td><strong>Factual approach to decision making</strong></td>
<td>Analysis of data and information</td>
<td>Delegated decision support tools</td>
<td>Analysing Cost and quality</td>
<td>Delegated analysis of data and information</td>
<td>Delegated analysis of data and information</td>
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<td><strong>Mutually beneficial supplier relationships</strong></td>
<td>Enhance the ability of both to create value</td>
<td>Co-operation in process redesigning</td>
<td>Co-ordination with suppliers</td>
<td>Productive relationships with clients/customers</td>
<td>Collaborative selected supplier relationships</td>
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Using these eight management principles, the similarities and differences of the management philosophies are described, enabling a more comprehensive description of the process orientation concept. The remaining part of this section explains more in detail the process orientation concept organised under the eight management principles, and uses literature from the above-mentioned philosophies to explain the key issues. By using best practice examples from the various philosophies it might be possible to start to understand the key issues needed to create a professional process oriented champion. This is important too for top management of companies to lead their organisations toward improved performance.

4.4.1 Customer focus

Satisfying the customer is becoming an increasingly important objective for organisations as customers become more knowledgeable and demanding. As Harrington
(1991) states, “customers happy with your output tend to stay with you!” Organisations should therefore concentrate on understanding customer needs and meet customer requirements and try to exceed expectations (SIS 2000). As a consequence, many organisations are starting to apply a customer-centric approach instead of the old technology-centric approach and recognising the importance of delivering one-to-one services (Masuda et al. 2000). This change of focus requires more flexible and responsive work processes for meeting the customer’s diverse requirements and providing on-demand services (Ibid.). Processes are the structure by which an organisation does what is necessary to produce value for its customers (Davenport, 1993). The need to understand those business processes that deliver or interact with the customer is therefore of great importance (Forsberg et al. 1999). The earlier described process approaches recognise the concordance when it comes to customers (see table 1).

The traditional business organisation’s sequential and disintegrated movement of products and services across business functions – engineering, marketing, manufacturing, sales, customer service and so forth – is often cost and time-consuming, which does not serve the customer well (Davenport 1993). The reason why processes have received increased attention is that the customer is five times more apt to turn away from a business because of poor business processes than poor products (Harrington 1991). In an effort to respond to increasing customer expectations, businesses must be willing to change and improve themselves on a continuous basis (Cates et al. 2000). This starts with an analysis of the processes from a customer perspective, trying to understand more about them. This knowledge then improves the internal ability for increasing customer value and enhancing performance. But not all development should be customer prescribed. Sometimes the producer is in a far better position than the customer to invent new designs and new services that create value for the customer (Deming 1982). Value for the customer is the amount he/she is willing to pay for a service or product. It is, needless to say, only happy customers who are loyal customers. Setting the goal of fulfilling customer demands and needs for the lowest price through continual improvement in which everyone is involved will go some way towards satisfying customers (Bergman and Klefsjö 1995).

4.4.2 Leadership

Leadership is, even in this new process oriented paradigm, an important factor. However, the practice has altered slightly from an authoritarian approach, to a practice where leaders are expected to coach their staff. The responsibility has gradually shifted from managing internal resources to managing the organisation (Gibbons et al. 1994). The critical challenge for leaders is to apply new manage-
ment innovations to coordinate the needs of individuals, functions, and processes to stimulate responsibility taking in all levels in the organisation. The leader’s main task is to create a common vision that can unify an organisation by establishing unity of purpose and direction (SIS 2000). Without direction, an organisation can pull itself apart.

Leadership is also becoming more important when information is overflowing the workplace and a comprehensive view is lacking. Drucker (1988) stated that the root cause of many problems plaguing organisations is the missing commitment of their leaders. This statement, 14 years after it was stated, is still valid for many companies. A crucial task for leaders is, therefore, to form and motivate the internal environment in which people can become fully involved and motivated towards achieving the common goals of the organisation (SIS 2000) and to act more as a coach than a figure of authority. This makes it essential to form clear strategies and processes, and be able to understand how to transform visions into goals. By drawing attention to processes, the focus is transferred from the finished result to the activities forming them. This means forcing managers to concentrate on the performance of the organisation rather than on the performance of individuals, functions, and companies (Womack and Jones 1994). Since processes create the result, they are also the first things that have to be controlled and developed.

As a consequence of this a new leadership role is emerging – the process owner. The process owner is responsible for designing and improving a particular process, measuring its performance, and training the frontline workers who perform it (Hammer and Stanton 1999). Thus, the process owner is relieved from the traditional staff responsibility, leaving that to line managers. That kind of split in authority may be hard for many executives to imagine, but there are companies that are making it work (Ibid.). An important part in the process owner’s obligations is to collaborate closely with other process owners and line managers, since processes often overlap and workers are often involved in several processes. This new leadership dimension is therefore seen as an alternative to the traditional, with the main tasks of improving, coordinating and educating the organisation. It is their responsibility to align and harmonise competing interests, while cultivating commitment and motivation (Garvin 1998): process is the key. Activities are the facilitators of strategy.

4.4.3 Involvement and commitment of people

Gaining the involvement and commitment of people is a prerequisite for a company competing in the open market. Without it all organisations are no more than a name and some fixed assets. People are the heart and soul of an organisation and their full involvement, at all levels, enables organisations to benefit from the fruits of
their commitment. Thus, gaining the commitment of the people who work in the process and the managers who oversee them is paramount. The power and capabilities of teams have for decades been recognised as a key building block of organisations, but it is only in the last decade that managers have become aware of, and accustomed to, the superiority of the team approach (Nadler et al. 1995). Teamwork has a central part in a process orientation in the form of process teams. Process teams are composed of individuals who have broad process knowledge and are self-sufficient to the degree that they leave little or no room for traditional supervision (Hammer and Stanton 1999). The team’s large responsibility and the degree of freedom favours commitment among workers and the payoffs can be enormous. Responsibilities include selecting suppliers, developing products, and overseeing routine production activities (Womack and Jones 1994).

Drucker (1998) observed that a decentralised responsibility requires a greater self-discipline and even greater emphasis on individual responsibility for relationships and communications. As mentioned in the previous section, this means that the role of the supervisor becomes more like that of a coach, teaching the workers how to execute the process, assessing their skills, overseeing their development, and providing assistance when requested (Hammer and Stanton 1999). An important factor for the commitment is a clear process that enables a clearer view of how work fits into the operations of the organisation as a whole. The individual is most often also given a larger authority increasing his/her influence on the execution of the job. The individual also becomes more focused on the processes. A job description framed in process terms also makes it easier for untrained individuals to step into new jobs and acquire necessary skills knowing from day one what he/she is supposed to do (Garvin 1998). This often improves the individual’s ability to understand the objectives of the firm and the meaning of his/her own job relative to those objectives (Davenport 1993). To conclude, people at all levels in the organisation must thus be stimulated to master the ability to perform effective teamwork, form valuable relationships with suppliers and customers, critically reflect on their own organisational practices and then change as required (Argyris 1991). Change in this context means reflecting critically on their own behaviour, identifying their work processes and then changing how they act.

4.4.4 Process approach

A process approach assumes a holistic perspective on the organisation placing a relatively strong emphasis on improving how work is done, in contrast to a product or service focused delivery, which places most of its energy on improving the product or the service. By not applying a holistic perspective on the organisational processes, the organisation is merely a group of individual small companies
being measured on goals that are not in tune with the total needs of the business and with separate commissions on profit. This often leads to sub optimisation, which negatively impacts the efficiency and effectiveness of the process (Harrington 1991). Adopting a process view of the organisation is a key aspect of process orientation, i.e. describing those aspects of a process that are relevant to controlling and coordinating the execution of its tasks (Georgakopoulos et al. 1995). In this respect, a process approach starts with the identification of processes, i.e. mapping processes by developing process models, using methodologies for capturing a process as a process specification. A process map can be seen as a blueprint for action and is the foundation for development and improvement related work, leading to new or improved working methods.

A process approach often deals with designing and improving an organisation’s standardised processes. Standardised processes offer many advantages, e.g. making it easier to measure, lowering overhead costs (information management cost) and increasing organisational flexibility whilst presenting one image to suppliers and customers (Hammer and Stanton 1999). A standardised process also facilitates reassigning people due to the fact that the process is performing in a similar way somewhere else. The results are often shorter cycle times, better quality, faster results and fewer defects. This structural element of processes is key to achieving the benefits of a process orientation by providing a convenient and intermediate level of analysis. By making the organisation more clearly described, deviations and problems are exposed providing new targets for improvement. Addressing these underlying processes, organisations have the ability to capitalise on new opportunities, eliminate causes leading to deviations and improve the overall performance. The ease with which secrecy can be maintained is also likely to mean that a process innovation is often more sustainable and valuable than product innovations (Porter 1985).

4.4.5 System approach to management

Managing interrelated processes as a system creates a holistic view and contributes to the organisation’s effectiveness and efficiency in achieving its goals (SIS 2000). A system approach to management must consider the entire management process because it facilitates the linkage between purpose of the organisation, strategic objectives, knowledge, technology, learning, and people/Culture (Rubenstein-Montano et al. 2001). A worthy motive for systemising the discipline of management is the fact that it is the most poorly defined of all processes and is rarely documented in process terms (Davenport 1993). Another reason is that management processes are where much of the money of an organisation is spent (Ibid.). A management process includes strategy formulation, formal planning and budgeting, decision-making, monitoring and performance measurement, resource allocation,
human resource management, infrastructure building, and communication linkages with relevant worlds. Having a process perspective enables managers to optimise the organisation from a holistic perspective and focus on broad, inclusive processes. Here, it is very important that management does not lose sight of the larger objective by focusing on individual tasks instead of processes (Hammer and Champy 1993; Paulson et al. 2000).

Identifying the activities forming the organisation and the resources needed makes it easier to improve the overall performance of the organisation. The organisational structure is the allocation of tasks and responsibilities to individuals and groups within the organisation, and the design of systems to ensure effective communication and integration of effort (Daft and Lengel 1986). Simply getting managers to think in terms of processes is the significant first step to achieving a process oriented systematic approach to management. A well-defined management system leaves room for reflection and analysis, time to think about strategic planning, dissection of customer needs, assessment of current work systems, and inventing new products. Another powerful level is to open up boundaries and stimulate the exchange of ideas. Boundaries inhibit the flow of information keeping individuals and groups isolated and reinforcing preconceptions. Organisational structure and internal systems facilitate interactions and communications for the coordination and control of activities (Daft and Lengel 1986). A greater degree of structure in management work enables managers to take advantage of IT and other change enablers and so become more efficient and effective, thereby leaving behind those who are unwilling (Davenport 1993). To conclude, work integration and coordination of the management function is highly pertinent to organisational success when trying to achieve a common goal and an interpretable strategy.

4.4.6 Continual improvement
Continual improvement should be a permanent objective of an organisation’s overall strategy (SIS 2000). “A company must, for its very existence, make use of stored knowledge that exists within the company, and learn how to make use of help from the outside when it can be effective” (Deming 1982). A process orientation encourages organisations to strive continuously to fulfil customer demands and needs for the lowest price through initiatives aimed at improvement in which everyone is involved (Bergman and Klefsjö 1995). Cates et al. (2000) suggest that an integrated, holistic, and systematic approach will be essential to organisations in the future promoting continuous improvement in new and innovative ways. There are many different process approaches, each involving a different procedure for improving the process. Continual improvement through regular self-assessment enables real quality and customer satisfaction to be achieved. Two major approaches to
improvement can be identified: that of the incremental and that of the radical approach. Predominantly, organisations are in need of incremental improvement, but once in a while there is a need for drastic measures calling for reengineering and the abandonment of old practices in hope of coming up with something completely new and better.

An approach to handling regular improvement – not a one-time effort – has to be anchored within the organisation and should include structure, routines, tools and methods. A structured and systematic way of working with continual improvement increases the potential benefits of a process initiative ten fold. Continual improvement and a commitment to learning should be firmly defined goals within any organisation (Garvin 1993). Simply letting managers and employees reason about their behaviour is often what it takes for an organisation to resolve its learning dilemma (Argyris 1991). One way of performing regular, continual improvement is to monitor and evaluate defined processes, thus enabling the organisation to take corrective and preventive action to eliminate discordance and avoid recurrence. Corrective actions take the form of analyses and evaluations of process discordance following process measurement, organisational audits and customer complaints. Preventive actions take the form of extensive analyses of external and internal data and information to prevent surprises and eliminate risk. To conclude, willingness to abandon what has long been successful is what makes an organisation truly successful, never being satisfied with the current performance always looking for new ways to improve (Hammer and Champy 1993).

4.4.7 Factual decision-making

Effective decision-making is based on the analysis of data and information (SIS 2000) linking the search for facts with the attempt to bring quality to management (Davenport 1993). More clearly described and structured processes are open to the measurement of the time and cost required for their execution in a variety of ways (Ibid.). However, measuring productivity does not improve productivity (Deming 1982). Collecting and analysing data and information as a result of monitoring and measurement from all relevant sources should form the basis for all factual decision-making and improvement programs. Enabling such an approach will need managers and specialists to think through what information is for them and, therefore, what data they need (Drucker 1988). Decisions should also be made as close to the source as possible to decrease response times; for example, delegating decision-making responsibilities by the increased use and sophistication of decision support tools. This would enable workers to make their own decisions, integrating decision-making and real work, making it a part of their work (Hammer and Champy 1993).
The organisation should be able to decide, collect and analyse data to demonstrate its suitability and effectiveness and to evaluate where continual improvement is most needed. A shift of focus from unit goals to process goals is what is required. Identifying and integrating process-related measures into the management agenda of an organisation could provide warnings of problems, raise issues related to corporate performance and identify unprofitable projects. The analysis of data should provide information relating to customer satisfaction, conformity to product requirement, characteristics and trends in processes and product, including opportunities for preventive action, and suppliers.

### 4.4.8 Mutually beneficial supplier relationship

An organisation and its suppliers are mutually dependent and a mutually beneficial relationship enhances the ability to improve products and processes, as well as create value for both parties (SIS 2000). Better coordination between suppliers and distributors using electronic networks presents the greatest opportunities for pursuing cost cutting when companies’ boundaries have reached a point of diminishing returns (Fisher 1997). A collaborative approach is therefore a natural way of handling supplier relations. A tight coordination with suppliers can shorten and improve product development and create the uniqueness in meeting customers’ needs, but only if information is shared mutually in both directions (Porter 1985). This means that both parties must share a substantial part of their information about cost, production techniques and every detail of their production process. With this knowledge, they can look for new ways to cut cost and improve quality, whilst simultaneously ensuring a reasonable profit for both parties (Womack et al. 1990). To be able to create such an open relationship with fewer suppliers requires clear agreements when it comes to target costing, profit sharing, process performance levels and the rate of continuous improvement (Womack and Jones 1994). If a supplier refuses to reveal these requirements the supplier must be free to leave (Ibid.). Rich and accurate information sharing is where most of these relationships fail. Consider, for example, the following: “if you are my supplier and we are negotiating over a price, the last thing you want to do is fully share with me information about your cost” (Fisher 1997). This kind of reasoning appears to be sound, because the price is seen as the true leverage of the company. However, if we both want to reduce our costs and improve quality this is what we have to do. Thus, mutually beneficial supplier relationships increase an organisation’s ability to achieve a culture of continual improvement and the ability to coordinate inter-organisational processes, as well as raising process and product quality.
4.5 Creating a to-be housing development process at NCC Housing

After the literature review of the process orientation area, the work of developing an improved to-be housing development process was initiated. With the as-is process description and the key principles of process orientation in mind and the insufficiencies encountered during the as-is identification, the work led to a more appropriate to-be process for NCC Housing. The following paragraphs in this section will describe how the process development work was executed at NCC Housing.

4.5.1 Initial workshop

As an initial action, before the extensive process development work was started, a number of cross-functional workshops\textsuperscript{33} were planned and held. The intention of these was to calibrate and closely examine the compiled as-is process model, so that it represented a true picture of the as-is situation. Eight participants including the researcher (who acted as a moderator for the workshop) were invited to represent a wide variety of professions within the organisation. The invitation to the workshop read:

You are invited to a workshop that will discuss the topic of process development. The aim of the workshop is to map and discuss relationships between activities in the processes. The results will enable us to develop and make our processes more effective.

During these workshops, issues concerning the previously mapped activity dependencies and the questions of whether or not they were accurate enough and whether or not they corresponded to the current situation were discussed. The procedure was kept simple by using activity lists\textsuperscript{34} of the different process phases and comprehensive process illustrations. To enable a sound discussion these were projected on a whiteboard so that everyone could participate in the discussion. During these sessions, the group would look at the projected material and discuss the accuracy of the documented activity dependencies. The only other perspective discussed was the resource perspective, but this time it also included external participation in the activities. The researcher moderated these discussions to enable everyone to participate with their knowledge and experience. This was necessary to progress towards a common goal of finishing the anticipated work, as

\textsuperscript{33} Over a period of a couple of months eight half-day workshops were performed.

\textsuperscript{34} These lists had been ordered according to the resulting dependencies of the as-is process model.
it otherwise tended to get stuck on issues of detail. The corrected activity dependencies of the housing development process taken from the workshop were examined with the help of a simulation tool using the DSM algorithm. The DSM simulation was performed in an attempt to try to optimise the order of activities. The DSM procedure as explained in the modelling review generates optimisation analyses of activity dependencies. The DSM procedure is founded on an algorithm that searches for relationships and visualises natural dependencies. To illustrate the DSM procedure shown in figure 21: A, B, C…symbolises activities, which according to the present process behaves according to the left matrix (A, B, C, D, E, F, G etc.), but after running a DSM optimisation analysis appears to be ordered according to the right matrix (A, B, I, E, C, D etc.), with a cluster of dependencies between the activities of B, I, E and C.

![Figure 21: Optimisation example using a DSM algorithm](image)

The result of the DSM simulation produced little improvement, as the dependencies of information activities are slightly more difficult to simulate than physical activities. The result did, however, give some indication of how to order and cluster the activities. Due to the cross-functional nature of the workshop group a number of new dependencies had emerged and a number of new perspectives of the housing development processes had been captured. This result led to and enabled a modest modification of the as-is process description.

**4.5.2 Process development organisation**

The results from the workshop and the following DSM analysis were then used as a foundation for the following process development work. To be able to cope with the extensive task of improving the housing development process it was obvious that various people had to be involved. Personnel in the organisation were consequently assigned to focus groups and a development organisation structure was established (see figure 22). The new development organisation consisted of a
steering group, a project management, a remittance group and two process development groups. The steering group included two appointed Process Owners35 (two Regional Managers at NCC Housing), the Quality Manager, the Housing Development Manager and the Project Management for the process development work.

The steering group’s objective was to decide about adaptation and implementation of new procedures brought forward by the development groups. The task of the project management36 was to support the steering group by coordinating and participating in the process development work groups. The project management also compiled the results from the process development groups and supplied it to the steering group. As support, the project management used the organisational development group for remitting the material before presenting the results to the steering group. It was thus the task of the project management to coordinate the development efforts between the two different groups to prevent sub-optimisation.

The organisational development function was used as a remittance group with the assignment of examining what was developed in the process development groups. Two process development groups were formed with the responsibility for a number of process phases each. Two process owners (see steering group constellation) were appointed given the full authority to make changes in their particular assigned process. For each group, including the process owner, participants with a special competency profile were appointed for their knowledge in the particular

35) The process owners were also working chairmen of the development groups.
36) The Project Management consisted of the researcher and a regional quality manager who, during the development work, altered the task of moderating the group sessions.
process phases. The process development groups were responsible for making sure that appropriate supporting and controlling documentation was created to support the new process procedure. They were also responsible to prepare the process for the new ISO 9000:2000 standard.

4.5.3 Process development work

Before the development groups started their work, NCC Housing’s strategy and the management principles of process orientation were presented and discussed, i.e. customer focus, leadership, involvement and commitment of people, process approach, system approach to management, continual improvement, factual decision-making and mutually beneficial supplier relationships. By bringing this up early in the development work it was easier to get the participants to focus on the important aspects of the development work. Using the organisational structure described earlier, the process development work continued for approximately 12 months of frequent focus group sessions. During this period of the development the use of complex process models were abandoned. There was full agreement that the information modelled in a process model could easily be replaced with simple MS PowerPoint™ illustrations and one perspective of the information being presented at a time.

The involvement of people from the operational parts of the organisation, in the development work, made it both more acceptable within the groups as well as in the rest of the organisation. However, as a consequence of using various people’s opinions, it was necessary for the project management – similar to the work in the initial workshops – to act as a moderator to capture the opinions of everyone in the groups. The result was a description of a work system describing the processes, inputs, outputs (record documents), control/support documentation (procedures, knowledge documents, checklists and templates) and resources (people and IT applications). The new TPC was divided into eight different process phases37 because of the process development work: project development, product development, sales, production management, detailed design, production, product delivery, and customer commitments and services (see figure 23). A number of decision-points (toll gates) were also included to minimise risk taking and enable a more effective risk management. The resulting to-be process and the new TPC is presented in the following section.

37) Natural activity clusters that divide the process into packages with distinct borders.
Figure 23: The housing developer’s to-be process map of the new TPC
4.6 The resulting to-be housing development process

The to-be process has taken care of those insufficiencies encountered in the identification of the as-is conditions. The process is today being implemented throughout the whole organisation on all new projects. Implementation was made easier because of the simultaneous introduction of a new process oriented IS. The IS is more thoroughly described in chapter 5. The process in itself does not handle imperfections or deviations from the surrounding environment; it merely helps the user to mitigate and prepare him/her for risks that might appear during a project. In every process phase and sub-process a plan-do-check-analyse (PDCA) cycle is assumed to be running. This section describes the resulting to-be process of the process development work at NCC Housing and elaborates the main activities of the eight process phases.

4.6.1 Project development

The project development phase is intended to create a tenable project idea to support the acquisition of a landed property. Here, the opportunities and risks, if any, are clarified for future development. Prerequisites for initiating a TPC are the company’s strategy, budget, area investigations, market investigations, sales statistics and lessons learned.

When an attractive site is located the initial activity is to perform a site investigation, evaluating the location and the surrounding environment; in other words, performing a site analysis and a competition investigation. If the site still looks promising a complementary ground investigation is being performed. Here, an environmental analysis is performed, photo documentation established and maps obtained. Based on these early results rough sketches of the proposed housing development begin to take shape.

A feasible sales price is derived from an extensive analysis of the capacity to pay in the locality. Based on this an early economical analysis is performed including a cost estimate of the land development and the preliminary production and living costs. Prior to the decision to purchase the land, a risk and opportunity analysis is performed where a contingency plan is produced to take account of possible risks. The result is then included in a project business plan that together with a memorandum regarding the purchase and a proposition to purchase the site forms the basis for a decision to purchase.

If the executive management at NCC Housing decides to approve the purchase of the site, a contract or some kind of agreement is drawn up with the seller and the registration of the land is concluded. In the event that a site is purchased and not de-
4.6.2 Product development

The product development phase is intended to design an appealing product for future customers. Here, possibilities and risks, if any, are clarified for future production and sales. A prerequisite for commencing the product development phase is a clear to go decision from the company’s executive management as described earlier.

Initially, the product characteristics are formulated from the base material produced in the project development phase. This includes performing a customer survey to identify desired product characteristics, identifying possible reference objects, performing an environmental analysis and the development of an environmental profile for the project. Based on this a program is made with preliminary product sketches to be used for displaying the developer’s intentions to the parties involved in the subsequent work. To be prepared for unwanted eventualities in the development planning process an action plan and communication plan for the process is created.

As a prerequisite for the development of the site the developer has certain obligations to the city or municipality. This is the case if the developer wants to create or change a detailed development plan for the property. A good way to start is to obtain the general plan for the municipality/city. Based on this and on earlier investigations a development programme is created with a new detailed development plan, illustrating the general characteristics of the intended use of the landed property. A developer’s brief with an environmental-impact assessment has to be produced and delivered to the correct authority. After the delivery the consultation period between the developer and the municipality/city is initiated. During this time the development is put out for public display allowing free scope for public objections and, if deemed necessary, appeals to the state. If there are no major public concerns about the new development the detailed development plan is approved.

In the period that follows, the developer concurrently commences with the building permit design and the principal document design. The former starts with a design brief which then is followed by the creation of building-permit documents. As mentioned earlier, the principal document design runs concurrently with the building permit design and outlines the design output and describes minimal technical requirements. Thus, this is where various analyses, administrative documents, archi-
tectural drawings and work specification are created, together with fire protection specifications and the master schedule. Based on this and the results of meetings, an application for a building permit is supplied to the municipality/city for approval.

A new sales price is derived, based on the market conditions and the intended product. The results from the principal document design are then supplied to the corporate contractor for a production price quote. Based on the results of this a final financial analysis is performed, including a cost estimate of the land development and the quoted production and living costs. The overall sales work is also planned here including the creation of a sales strategy and sales forecast. From the sales strategy, advertising resources and capital requirements are estimated, a sales budget and a time schedule is created together with a pricing strategy, which has to be synchronised with the project schedule. Hence, the financing of the production has to be established. This is performed by a quotation inquiry to a financial institution, which if accepted is followed by the drawing up of a financing contract and the establishment of a payment plan for the project.

Prior to the decision to commence production, a risk and opportunity analysis is performed to detect new and unexpected risks and possibilities, whereby a contingency plan is produced to take account of possible risks during the production phase. The result is then incorporated into a project business plan that, together with a memorandum regarding the decision to commence production, forms the basis for a decision to commence with production of the property. If the executive management decides to approve the developed project, this instigates the sales, production management and the detailed design phases.

4.6.3 Sales

The sales phase is intended to control the sales efforts of the developer by creating conditions for satisfied customers. This is taken care of by providing the customer with sufficient information and service and, at the same time, taking care of the internal coordination with the contractor so that the right product is delivered. A prerequisite for the sales phase is the sales strategy and the time schedule, created in the product development phase, which together control sales activities.

Initiated by the decision to commence production, the sales operation starts with the performance of pre-sales planning, where advertisements, contacts with the

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press, open houses, sales material and handling the choice of extras are scrutinised
and prepared. When this is completed the sales activities are started. The initial
stage involves capturing the customer’s interest in the product. This is achieved
through advertisements in newspapers, sales boutiques, on the Internet and
sending out letters of interest to customers registered in the interest database. Other
customer contacts, such as enquiries by email, telephone and from the sales
boutique are used. Reviews of sales competition in the surrounding area are also
undertaken. The interest register is also kept up-to-date.

Meeting the customer, through personal consultation, supplying attractive brochures
describing the area, answering questions from the customer and convincing the
customer about the advantages of choosing the developer’s product in comparison
to competitive products/developments follows. This also includes taking care of
planned open houses and scheduling individual shows of the product to potential
customers in a professional manner. Taking care of product reservations and the
drawing up of reservation agreements with the customer hopefully follow. Subse-
quently, there is assistance to customers regarding banking contacts and providing
customers with information about what happens when purchasing a property.
Orders for extras, revisions/additions, entering orders into the production and
product delivery process need also to be considered. The penultimate action is to
sell the product/service and draw up the contract of sale and bill of sale with the
customer. Finally, the house owner address list is brought up to date and sales
status reports are generated.

4.6.4 Production management

The production management phase is intended to control the production and sales of
the developer’s product securing a high product quality and creating conditions for
satisfied customers. This involves taking necessary action, when it comes to
control, coordination of the production and providing the contractor with clear
instructions. The prerequisite for the production management phase are the prin-cipal
documents and master schedule for production.

Initiated by the decision to commence production, a tender procedure with con-
tractors is carried through based on the principal documents from the developer.
The developer then collects the contractors’ bids according to the tender docu-
ments for building, earthwork and miscellaneous. Subsequently, the contracts/
agreements should be signed after the contracts have been negotiated and
reviewed. Before starting production the developer has to notify the correct
authorities. Thus, file an internal project notification, insurance notification, a
preliminary application to the Swedish Work Environment Authority, production
notification to the municipality/city and notification of liable quality manager according to the law on planning and building (PBL). The developer also has to establishing a production bond, notification of insurance, third party liability insurance, and warranties/bonds of invested capital. Also, together with the contractors establish a production schedule, a choice of extras schedule, an occupancy schedule and an inspection schedule to secure a smooth handling of the production and prepare products for delivery. Before starting the actual construction activities the developer has a consultation meeting with the municipality/city where a control plan according to the law on planning and building (PBL) is established.

The developer manages the production and delivery process through production meetings, starting with a project brief with the contractor, a production start meeting and frequent production meetings (every second to fourth week). To ensure that the production is going to run well the developer asks for the contractor’s quality and environmental plans; and to analyse the environmental restrictions an environmental analysis and a final environmental profile are performed. In addition, control plans and audit reports are monitored and checked to ensure product/service quality. Production costs are also monitored and checked against the production budget and quarterly forecasts are checked against actual disbursement to prevent surprises. Costs for change orders and additional work are documented and costs and revenues for choices of extras are checked against previously established plans.

4.6.5 Detailed design

The detailed design phase is intended to produce complete production drawings and specifications enabling an efficient production phase. The documentation is intended to make clear the risks and opportunities during the production phase. Prerequisites for the detailed design are the principal documents and master schedule for the production phase, which is supplied to the contractor by the developer. From the developer’s perspective the detailed design phase is initiated by the distribution of tender documents to the contractors involved in the production. However, prior to that, the developer selects an appropriate design manager to control the detailed design. Hence, the design manager creates design directions; a design schedule, an interface list and a distribution plan that forms the basis for the detailed design control. To control and manage the detailed design and the CAD coordination the developer carries through an initial design brief with the parties concerned. To assure a high detailed design quality, the developer conducts design meetings with the design team on a regular basis throughout the whole of the detailed design phase.
The developer also makes it clear that certain project analyses must be performed, i.e. those for energy, fire, noise and sound. Through participation in the detailed design the developer sees to it that there are no question marks and that sufficient drawings and specifications are produced. The document check-up is controlled though a check-up memo and a check-up protocol. The document check-up follows the designer’s self-control plan and occupational safety and health check-list. Finally, the documents are put together and priced to form the bid, which is received by the developer who, through negotiations with the contractor, draws up a contract for the production works.

4.6.6 Production
The developer does not have its own production capabilities, having the whole production phase outsourced to internal contractors within the same corporation. The developer controls and coordinates the production phase through its own production management function. The developer strives to have partnering agreements as often as possible with the contractors to eliminate conflicting goals and eliminate double profit mark-ups. In addition, the intention is to minimise waste and receive a product that corresponds with the proposed design, with customisations as a result of the choice of extras.

4.6.7 Product delivery
The product delivery phase is intended to ensure that the developer provides the customer with a product having zero defects. Also, to assure that the project result is properly followed up and documented, records are gathered of the as-is for placing in the archive.

From the sales, production and production management phases as-is documentation is compiled in the form of drawings and specifications describing the actual product from changes performed during the production phase. The developer also performs and collects reports from the final tests and controls, i.e. functionality tests, official inspections, self inspections, final controls from the contractors and subcontractors, together with a final self inspection. As a final confirmation that the developer has received the required product, the developer makes sure that product inspections are performed by a third party. The developer is present at all inspection occasions, i.e. the final inspection and post inspections if any. A final check is performed and a letter of proof of zero defects is obtained.

Customer documents are put together in the form of operating and maintenance instructions and home documents: these documents are handed over to the cus-
customer. They comprise product information, i.e. technical aspects, practical arrangements, keys, subscriptions and waste handling. Previously, billing the customer and secure/check that payments have been taken care of by the customer. To summarise the sales activities a final sales meeting is performed. Two weeks after the customer has moved in a moving-in survey questionnaire is posted to the customer asking him/her to evaluate the performance and service supplied by the developer.

In connection with the project’s completion and handover, the developer holds an end-meeting with the contractors, where the project is evaluated from their perspective. As a supplement to this, the developer holds an internal end-meeting where suppliers are evaluated and lessons learned are captured in the form of measures and successful activities. To ensure that the developer receives both qualitative and quantitative information the executive management of the developer requests decision support material to signal that the appropriate historical information has been gathered. When the decision to end the project is taken the project is handed over to the developer’s warranty group, which takes care of customer complaints during the warranty period.

4.6.8 Customer commitments and services

The customer commitment and services phase is intended to ensure that the developer’s customers feel satisfied with purchase of their new home and are taken care of sufficiently to ensure that it stays that way. With the help of the records and other documentation the developer continues to provide the customer with help. An important activity in this phase is handling customer considerations, complaints and claims. Negative outcomes are best prevented through continual contact between the developer and the customer. Dialogue with customers enables agreement on the best possible solution to the problem. One way to minimise disputes is to be keen to hear about the slightest problem expressed by a customer.

One year after the purchase, a survey is mailed to the customer, asking him/her to evaluate his/her experience of living in one of the developer’s homes. Customers are given room to express themselves and provide their opinions about their first year in the new home. This survey is then analysed and brought back to the developer’s operations. During the warranty period the developer is also obliged to correct defects, in accordance with the developer’s warranty. Before expiration of the warranty period (two years after delivery to the customer) an inspection is undertaken to hand over a defect-free product to the owner.
4.7 Conclusions

The research presented in this chapter is based largely on a literature review of current best practice within the process orientation field together with an extensive development effort conducted on a large housing developer. This study has extended the scope of process orientation to incorporate the management principles of customer focus, leadership, involvement and commitment of people, a process approach, systems approach to management, continual improvement, factual approach to decision-making and mutually beneficial supplier relationships. During the process development work, the importance of involving people was found to be crucial for the result as well as the acceptance of the new working system. It was also noticed that potentially complex process models were easily replaced with straightforward illustrations in the form of tables and models. During the study, a number of important steps and suggestions for performing a process orientation became apparent and can be summarised as follows.

- Establish aim and objectives for the development work
- Establish a development organisation
- Identify and define the *as-is* processes
- Implement a process oriented information system
- Continually improve process performance

Furthermore, the organisation now understands that a process orientation is about continuously striving for improvement and is not a one-time effort. The increased focus on processes has also encouraged executives, middle management and other personnel to become active in discussions of how things work or ought to be working. Thus, the focus on processes brings an organisation closer to performing against defined goals. Consequently, one can conclude that one of the main prerequisites for a significant improvement in an organisation is to understand the bigger picture. Another conclusion that can be drawn from this work is the importance of IT for the instantiation of a work system, which is more thoroughly described in the following chapter.
5. Process instantiation and information system development

5.1 Introduction
Process orientation initiatives have tended to be supported by paper-based process models and procedures, describing the ‘dos’ and ‘don’ts’. This often makes them too complex for users, leading to little benefit to the organisations despite the substantial effort put into describing the processes. Progressive computerisation of processes has increased the flow of information, but not necessarily improved efficiency and cost effectiveness. One of the many reasons for this may lay in an over-confidence in the technologies themselves rather than seeing them as enablers of major improvement (Davenport 1993). Thus, the focus on technology instead of on information has led to a backlash against information issues in general. Most organisations report rising costs instead of cost reductions (Maguire 2000). Even so, IT is an essential component for improving flow efficiency in a value chain (Paulson et al. 2000). However, without process knowledge, the use of IT to improve efficiency and cost effectiveness will continue to disappoint. Since, process orientation success is linked to the extent to which one can manage interdependencies between activities, people and materials, IT is seen as a principal enabler. This chapter discusses the important role of IT as an enabler of a process instantiation and the development of a process oriented IS supporting housing development projects.

5.2 Information technology as enablers of process orientations
Today, it is more the rule than the exception that IS projects run over budget, behind schedule, provide poor quality, or simply fail to satisfy user requirements adequately (Coombs et al. 1999). Until recently, IT has been seen as a driver for the
development of many construction organisations and operational processes (Aouad et al. 1999). This is about to change as business and work processes start to be seen as ways to achieve competitive advantage. Davenport (1993) stated that process thinking powered by IT could yield the levels of improvement in processes required by a modern business environment. IT is also often presented as the solution to a company’s problem, but the technology itself is not sufficient to make the improvement happen by itself (O’Dell and Grayson 1998). IT is only useful if it helps employees do their work better and more efficiently.

Instead of seeing IT as a solution, IT should be seen as a competent enabler of a process orientation allowing organisations to change radically their ways of conducting work in different ways. IT is especially interesting in the effective implementation of processes in terms of managing information and communication, since every process activity creates and uses information (Porter 1985). In recent years, due to the growing use of the Internet, interest has shifted from systems that support functional processes to systems that support processes capturing the entire value chain of a product or service (Masuda et al. 2000). By using web-based ISs as implementation vehicles, organisations can naturally integrate work process into daily work procedures and simultaneously manage more information.

In construction the notion of projects takes on particular importance, due to the fact that all revenue is generated in this respect. Moreover, there is a strong correlation between the communication process and the project process (Lee et al. 2001). This correlation lends support to the assumption that projects, due to the use of ISs, can reduce information management costs considerably. So, a principal aim in the construction sector is to improve communication and information management in the project context by providing a process-architecture. As the construction sector gets more and more familiar with IT there is a tendency to demand more access to information and other people’s knowledge, but also more effective tools that quickly become part of daily work (O’Dell and Grayson 1998). From an information process perspective this would help improve communication and dissemination of information within an organisation as well as between organisations (Aouad et al. 1999). Consequently, modern information and communication technologies are seen as key facilitators in supporting organisational information processing (Maier, 1998). Available technologies that support the development of ISs are:
• integrated databases;
• electronic data interchange (EDI);
• product document systems;
• Internet and intranet applications;
• document management systems;
• groupware systems; and
• conferencing systems.

Paulson et al. (2000) states that the Internet is a good basis for the development of a process oriented ISs. Thus, what is needed is an IS that describes the process and helps people manage information and communication, i.e. to develop, acquire, identify, preserve, utilise and disseminate information. In the broadest sense, these technologies enable new forms of organisational designs by taking care of communications, links and knowledge enhancement previously performed by the hierarchy (Nadler et al. 1995). These technologies often have an open architecture that can be adapted to fit organisations existing features and develop new systems (Orlikowski and Hofman 1997). Special features of advantages of such systems are that they allow organisations to function independently of time and place to manage information, facilitate collaboration and teamwork, facilitate learning, and support communication and coordination (Nadler et al. 1995; Orlikowski and Hofman 1997; O'Dell and Grayson 1998; Aouad et al. 1999; Maier and Lehner 2000).

5.3 Developing an information system supporting the process oriented work system

Based on the reasoning in the previous section and the process orientation work it was decided to develop a web-based IS for housing development projects. Instead of laboriously describing data elements a somewhat more pragmatic approach was taken to the development, where the document was put under the spotlight. Davenport (1993) states that managers “understand the document as a unit of information but they are not usually interested in data elements.” So by using the document as the main construct of the IS, projects can improve their information management and when properly used can become a success factor in a project’s communication network (Lee et al. 2001). Therefore, the latest and most sophisticated IT was not used to fulfil the process instantiation. Moreover, it was decided to use the Internet as an interface for the IS, as distance and location are often difficult to control in housing development projects. In this way, it is possible to manage information across the whole value chain, connecting people to people, information to people and people to information.
So, when the as-is housing development process had been identified and defined the journey had just begun. The next step was, simultaneously with the process development work described in chapter four, to instantiate the process description through the development of a process-oriented IS. This allowed the information from the process description to act as a template for the project plan, which guides the project. The new IS was developed to integrate all project-related systems (management system, quality management system, environmental management system, project control system and operation control system) into one tool, combining the concepts of project collaboration tools and quality management systems. In doing so, this simplified information/documentation handling and improved system usability. By structuring the system after the housing development process, the flows became increasingly more clear and accessible for the users, guiding their daily work and facilitating information and communication exchange throughout the entire project. The following paragraphs briefly describe the development of the IS.

5.3.1 Specification of requirements
Prior to the development of the new process-oriented IS, a thorough review of the needs was performed. The experience from an internally developed IS was taken into consideration when introducing the requirements into the specifications. Based on these specifications the development was put out for tender early in the summer of 2000. Based on the best proposal, a contract was signed with an IS developer. The contract was based on the following requirements for the new IS (see table 2). The finished IS was delivered to NCC Housing in early 2001.
5.4 Information system description

The development of the new process oriented IS (referred to PDS) was performed in collaboration with Lotus as the IS was to be based on its standard packages of Domino.doc, Teamroom™ and Dols (Domino OffLine Services) (see figure 24). To integrate the IS with non-compliant desktop applications the IS uses a web-interface both online and offline. The IS, because of its general appearance – handling documents in projects between stakeholders – becomes the core for all projects. For this reason, the IS will become the most widely used IT application and will

<table>
<thead>
<tr>
<th>Table 2: The main requirements in the IS development specifications</th>
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<tbody>
<tr>
<td>• Process oriented</td>
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<tr>
<td>• Workflow and document control</td>
</tr>
<tr>
<td>• Role based access and security handling</td>
</tr>
<tr>
<td>• Dynamic system environment</td>
</tr>
<tr>
<td>• Digital filing</td>
</tr>
<tr>
<td>• Including project documentation needs and document structure</td>
</tr>
<tr>
<td>• Supporting all types of documents</td>
</tr>
<tr>
<td>• Supporting meta-data about documents</td>
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<tr>
<td>• Event notification</td>
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<tr>
<td>• Mail handling</td>
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<tr>
<td>• Supporting comments about documents</td>
</tr>
<tr>
<td>• Meta-data and full-text search handling</td>
</tr>
<tr>
<td>• Version handling support</td>
</tr>
<tr>
<td>• Document status support</td>
</tr>
<tr>
<td>• Automated access updates at document approval</td>
</tr>
<tr>
<td>• Off-line handling</td>
</tr>
<tr>
<td>• User initiated or scheduled automatic synchronisation</td>
</tr>
<tr>
<td>• Web-based technology</td>
</tr>
<tr>
<td>• Support dial-up connections</td>
</tr>
<tr>
<td>• Centrally located servers and documents</td>
</tr>
<tr>
<td>• Document tractability</td>
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<tr>
<td>• Possibility to exchange information, share working material and coordinate work</td>
</tr>
<tr>
<td>• Supporting information subscription</td>
</tr>
<tr>
<td>• Project calendar</td>
</tr>
<tr>
<td>• Addresses to project members</td>
</tr>
<tr>
<td>• Document register printouts</td>
</tr>
<tr>
<td>• Access managed by project coordinator</td>
</tr>
<tr>
<td>• Possibility to restrict project phase access capability</td>
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<tr>
<td>• Possibility to limit access by time restriction for each catalogue</td>
</tr>
<tr>
<td>• Supporting links to other information systems</td>
</tr>
<tr>
<td>• 50 000 stakeholders</td>
</tr>
<tr>
<td>• 45 000 external stakeholders</td>
</tr>
<tr>
<td>• User-friendly</td>
</tr>
<tr>
<td>• Possibility to trace who has read the document</td>
</tr>
<tr>
<td>• Supporting report creation</td>
</tr>
<tr>
<td>• Notification through user interface, mail</td>
</tr>
</tbody>
</table>

5.3.2 Integrating the process structure in the information system

Based on the specification list, work was started by the IS developer. The requirements as described were followed and every week there was a presentation of what had been developed, so that NCC Housing could see how the project was running. It was also a good time to comment on over-complicated features that might hinder user satisfaction. The new process oriented IS was developed on a common platform, enabling the whole corporation and external stakeholders to benefit from it. The following section gives a more detailed description of the IS.
affect more people than any other IT system within the corporation. The remaining part of this section will describe the functions of the IS. The first interaction with the IS presents the process phases as file folders in the left tree structure (see figure 25). This view corresponds to the library database of Domino.Doc. Thus, the library database is the top of the hierarchy and the entry point into the IS. This top level provides a navigational structure and supports the user in searching for documents and performing administrative tasks such as preparing documents.

The file folders found on the start page are then decomposed to display subprocesses (see figure 26). In this example, the site investigation subprocesses have been selected. These correspond to the so-called file cabinets, which are accessible through the library database. From the sub-processes it is then possible to access...
the activities, which appear in a drop list from the top of the web page. In Domino.Doc these correspond to the binders. In figure 26 the activity is "lägesvärdering" (site valuation in Swedish) which can be seen as a white marking of the activity. Users will not generally work directly with the Domino.Doc server, but instead will access documents from desktop applications that have been integrated with it. The basic element is the activity template (see figure 27), which acts as an identity paper for any piece of information being stored in Domino.Doc. The identity paper contains information about the author of the information, title, creation date, modification date, document-version and distribution history. Documents can (and typically are) organised into activities. One can set up a binder to include only certain types of documents or be viewed by certain users only. For example, it is possible to have a binder for project documents that one’s own project team can access. From this interface, by the "hämta" button it is possible to access help documents for the activity from the work system, i.e. procedures, knowledge documents, checklists and templates (see figure 28). In figure 29 a document has been attached to the activity template. When this activity template is later published in the IS it is accessible for everyone authorised in the project IS and contains a short description of the content and a record of who created the document, when it was published and which version (see figure 30 and figure 31).

Figure 26: The filing cabinet database structure of the IS
Figure 27: Activity templates in the IS

Figure 28: Support documents found under the *Hämta* button in the activity template
Figure 29: An attached document to the activity template

Figure 30: A published activity template with adherent documents
In terms of the archive, the aim is that all projects longer than six months will use PDS to file project documents. Since documents will be saved in one single place it will always be easy to access a document of current interest from different locations through a web-connection (see figure 32).

Figure 31: Document available to everyone authorised in the project

Figure 32: An schematic of what is covered by the IS
The IS fulfils the requirements envisioned by Georgakopoulos et al. (1995) of an environment supporting coordination and collaboration of humans, one that improves human throughput (see figure 33). People must, however, ensure the consistency of documents and workflow results. Figure 33 shows an example of how the IS is being used to support the information management process of participants in a project. Simply put, the participants share a common desktop where information is created, read, distributed, organised or stored. The IS also supports offline work, i.e. the software is downloaded to a computer enabling the user to continue to work without being connected to the Internet. However, this requires the user to synchronise with the server before going off-line. By doing so the user can be sure that he/she has the latest information on the computer.

![Diagram of project participants and their activities](image)

**Figure 33: An example of how the IS is being used within a project**

### 5.5 Conclusions

As previously indicated in this chapter, IT is seen as an important enabler of a process orientation and especially the implementation of ISs. For over two decades there has been a common understanding that the benefit of introducing ISs is to reduce the cost of managing jobs. In the construction sector, not unlike other industrial sectors, IT has been successfully implemented in its various places, e.g. in planning, cost estimating and design, but there has been little attention to the use of IT within a process context. This chapter has described the development of an IS which supports a shared workspace and effective document management, thus allowing communication, collaboration and coordination between project participants, but also taking care of general document management characteristics such as version handling, template storage and document storage. The IS provides a
process-oriented point of view of a single project to information and people. It can be concluded that an effective IS can be implemented if users, managers, and IS developers work together as a team during the development process, and the intended process which the system is supposed to support is known. As the web-based IS aimed at combining a process oriented work system with an IS, the opportunity to assess the impact of the process perspectives on the success of the IS was evident.
6. Developing an assessment instrument to measure information system success

6.1 Introduction

After the development of the new IS, there was a need to assess the success of the IS as well as the impact of the process perspectives. Aouad et al. (1999) state that when it comes to evaluating the benefits from research, where both processes and ISs have been studied, these have repeatedly been considered as independent processes without any apparent connection between them. Alter (1999) also points out what he calls the Siamese twin problem, that is, the lack of integration between work systems and ISs. These two conclusions are supported by Seltsikas (2001) who declares that when consulting the literature the lack of in-depth examples of the relationship between ISs and holistic process approaches is clearly evident. Quality of the information management process is rarely described or measured, and ISs are being developed without anyone being fully aware of their impact. Not surprising for such a generic concept, most evidence of success is anecdotal and the literature on process orientation lacks extensive research on an empirical basis (McCormack 1999a). This does, however, make the concept of process quality an ideal subject for testing empirically, by using evidence from the literature. The problem addressed is supported by research in organisational development and ISs as well as in ITC (Björk 1999; Aouad et al. 1999, Alter 1999; Seltsikas 2001).

The only way to evaluate if an IS fulfils its intended objectives is to assess it after implementation. This is why the approach is becoming increasingly important when assessing ISS. Many researches have rejected the approach of only using one dependent variable for measuring ISS and instead advocate a measure of interdependent constructs (DeLone and McLean 1992). The remaining part of this chapter will describe the development of an augmented ISSM, including a common set of variables to measure the dimension of process quality (information
(knowledge) management process). Based on these variables and the process orientation literature review a number of highly recurring process quality measures will be identified. This enables an empirical investigation of the influence of process quality on ISs in addition to the ability to measure IS impact on both individuals and project groups. The two fist sections, as follows, describe the information process and the relationships between the entities of data, information and knowledge. The subsequent sections will then describe the concept of ISs more thoroughly, the assessment of ISS and, finally, the development of a hypothesis construct in the form of an improved instrument for measuring ISS.

6.2 The information process

Until now processes and the principles behind them have been described in a broad sense. In a highly conceptual way the process can be divided into information processes, which generates information and material processes that produce services of physical objects (Björk 1999). The information process initiates and controls the necessary material activities that are required for the production of an object also requiring feedback from the same (Ibid.). Kock et al. (1997) state that “business-related information has been identified as the single most important factor ultimately defining organisational competitiveness.” Thus, the information process is critical to fitness and success of the organisation (Schein 1992). In construction the information process starts well before the material process with the project development phase and the product development phase. If studying the project management discipline within housing development projects, it is primarily (if not entirely) located in the information process, making the information process an appropriate candidate for improvement. Kock et al. (1997) state that, based on a study of 22 business processes in two continents, there is a need to focus on the information processes when involved in a process initiative. The assessment, in this study, focuses entirely on the information process, which will become clearer later on in this chapter.

6.2.1 Information, data and knowledge

The entities of information, data and knowledge are closely related. These terms are used constantly in our daily work but are generally confused with each other (Kaye 1995; Kock et al. 1997). For this reason, it is difficult to compare research results dealing with information impact. In general though, data are regarded as raw facts, information is considered as an organised set of data, and knowledge is perceived as meaningful information by the interpretation of individuals (Bhatt 2001). The following part of this section will focus on the differences between the entities and the use of these in this research.
DATA
More precisely data can be explained as syntactic entities, patterns without meaning, which form input to an interpretation process – see figure 34 – (Aamodt and Nygård 1995). The most common description of the relationship between the different concepts is that data becomes information when provided with relevance, meaning and purpose (Drucker 1988). In other words, data becomes information when it is presented as a message that makes a difference to the receiver of the message (Andersson 2000). Thus, data becomes information when it is provided with knowledge (Drucker 1988).

Figure 34: The data-information-knowledge model (Aamodt and Nygård 1995)

INFORMATION
Information can be described as interpreted data, i.e. data with meaning, which creates an input to a knowledge-based process (Aamodt and Nygård 1995). Thus, information is data that have been put into context (Sverlinger 2000). In contrast to popular belief, information is not an entity that can be processed automatically by computers but is the result of human interpretation of data (Lueg 2001).

KNOWLEDGE
Information transforms to knowledge through comparison, consequence, connections and conversation by humans (Andersson 2000). Knowledge is therefore learned information transformed by the learning process of humans (Aamodt and Nygård 1995). One way of transferring knowledge is through socialisation between individuals. Another way is to deliver information that people can make meaning of, represented by virtue of facts, rules, manuals or best practices descriptions (Lueg 2001). Thus, for information to become knowledge one has to supply
knowledge. In general, the role of knowledge is to play the active part in the process of transforming data into information, deriving other information, and acquiring new knowledge (see figure 34). Hence, information is descriptive and knowledge is eminently predictive (Kock et al. 1997).

### 6.2.2 Common use of the word information in the study

Among professionals in the construction industry the words of data, information and knowledge are used in a casual manner and often no distinctions are made between them. As can be observed from the previous description of the different words this does not reflect the true position. Knowledge is achieved through individual learning whilst information can be put together by elaborating data with the help of earlier achieved knowledge. The word information is a well-established word among personnel in the environment surrounding the company under study as well as in the construction sector at large. The word is, however, used synonymously with both information and data. Since the respondents, as well as those in the wider sector, do not distinguish between information and data, the word information has been used in dialogue and discussion. No distinction is made either in the conclusions between these. Knowledge is, however, interpreted as information being learned and reflected upon by an individual. For these reasons, what constitutes knowledge is referred to as knowledge, but what constitutes information and data is referred to as information in dialogue with the respondents (PMs). Information is therefore used as a synonym for both data and information in the questionnaire survey instrument, whereas knowledge is understood as learned and reflected-upon information.

### 6.3 Information systems

ISs as described previously are seen as powerful enablers of process orientation initiatives and the purpose of these is to support the use of information in an organisation. The computerised IS basically consists of an information base, a set of information processes, and IT (Boman et al. 1997). ISs are increasingly being implemented for strategic reasons such as enabling improved organisational performance by streamlining information management tasks (Kennerley and Neely 1998). Samuelsson et al. (1977) defines an IS as:

… that combination of human and computer-based capital resources which results in the collection, storage, retrieval, communication, and use of data for the purpose of efficient management (planning, decision-making, reporting and control) of operations in organisations.
Usually an IS is referred to a computerised system that supports users in the creation, acquisition, identification, preservation, utilisation and dissemination of information for decision making, control, analysis and visualisation in an organisation. Thus, ISs are intended to store and process structures that are to be implemented as information for the user and provide the means for documenting the trivia of business activities (Aamodt and Nygård 1995). Consequently, an IS must support users, business processes, work practices and indirectly the strategies of an organisation. ISs are called many things in emphasising the ownership, functions and disciplines in which they are used or for which they have been developed. The following names can be related to ISs:

- executive information systems;
- management information systems;
- cooperative information systems;
- knowledge management system;
- document management systems;
- workflow management systems;
- organisational memory systems; and
- process management systems.

Many ISs use the same technical platforms, e.g. workflow management systems, process management systems, knowledge management systems, document management systems, organisational memory systems and cooperative information systems. These different ISs have in many cases used Lotus Notes databases as the technical platform (Georgakopoulos et al. 1995; De Michelis et al. 1998; O’Dell and Grayson 1998; Abecker et al. 1998). One of the main tasks of an IS is to assist the user in the execution of task, but also present relevant information that helps users do their jobs better and more effectively (Abecker et al. 1998). A common feature of ISs is that they all handle structured and formalised information, but recently they have started to support informal communication (conference systems and workflow systems) (Boman et al. 1997). Thus, an IS is the necessary infrastructure for the organisation to implement information management processes (Hall et al. 2001). An IS should, therefore, in an organisational context, support the characteristics of decision-making, learning, information management, information sharing, communication, coordination, cooperation and collaboration.

6.4 Information system success

A substantial body of ISs research has been concerned with IS implementation and ISS (Larsen and Myers 1999). Ives et al. (1984) found that IS survey research suffered from poor instruments and lack of control. Baroudi and Orlikowski
(1988) found a general lack of statistical power in IS research. As a consequence of these, the assessment of ISs has been given much attention over the past two decades, and a plethora of instruments have been developed and used (Baroudi and Orlikowski 1988; Doll and Torkzadeh 1988; Lewis 1995; Seddon and Kiew 1996; McGill et al. 2000a; Barnes and Vidgen 2002). In these instruments, different foci have been applied, where some researchers have chosen to focus on the system itself (Sanders 1984; Davis 1989) while some have chosen to study the information output of the IS (Doll and Torkzadeh 1988; Baroudi and Orlikowski 1988).

Others have focused on measuring actual use and user satisfaction, while others have concentrated on measuring individual and organisational performance due to the use of the IS (DeLone and McLean 1992). As DeLone and McLean (1992) point out “it is hard to deny the success of a system, which its users say that they like.” Doll and Torkzadeh (1988) define user satisfaction as “the affective attitude towards a particular computer application by an end-user who interacts with the application directly” or “the sum of one's positive and negative reactions to a set of factors.” Several instruments have been developed and the most used is the 12-item instrument by Doll and Torkzadeh (1988) (Seddon and Yip 1992). Even though the user satisfaction construct has often been used to evaluate IS effectiveness, “there is no clearly articulated theory relating user satisfaction and IS success” (Woodroof and Kasper 1998). A focus, which has gained ground, is that of measuring individual and organisational impact (Coombs et al. 1999). This can be seen as a response to earlier research, which tended to focus on system issues and performance criteria rather than on individual and organisational impact (Kennerley and Neely 1998). However, accurate measures are needed. To cite Chen et al. (2000): “without an accurate measure of success, organisations cannot evaluate the success of their costly IS projects.”

Many researchers have however rejected the approaches of only using one dependent variable for ISS and instead advocated a measure of interdependent constructs. If any work on ISS can be distinguished from others it is DeLone and McLean’s (1992) ISSM. Their model has received much attention among researchers of ISs. Myers et al. (1998) state that DeLone and McLean’s ISSM is the most comprehensive assessment model offered by the IS research community so far. The ISSM is today accepted as one of the more complete and better-known models (Kennerley and Neely 1998). Since its introduction in 1992 the ISSM has been referred to, and made use of, in over 150 articles in refereed journals and conference proceedings (DeLone and McLean 2001). If one wishes to apply an embracing perspective on the construct of ISS, DeLone and McLean’s (1992) ISSM is the most acknowledged model today. The remaining part of this section will describe the ISSM.
6.4.1 Information system success model

DeLone and McLean developed their ISSM in 1992. They based their success model on Shannon’s (1948) and Shannon and Weaver’s (1949) pioneering work on the theory of communication and Mason’s (1978) later work on information ‘influence theory’ (see table 3). Shannon and Weaver’s (1949) communication theory demonstrates the sequential nature of information, as a form of communication, through the categories of technical level, semantic level and effectiveness or influence. In this serial nature of information the IS (technical level) produces information (semantic level), which is communicated to an intended person who is influenced by the information (Shannon 1948).

Table 3: Categories of ISS (DeLone and McLean 1992)

<table>
<thead>
<tr>
<th>Source Dimensions</th>
<th>Source</th>
<th>Technical level</th>
<th>Semantic level</th>
<th>Effectiveness or influence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shannon and Weaver (1949)</td>
<td>Production</td>
<td>Product</td>
<td>Receipt</td>
<td>Influence on recipient</td>
</tr>
<tr>
<td>Mason (1978)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DeLone and McLean (1992)</td>
<td>System quality</td>
<td>Information quality</td>
<td>System use</td>
<td>User satisfaction</td>
</tr>
</tbody>
</table>

Mason (1978) extended their model by presenting a series of events that take place at the receiving end of an IS. Instead of effectiveness or influence Mason (1978) presented the categories of receipt of information, influence on receipt and the influence on system, also renaming technical level and semantic level to product and production respectively. Thus, information flows through a sequence of phases from its production to its influence on individual and/or organisational performance (DeLone and McLean 1992). DeLone and McLean developed the model of ISS to provide order to the criterion measures utilised in IS evaluations. Based on the process nature of information previously described they came up with six main variables based on Mason’s (1978) categories, i.e. system quality (production), information quality (product), system use (receipt), user satisfaction and individual impact (influence on recipient), and organisational impact (influence on system). However, instead of having one category of influence on receipt, this category was divided into user satisfaction and individual impact. To develop the ISSM and get a representative view of the work that had been done, over 180 articles were reviewed to identify different ISS measures. These measures were then grouped under the appropriate dimensions of ISS (see table 4 page 100).

Thus, each of these dimensions is a composite of numerous and similar measures referred to in the literature. The result was the ISSM shown in figure 35, which is an attempt to reflect the interdependent, process nature of ISS. In the model, "system
quality and information quality singularly and jointly affect both system use and user satisfaction. Additionally, the amount of system use can affect the degree of user satisfaction – positively or negatively – as well as the reverse being true. System use and user satisfaction are direct antecedents of individual impact; and lastly, this impact on individual performance should eventually have some organisational impact” (DeLone and McLean 1992).

The ISSM provides a valuable evaluation framework and according to Seddon and Kiew (1996) the model contributes to the classification of the multitude of ISS measures and provides a model of interdependencies between these. Linking the measures to a variety of contingency variables has undoubtedly brought a higher degree of sophistication to the assessment of ISS and has given researchers a method for selecting the most apt measures for the situation at hand (Arogyasamy 2000).

![Figure 35: The ISSM (DeLone and McLean 1992)](image)
DeLone and McLean (1992) state that the appropriateness of the measures are dependent on “the objectives of the research, the organisational context, the aspect of the IS which is addressed by the study, the independent variable under investigation, the research method, and the level of analysis.” Consequently, researchers should create a comprehensive measurement instrument by systematically combining individual measures from the ISSM (*Ibid*). DeLone and McLean (1992) also state that there clearly is a need for development and validation before it can serve as a basis for the selection of appropriate ISS measures. Since the model was

<table>
<thead>
<tr>
<th>System quality</th>
<th>Information quality</th>
<th>System use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data accuracy</td>
<td>Importance</td>
<td>use/ duration of use:</td>
</tr>
<tr>
<td>Data currency</td>
<td>Relevance</td>
<td>Number of inquiries</td>
</tr>
<tr>
<td>Database contents</td>
<td>Usefulness</td>
<td>Amount of connect time</td>
</tr>
<tr>
<td>Ease of use</td>
<td>Informativeness</td>
<td>Number of functions used</td>
</tr>
<tr>
<td>Ease of learning</td>
<td>Usableness</td>
<td>Number of records accessed</td>
</tr>
<tr>
<td>Convenience of access</td>
<td>Understandability</td>
<td>Frequency of access</td>
</tr>
<tr>
<td>Human factors</td>
<td>Readability</td>
<td>Frequency of report request</td>
</tr>
<tr>
<td>Realisation of user requirements</td>
<td>Clarity</td>
<td>Number of reports generated</td>
</tr>
<tr>
<td>Usefulness of system features and functions</td>
<td>Format</td>
<td>Used by whom? Direct vs., chauffeured use Binary</td>
</tr>
<tr>
<td>System accuracy</td>
<td>Appearance</td>
<td>Use:</td>
</tr>
<tr>
<td>System flexibility</td>
<td>Content</td>
<td>Use vs. Non-use Actual vs.</td>
</tr>
<tr>
<td>System reliability</td>
<td>Accuracy</td>
<td>Reported use</td>
</tr>
<tr>
<td>System sophistication</td>
<td>Precision</td>
<td>Nature of use:</td>
</tr>
<tr>
<td>Integration of systems</td>
<td>Sufficiency</td>
<td>Use for intended purpose</td>
</tr>
<tr>
<td>System efficiency</td>
<td>Completeness</td>
<td>Appropriate use</td>
</tr>
<tr>
<td>Resource utilisation</td>
<td>Reliability</td>
<td>Type of information used</td>
</tr>
<tr>
<td>Response time</td>
<td>Currency</td>
<td>Purpose of use</td>
</tr>
<tr>
<td>Turnaround time</td>
<td>Timeliness</td>
<td>Levels of use:</td>
</tr>
<tr>
<td></td>
<td>Comparability</td>
<td>General vs. Specific</td>
</tr>
<tr>
<td></td>
<td>Quantitiveness</td>
<td>Recurring use</td>
</tr>
<tr>
<td></td>
<td>Freedom from bias</td>
<td>Institutionalisation / routinisation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Report acceptance of use</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Percentage used vs. Opportunity for use</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Voluntariness of use</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Motivation of use</td>
</tr>
</tbody>
</table>

Table 4: ISS dimensions and their adjacent variables (DeLone and McLean 1992)
### User satisfaction
- Satisfaction with specifics
- Overall satisfaction
- Single item measure
- Information satisfaction:
  - Difference between information needed and received
- Enjoyment
- Software satisfaction
- Decision-making satisfaction

### Individual impact
- Information understanding
- Learning
- Accurate interpretation
- Information awareness
- Information recall
- Problem identification
- Decision effectiveness:
  - Decision quality
  - Improved decision analysis
  - Correctness of decision
  - Time to make decision
  - Confidence in decision
  - Decision-making participation
  - Improved individual productivity
  - Change in decision
  - Causes management action
  - Task performance
  - Quality of plans
  - Individual power of influence
  - Personal valuation of IS
  - Willingness to pay for information

### Organisational impact
- Application portfolio:
  - Range and scope of application
  - Number of critical applications
  - Operating cost reductions
  - Staff reductions
  - Overall productivity gains
  - Increased revenues
  - Increased sales
  - Increased market share
  - Increased profits
  - Return on investment
  - Return on assets
  - Ratio of net income to operating expenses
  - Cost/benefit ratio
  - Stock price
  - Increased work volume
  - Product quality
  - Contribution to achieving goals
  - Service effectiveness

Defined it has been widely used as a basis of empirical research (Kennerley and Neely 1998). Many researchers have tried parts of the model and a number have added new variables leaving out the important variables of individual and organisational impact and vice versa. However, no attempt has been made to develop an instrument that embraces the entire construct. Consequently, there has been no complete empirical test of the relationships in the ISSM, even though several of the relationships of the models have been empirically tested (Seddon and Kiew 1996). The following section describes the extension of the ISSM for the purpose of de-
developing an assessment instrument to measure ISS as well as the impact of process quality.

6.5 Extending the information system success model

As mentioned earlier, Boman et al. (1997) state that an IS consists of an information base, a set of information processes and IT. In McLean and DeLone’s (1992) ISSM there is a measure for the information base (information quality), for the IT (system quality), but no measure for the information process (process quality). Although it is a comprehensive model it does not include the all-important variable, which measures the perceived quality of the process which the IS supports. Even though many ISs researchers have mentioned the importance of a process perspective it is rarely used when assessing ISS. This important measure is consequently missing and, as stated earlier in this thesis, is an important measure for assessing a process oriented IS. Consequently, the dimension of process quality had to be developed and added to the original ISSM for it to be used in the final assessment instrument. Since the dimension of process quality rarely is used to measure ISS, a common set of variables, based on a number of information (knowledge) management process frameworks, were extracted from the literature (see table 5).

These variables were then accompanied with a number of frequently recurrent measures in the literature displaying the information management process. The variables from the ISSM, displayed in table 4, were chosen based on the objectives of the study, the functionality of the IS and the organisational context as suggested by DeLone and McLean (2001). These were chosen because of their relevance in testing the particular IS developed in connection with this research. DeLone and McLean’s (1992) ISSM was consequently augmented and updated to include the dimensions of process quality enabling an empirical investigation of the influence of process quality on ISS and individual/project performance (see figure 36). In the following section the dimensions of process quality, system quality, information quality, system use, user satisfaction, individual impact and finally project (group) impact are described from a project perspective.
6.5.1 Process quality

Information (knowledge) management is, from an organisational perspective, understood as the management of the information and communication infrastructure as well as the systems supporting the organisational processes, rules and regulations (Maier 1998). A recent process orientation strategy has been to focus on the information management process, addressing the issues of IS efficiency and success, and taking advantage of advancements in technology. These recent approaches in process orientation have focused on improving information management with process-oriented ISs. A key factor in process-oriented information management is the structure, as this rests on an information architecture that supports a process view of the organisation. It is generally accepted that manipulating and generating information is a large part of the operational, as well as the managerial processes (Davenport 1993). Drucker (1954) stressed the importance of information to the managerial profession as its specific tool, stating that a manager:

… does not handle people; he/she [he] motivates, guides, organises people to do their own work. No matter whether the manager’s job is engineering, accounting or selling, his/her [his] effectiveness depends on his/her [his] ability to listen and to read, on his/her [his] ability to speak and to write.

Information management is thus a natural target for a process orientation and it is felt to be a key to an organisation’s competitive success. It is, therefore, critical to understand how the information management process can be organised and effectively managed (Seltikas 2001). Instead of business process reengineering the previously complementary activity of information process reengineering is brought under the spotlight (Georgakopoulos et al. 1995). Thus, “a process orientation may serve to institutionalise unstructured information processes, and thereby help prevent the departure of irreplaceable information skills (Davenport

![Diagram of the extended ISSM (hypothesis model) with nodes for System quality, Information quality, Process quality, Project (group) impact, Individual impact, User satisfaction, System use, and arrows connecting them.](image-url)
As a consequence of the importance of understanding the processes of managing information many attempts have been made to create some kind of framework such as establishing a theory of information management. Over the years, a number of information (knowledge) management process frameworks have been presented (see table 5). These frameworks provide a foundation upon which the process of information management can be understood, measured and evaluated. Thus, enabling improvements to the information management process to be assessed from an individual, group and organisational perspective.

Table 5: Information (knowledge) management process frameworks

<table>
<thead>
<tr>
<th>Source</th>
<th>Framework variables</th>
</tr>
</thead>
<tbody>
<tr>
<td>Liebowitz and Beckman (1988)</td>
<td>Information capture and formalisation, information assessment, information storage, information sharing and distribution information retrieval and use, and information creation.</td>
</tr>
<tr>
<td>Marquardt (1996)</td>
<td>Information acquisition, information creation, information transfer and utilisation, and information storage.</td>
</tr>
<tr>
<td>Harris (1998)</td>
<td>Information creation, information capturing, information organising, information access, information use and information sharing.</td>
</tr>
<tr>
<td>Björk (1999)</td>
<td>Information creation, person-to-person communication, information search and retrieval and Information distribution.</td>
</tr>
<tr>
<td>Rubenstein-Montano et al. (2001)</td>
<td>Information acquisition, information generation and creation, information organising, information sharing and information usage.</td>
</tr>
</tbody>
</table>
The similarities in the different frameworks are apparent. By comparing them it can be noticed that all can fit within the framework presented by Abecker et al. (1998). Based on the Abecker et al. (1998) nomenclature, a common set of variables has been extracted including quality measures of the information management process derived from the literature. In the following section the variables of development, acquisition, identification, preservation, utilisation and dissemination of information (knowledge) are described from a project perspective. Table 6 displays the variables, their measures and sources in the literature.

**Information development** – The information development variable involves the measure of support in creating new information – documentation. The creation of information is discovered through research, experimenting and creative thinking (Liebowitz and Beckman 1998). Björk (1999) describes the creation of new information as one of the early exclusivities of IT.

**Information acquisition** – Information acquisition have been recognised as an area of neglect, with little attention given to the specific problems of project-based organisations (Hall et al. 2001). Abecker et al. (1998) state that information acquisition is made easier with a process perspective. The information acquisition variable therefore contains measures such as capture and formalisation of existing information, i.e. sufficient process and activity representation (Liebowitz and Beckman 1998). An important aspect of the information management process is thus a formal representation of the project process in terms of a process structure for information management (Davenport 1993; Liebowitz and Beckman 1998; Maier and Remus 2001), sufficient detail level in the activity structure (Björk 1999), sufficiently defined process (Davenport 1993; Harris 1998) and activity related information (Davenport 1993). The process structure is the dynamic view that organisations use for delivering value (Ibid.). Consequently, these are important quality measures of the information management process. Maier and Remus (2001) emphasise the importance of using a process structure for information management. Björk (1999) also states that activity related information is essential for the information management process.

Another important aspect for information acquisition is clarity of information context. Thus clarity of process workflow (Brache and Rummelr 1988; Georgakopoulos et al. 1995; Kock et al. 1997; Abecker et al. 1998; Masuda et al. 2000), clarity of performance expectations (Brache and Rummelr 1988) and clarity of important process decision points (Davenport 1993; Aouad et al. 1999) are appropriate measures for evaluation. By integrating decision-making in the process description, decision-making becomes part of the work, clarifying the decision points (Hammer and Champy 1993; Aouad et al. 1999). By using a well-defined process structure,
as described above, the clarity of the process workflow is enhanced (Masuda et al. 2000). The final aspect of information acquisition has to do with the information process description, therefore, making measures like visualisation of logical process work routines (Malmström et al. 1998) and standard process procedure description (Davenport 1993, Hammer and Stanton 1999) appropriate for evaluation. Standardised and logical flows are easier to measure, evaluate, redesign and improve (Nilsson 1999).

**Information identification** – The information identification variable involves measures such as retrieval, search, navigation, publication and availability of information. By integrating the process definitions into everyday work, identification of information is made easier (Harris 1998). Important aspects of information acquisition are support retrieval of decision-making information (Björk 1999), satisfactory information search function (Björk 1999), satisfactory information retrieval function (Björk 1999; Gilchrist and Kibby 2000; Barnes and Vidgen 2000) and effective information retrieval (Björk 1999; Gilchrist and Kibby 2000). This is an area where much business effort is placed on increasing productivity (Gilchrist and Kibby 2000). These are good measures for process quality. Other aspects of information identification are measures such as ease to navigate (Maier and Lehner 2000; Gilchrist and Kibby 2000), publication of information (Maier and Lehner 2000) and information availability (Aouad et al. 1999). Gilchrist and Kibby (2000) state that a corporate taxonomy provides a knowledge map that facilitates navigation and access to the intellectual capital of the organisation. A process map is an example of a taxonomy, which can simplify these aspects. Another important measure of information identification is the ability and availability of information publication (Maier and Lehner 2000). As a solution, Abecker et al. (1998) suggests a document database, which is cheap and plentiful, as well as an easily available source of information.

**Information preservation** – The information preservation variable involves measures such as storing, organising and representing the information repository (Liebowitz and Beckman 1998). Harris (1998) also includes establishing systems and principles for organising, indexing, cataloguing and content classification as well as creating standards and consistent vocabularies in the organising concept. The information preservation variable also involves aspects such as information structuring (Maier and Lehner 2000; Gilchrist and Kibby 2000), documents necessary to create in each activity (Davenport 1993) and clarification of record documents (SIS 2000). The information structuring measure, measures process quality in terms of the ability to structure information from the user perspective (Gilchrist and Kibby 2000). Also, a good process makes it clear what documents are impor-
tant for a specific activity and which documents are record documents. A record
document is something that states the achieved result from the process or provides
evidence of activities performed (SIS 2000).

Other aspects of information preservation are sufficiently organised information
(Lewis, 1995), documentation of existing information (Conklin 1996; Liebowitz and
Beckman 1998; Maier and Lehner 2000; Maier and Remus 2001) and facilitating
version handling (Gibbons et al. 1994). A recent study of organisational perfor-
man...
Resource control is natural parts of the information management process (Davenport 1993). Decision-making as well, being a part of everyone’s job, stresses the importance of greater control (Hammer and Champy 1993). As Davenport (1993) states, “information is particularly relevant to management decision-making.” A formal planning process is a source of information that can support advancement in management (Ibid.), making this and the above aspects good measures of a well functioning information management process.

**Information dissemination** – The information dissemination variable includes measures such as communication, coordination, collaboration, sharing (exchange) and distribution. Information dissemination in project-based industrial sectors such as construction has been identified as a neglected area (Hall et al. 2001). An important aspect of the information management process is, therefore, increased support in peer-to-peer communication (Björk 1999), overall communication (Draft and Lengel 1986; Orlikowski and Hofman 1997; Harris 1998; Malone et al. 1999; Björk 1999; Maier and Lehner 2000; Masuda et al. 2000) and coordination (Porter 1985; Davenport 1993; Orlikowski and Hofman 1997; Fisher 1997; Garvin 1998; Tuomisto and Vesiluoma 1999; Aouad et al. 1999). Hence, improved communication and coordination between people and processes is a good measure of information management process quality. Georgakopoulos et al. (1993) and Orlikowski and Hofman (1997) state that good IS enables increased support of communication and coordination. Other important aspects are in information exchange (Davenport 1993; Tushman and Anderson 1997; Kock et al. 1997; Malmström et al. 1998) and collaboration (Georgakopoulos et al. 1995; Nadler et al. 1995; O’Dell and Grayson 1998; Orlikowski and Hofman 1997; Liebowitz and Beckman 1988; Kagioglou et al. 1999; Nelson et al. 1999; Tuomisto and Vesiluoma 1999) between project members. Improved information exchange capabilities are enabled by implementation of well-developed information exchange models supported by process models (Malmström et al. 1998). Kock et al. (1997) states that, based on research findings, built-in shared information between members of organisations minimises losses in information and knowledge exchange.

The aspect of collaboration is enhanced and facilitated by broader and more rapid information dissemination and is thus a good quality measure (Nadler et al. 1995). Shared information is consequently a good platform for teamwork (Nadler et al. 1995; Liebowitz and Beckman 1998). Georgakopoulos et al. (1995) and Orlikowski and Hofman (1997) also, state that good IS enables increased support of collaboration for people who implement a process. Information distribution (Davenport 1993; Liebowitz and Beckman 1998; Tuomisto and Vesiluoma 1999; Björk 1999; Maier and Lehner 2000; Maier and Remus 2001; Rubenstein-Montano et al. 2001) is another important aspect of information dissemination.
Distribution of information to users, based on interest and work, improves collaboration and coordination capabilities. Many problems appearing in a project are related to information distribution to other people in the organisation, thereby making it a good measure for process quality (Tuomisto and Vesiluoma 1999).

The final aspects of information dissemination are communication with the project organisation (Nadler et al. 1995; Orlikowski and Hofman 1997; Aouad et al. 1999; Harris 1998; Maier and Lehner 2000), communication between project members (Davenport 1993; Nadler et al. 1995; Orlikowski and Hofman, 1997; Aouad et al. 1999; Harris 1998; Barnes and Vidgen 2000; Maier and Lehner 2000) and effective communication between various members of the project team (Davenport 1993; Nadler et al. 1995; Orlikowski and Hofman 1997; Garvin 1998; Harris 1998; Aouad et al. 1999). Aouad et al. (1999) states that there "is an emergent need to integrate and communicate information between the various members of the project team," thus making this a good measure for process quality. Equally important, is the one-way communication to the project organisation. When it comes to communication efficiency between project members, this rests on process quality and the amount of interpersonal communication and information dissemination (Garvin 1998).
<table>
<thead>
<tr>
<th>Variables</th>
<th>Measures</th>
<th>Sources</th>
</tr>
</thead>
<tbody>
<tr>
<td>Information development</td>
<td>1. Support in creating new information – documentation.</td>
<td>1. (Liebowitz and Beckman 1998; Björk 1999)</td>
</tr>
<tr>
<td></td>
<td>2. Activity related information.</td>
<td>1. (Björk 1999)</td>
</tr>
<tr>
<td></td>
<td>3. Process structure for information management.</td>
<td>(Davenport 1993)</td>
</tr>
<tr>
<td></td>
<td>4. Sufficiently defined process.</td>
<td>(Davenport 1993; Liebowitz and Beckman 1998; Maier and Remus 2001)</td>
</tr>
<tr>
<td></td>
<td>5. Clarity of important process decision points.</td>
<td>(Davenport 1993; Harris 1998)</td>
</tr>
<tr>
<td></td>
<td>6. Clarity of process workflow.</td>
<td>(Davenport 1993; Hammer and Champy 1993; Aouad et al. 1999)</td>
</tr>
<tr>
<td></td>
<td>7. Clarity of performance expectations.</td>
<td>(Brache and Rummier 1988; Georgakopoulos et al. 1995; Kock et al. 1997;</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(Malmström et al. 1998)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(Davenport 1993; Hammer and Stanton 1999; Nilsson 1999)</td>
</tr>
<tr>
<td>Information acquisition</td>
<td>1. Support retrieval of decision-making information</td>
<td>1. (Björk 1999)</td>
</tr>
<tr>
<td></td>
<td>2. Satisfactory information search function.</td>
<td>(Björk 1999)</td>
</tr>
<tr>
<td></td>
<td>3. Satisfactory information retrieval function.</td>
<td>(Gilchrist and Kibby 2000)</td>
</tr>
<tr>
<td></td>
<td>4. Easy to navigate.</td>
<td>(Maier and Lehner 2000; Glérist and Kibby 2000)</td>
</tr>
<tr>
<td></td>
<td>5. Publication of information.</td>
<td>(Maier and Lehner 2000)</td>
</tr>
<tr>
<td></td>
<td>6. Availability of information.</td>
<td>(Maier and Lehner 2000; Glérist and Kibby 2000)</td>
</tr>
<tr>
<td></td>
<td>7. Effective information retrieval.</td>
<td>(Brache et al. 1998; Aouad et al. 1999)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(Abecker et al. 1998; Björk 1999; Glérist and Kibby 2000)</td>
</tr>
<tr>
<td></td>
<td>2. Activity documents necessary to create.</td>
<td>(Davenport 1993)</td>
</tr>
<tr>
<td></td>
<td>3. Record documents clarification.</td>
<td>(SIS 2000)</td>
</tr>
<tr>
<td></td>
<td>4. Sufficiently organises information.</td>
<td>(Lewis 1995)</td>
</tr>
<tr>
<td></td>
<td>5. Documentation of existing information.</td>
<td>(Georgakopoulos et al. 1995; Conklin 1996; Liebowitz and Beckman 1998;</td>
</tr>
<tr>
<td></td>
<td>6. Facilitates version handling.</td>
<td>Maier and Lehner 2000; Maier and Remus 2001)</td>
</tr>
<tr>
<td></td>
<td>7. Personal information feels secure.</td>
<td>(Gibbons et al. 1994; Andresen et al. 2000)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(Davenport 1993; Boman et al. 1997; Abecker et al. 1998; Aouad et al. 1999; Maier and Remus 2001; Rubenstein-Montano et al. 2001)</td>
</tr>
</tbody>
</table>
### Variables

<table>
<thead>
<tr>
<th>Information utilisation</th>
<th>Measures</th>
<th>Sources</th>
</tr>
</thead>
</table>
|                                          | 1. Support workers do their jobs better and more effectively.  
2. Support in individual learning.  
3. Structured project management work.  
4. Greater process understanding.  
5. Support in resource control.  
7. Support (information) in decision-making.  
8. Support in formal planning of project activities.                                                                                                                                                                                                                      | 1. (Boman et al. 1997; Abecker et al. 1998)  
2. (Davenport 1993; Garvin 1993; Abecker et al. 1998; Maier and Lehner 2000; Rubenstein-Montano et al. 2001; Hill et al. 2001).  
3. (Davenport 1993)  
5. (Davenport 1993; Gibbons et al. 1994; Abecker et al. 1998; Prasad 1999).  
6. (Georgakopoulos et al. 1995)  
8. (Davenport 1993).                                                                                                                                                                                                                                                         |                                                                                                                                                                                                            |
|                                          | 1. Supports peer-to-peer communication.  
2. Supports communication and coordination in projects.  
3. Collaboration between project members.  
4. Information exchange between project members.  
5. Distribution of information to project participants.  
6. Communicating information between various members of the project team.  
7. Communication with the project organisation.  
8. Communication effectiveness between project members.                                                                                                                                                                                                                  | 1. (Björk 1999)  
5. (Davenport 1993; Liebowitz and Björk 1999; Maier and Lehner 2000; Beckman 1998; Tuomisto and Vesiluoma 1999; Maier and Remus 2001; Rubenstein-Montano et al. 2001).  
6.5.2 System quality

The system quality dimension involves the variables of ease of use, ease of learning, usefulness of system features and functions, system reliability, integration of systems, system efficiency and response time. It also includes measures of the information processing system itself (see table 7). Thus, the system quality dimension evaluates the quality of the information processing system itself and has to do with aspects such as whether or not there are bugs in the system (DeLone and McLean 1992).

The database content covers the aspect of information content meeting needs (Doll et al. 1988). The ease of use variable covers aspects such as ability to remember use of features (DeLone and McLean 1992), number of steps per task (DeLone and McLean 1992), ease of getting the system to do what is wanted (DeLone and McLean 1992), getting the system to do what you want it to do (Davis 1989; Malhotra and Galletta 1999) and user friendliness (Doll and Torkzadeh 1988; Seddon and Kiew 1996; Staples et al. 2002). Users are demanding user-friendly applications with simple interfaces while developers tend to focus on state-of-the-art applications (Staples et al. 2002). The ease of learning variable on the other hand covers the aspects of easy to learn compared to other systems (Seddon and Kiew 1996) and ease of learning how to use the system (Davis 1989; Lewis 1995; Goodhue 1995; Seddon and Kiew 1996; Malhotra and Galletta 1999).

Convenience of access covers the aspect of finding the system convenient to access (DeLone and McLean 1992). The usefulness of system features and functions variable covers aspects such as system importance for this organisation (Sanders 1984; Malhotra and Galletta 1999), whether or not the system is useful (Sanders 1984; Davis 1988) and personal benefit from the existence of the system (Sanders 1984). System flexibility covers the aspect of system functions allowing individual work procedures (DeLone and McLean 1992). While, the system reliability and integration of systems variables cover aspects such as performing an operation leading to predicted results (DeLone and McLean 1992), accountability of system availability when needed (Goodhue 1995) and satisfactory integration with different systems within the organisation (Abecker et al. 1998; Paulson et al. 2000).

Finally, the system efficiency variable covers aspects such as clarity of information by on the system screen and ease of finding information when needed (Lewis 1995). The response time variable covers the question of whether or not general system speed is sufficient (Davenport 1993; Zmud et al. 1994; Gibbons et al. 1994). As people become more and more accustomed to using computer systems they tend to demand increased speed in information transmission (Gibbons et al.
1994), i.e. elapsed time between a user-initiated request for service or action and a reply to that request (Li 1997).

Table 7: System quality variables, measures and sources

<table>
<thead>
<tr>
<th>Variable</th>
<th>Measures</th>
<th>Sources</th>
</tr>
</thead>
<tbody>
<tr>
<td>Database content</td>
<td>1. Information content meeting the needs.</td>
<td>1. (Doll et al. 1988)</td>
</tr>
<tr>
<td>Ease of use</td>
<td>1. Ability to remember usage of feature.</td>
<td>1. (DeLone and McLean 1992)</td>
</tr>
<tr>
<td></td>
<td>2. Number of steps per task.</td>
<td>2. (DeLone and McLean 1992)</td>
</tr>
<tr>
<td></td>
<td>3. Ease of getting the system to do what is wanted.</td>
<td>3. (DeLone and McLean 1992)</td>
</tr>
<tr>
<td></td>
<td>4. Get system to do what you want it to do.</td>
<td>4. (Davis 1989; Malhotra and Galletta 1999)</td>
</tr>
<tr>
<td></td>
<td>5. User friendly.</td>
<td>5. (Doll and Torkzadeh 1988; Seddon and Kiew 1996; Staples et al. 2002)</td>
</tr>
<tr>
<td>Ease of learning</td>
<td>1. Easy to learn compared to other systems.</td>
<td>1. (Seddon and Kiew 1996)</td>
</tr>
<tr>
<td></td>
<td>2. Ease of learning how to use the system.</td>
<td>2. (Davis 1989; Lewis 1995; Goodhue 1995; Seddon and Kiew 1996; Malhotra and Galletta 1999)</td>
</tr>
<tr>
<td>Convenience of access</td>
<td>1. Finding the system extremely convenient to access.</td>
<td>1. (DeLone and McLean 1992)</td>
</tr>
<tr>
<td>Usefulness of system features</td>
<td>1. System importance for this organisation.</td>
<td>1. (Sanders 1984; Malhotra and Galletta 1999)</td>
</tr>
<tr>
<td></td>
<td>2. System is extremely useful</td>
<td>2. (Sanders 1984; Davis 1989)</td>
</tr>
<tr>
<td></td>
<td>3. Personally benefit from the existence of the system.</td>
<td>3. (Sanders 1984)</td>
</tr>
<tr>
<td>System flexibility</td>
<td>1. System functions allowing individual work procedures.</td>
<td>1. (DeLone and McLean 1992)</td>
</tr>
<tr>
<td>System reliability</td>
<td>1. Performing an operation leads to predicted results.</td>
<td>1. (DeLone and McLean 1992)</td>
</tr>
<tr>
<td></td>
<td>2. Accountability of system availability when needed.</td>
<td>2. (Goodhue 1995)</td>
</tr>
<tr>
<td>Integration of systems</td>
<td>1. Integrates different systems within the organisation well.</td>
<td>1. (Abesker et al. 1998; Paulson et al. 2000)</td>
</tr>
<tr>
<td>System efficiency</td>
<td>1. Clarity of information by organisation on system screen.</td>
<td>1. (Lewis 1995)</td>
</tr>
<tr>
<td></td>
<td>2. Ease of finding information that is needed.</td>
<td>2. (Lewis 1995)</td>
</tr>
<tr>
<td>Response time</td>
<td>1. General system speed is fast enough.</td>
<td>1. (Davenport 1993; Zhud et al. 1994; Gibbons et al. 1994)</td>
</tr>
</tbody>
</table>

6.5.3 Information quality

The information quality dimension involves the variables of relevance of information, usefulness, usableness, understandability, clarity, format, content, accuracy, sufficiency, completeness, reliability and timeliness (see table 8). Thus, the information quality variable evaluates the quality of the IS output, i.e. the quality of the information that the system produces (DeLone and McLean 1992).

The relevance of information variable covers the aspect providing relevant information (Barnes and Vidgen 2000). While the usefulness variable covers the
aspects of usefulness of output information (Baroudi and Orlikowski 1988) and usefulness for experienced as well as inexperienced users (DeLone and McLean 1992). The variables of **usableness**, understandability and clarity cover aspects such as effectiveness in helping to complete work tasks (Lewis 1995), providing easy to understand information (Lewis 1995; Barnes and Vidgen 2000) and information output clarity (Lewis 1995; Seddon and Kiew 1996; Li 1997). These measures evaluate the degree to which information output is unambiguous and meaningful (Li 1997).

The **format** and **content** variables cover the aspects of presenting information in an appropriate format (Doll and Torkzadeh 1988; Goodhue 1995; Seddon and Kiew 1996; Barnes and Vidgen 2000) and good quality of the information content (Seddon and Kiew 1996). Format has to do with the system layout and the display of the information output (Li 1997). The variables of accuracy, sufficiency and completeness on the other hand cover the aspects of up-to-date (information) for purpose (Doll and Torkzadeh 1988; Gibbons et al. 1994; Goodhue 1995; Seddon and Kiew 1996), delivered information sufficiency (Seddon and Kiew 1996) and completeness and adequacy of information (Baroudi and Orlikowski 1988). Access to accurate, up-to-date information has always been important for satisfying intended uses and users (Gibbons et al. 1994). The **reliability** variable covers aspects such as reliability of output information and reliability superior to other systems (Baroudi and Orlikowski 1988). Finally, the variable of **timeliness** covers the aspect of providing timely information (Baroudi and Orlikowski 1988; Seddon and Kiew 1996; Barnes and Vidgen 2000) and the availability of information output at a suitable time for the user (Li 1997).

### 6.5.4 System use

The system use dimension involves the variables of frequency of report request, appropriate use, purpose of use, number of reports generated, regulation of use, amount of connected time and frequency of access (see table 9). In other words, it is the consumption of the information output of an IS by the user, namely, the frequency, appropriateness of system and information use activities (DeLone and McLean 1992).

The **frequency of report request** variable covers aspects such as frequency of accessing support documents (Malhotra and Galletta 1999), frequency of locating produced documents (Malhotra and Galletta 1999), frequency of storing produced documents (Davenport 1993; Malhotra and Galletta 1999) and frequency of studying produced documents (Malhotra and Galletta 1999). The variable of **appropriate use** covers aspects such as use in support of project development, use
Table 8: Information quality variables, measures and sources

<table>
<thead>
<tr>
<th>Variables</th>
<th>Measures</th>
<th>Sources</th>
</tr>
</thead>
<tbody>
<tr>
<td>Relevance of info</td>
<td>1. Provides relevant information.</td>
<td>1. (Barnes and Vidgen 2000)</td>
</tr>
<tr>
<td>Usefulness</td>
<td>1. Usefulness of output information.</td>
<td>1. (Baroudi and Orlikowski 1988)</td>
</tr>
<tr>
<td></td>
<td>2. Usefulness for experienced as well as inexperienced users.</td>
<td>2. (DeLone and McLean 1992)</td>
</tr>
<tr>
<td>Usableness</td>
<td>1. Effective in helping complete work tasks.</td>
<td>1. (Lewis 1995)</td>
</tr>
<tr>
<td>Understandability</td>
<td>1. Provides easy to understand information.</td>
<td>1. (Lewis 1995; Barnes and Vidgen 2000)</td>
</tr>
<tr>
<td>Clarity</td>
<td>1. Information output clarity.</td>
<td>1. (Lewis 1995; Seddon and Kiew 1996; Li 1997)</td>
</tr>
<tr>
<td>Format</td>
<td>1. Presents information in an appropriate format.</td>
<td>1. (Doll and Torkzadeh 1988; Goodhue 1995; Seddon and Kiew 1996; Barnes and Vidgen 2000)</td>
</tr>
<tr>
<td>Content</td>
<td>1. Good quality of the Information content.</td>
<td>1. (Seddon and Kiew 1996)</td>
</tr>
<tr>
<td>Accuracy</td>
<td>1. Up to date (information) for purpose.</td>
<td>1. (Doll and Torkzadeh 1988; Gibbons et al. 1994; Goodhue 1995; Seddon and Kiew 1996)</td>
</tr>
<tr>
<td>Sufficiency</td>
<td>1. Delivered information sufficiency.</td>
<td>1. (Seddon and Kiew 1996)</td>
</tr>
<tr>
<td>Completeness</td>
<td>1. Completeness adequacy of information.</td>
<td>1. (Baroudi and Orlikowski 1988)</td>
</tr>
<tr>
<td>Reliability</td>
<td>1. Reliability of output information.</td>
<td>1. (Baroudi and Orlikowski 1988)</td>
</tr>
<tr>
<td></td>
<td>2. Reliability superior to other systems.</td>
<td>2. (Baroudi and Orlikowski 1988)</td>
</tr>
<tr>
<td>Timeliness</td>
<td>1. Provides timely information.</td>
<td>1. (Baroudi and Orlikowski 1988; Seddon and Kiew 1996; Barnes and Vidgen 2000)</td>
</tr>
</tbody>
</table>

Table 9: System use variables, measures and sources

<table>
<thead>
<tr>
<th>Variables</th>
<th>Measures</th>
<th>Sources</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency of report request</td>
<td>1. Frequency of accessing support documents.</td>
<td>1. (Malhotra and Galletta 1999)</td>
</tr>
<tr>
<td></td>
<td>2. Frequency of locating produced documents.</td>
<td>2. (Malhotra and Galletta 1999)</td>
</tr>
<tr>
<td></td>
<td>3. Frequency of storing produced documents.</td>
<td>3. (Davenport 1993; Malhotra and Galletta 1999)</td>
</tr>
<tr>
<td></td>
<td>4. Frequency of studying produced documents.</td>
<td>4. (Malhotra and Galletta 1999)</td>
</tr>
<tr>
<td>Appropriate use</td>
<td>1. Use in support of project development.</td>
<td>1. (Lindfors 2001a)</td>
</tr>
<tr>
<td></td>
<td>2. Use in support of project management.</td>
<td>2. (Lindfors 2001a)</td>
</tr>
<tr>
<td></td>
<td>3. Use for planning.</td>
<td>3. (DeLone and McLean 1992; Davenport 1993)</td>
</tr>
<tr>
<td>Purpose of use</td>
<td>1. Use for getting instructions.</td>
<td>1. (DeLone and McLean 1992)</td>
</tr>
<tr>
<td></td>
<td>2. Use for storing information.</td>
<td>2. (Davenport 1993)</td>
</tr>
<tr>
<td></td>
<td>3. Use for project control.</td>
<td>3. (DeLone and McLean 1992)</td>
</tr>
<tr>
<td>Number of reports</td>
<td>1. How many documents produce, stored generated, read, altered and distributed per week.</td>
<td>1. (DeLone and McLean 1992)</td>
</tr>
<tr>
<td>Regulatory of use</td>
<td>1. Number of times used during a week.</td>
<td>1. (Malhotra and Galletta 1999)</td>
</tr>
<tr>
<td>Amount of connect time</td>
<td>1. Hours using the system per week.</td>
<td>1. (Malhotra and Galletta 1999)</td>
</tr>
<tr>
<td>Frequency of access</td>
<td>1. Frequency of use.</td>
<td>1. (Malhotra and Galletta 1999)</td>
</tr>
</tbody>
</table>
in support of project management and use for planning (DeLone and McLean 1992; Davenport 1993; Lindfors 2001a). Whilst, the purpose of use variable covers aspects such as use for getting instructions (DeLone and McLean 1992), use for storing information (Davenport 1993) and use for project control (DeLone and McLean 1992). Finally, the variables of number of reports generated, regulatory of use, amount of connected time and frequency of access cover the variables of how many documents are produced, stored, read, altered and distributed per week (DeLone and McLean 1992), number of times used during a week (Malhotra and Galletta 1999), hours using the system per week (Malhotra and Galletta 1999) and frequency of use (Malhotra and Galletta 1999).

### 6.5.5 User satisfaction

The user satisfaction dimension involves the variables of software satisfaction, decision-making satisfaction, satisfaction with specifics, information satisfaction and overall satisfaction (see table 10). This covers the user’s response to the use of the output of an IS, i.e. how well the user’s needs are being fulfilled (DeLone and McLean 1992).

**Table 10: User satisfaction variables, measures and sources**

<table>
<thead>
<tr>
<th>Variables</th>
<th>Measures</th>
<th>Sources</th>
</tr>
</thead>
<tbody>
<tr>
<td>Software satisfaction</td>
<td>1. Satisfaction using the (software) system.</td>
<td>(Lewis 1995; Chin and Lee 2000)</td>
</tr>
<tr>
<td></td>
<td>2. Satisfaction with the user interface.</td>
<td>(Lewis 1995; Saleem 1996)</td>
</tr>
<tr>
<td></td>
<td>3. Satisfaction with input screens.</td>
<td>(Lewis 1995; Saleem 1996)</td>
</tr>
<tr>
<td>Decision-making</td>
<td>1. Satisfaction with the support given by the system in important decision-making.</td>
<td>(Davenport 1993; Aouda et al. 1999)</td>
</tr>
<tr>
<td>satisfaction</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Satisfaction</td>
<td>1. Satisfaction with information handling capabilities.</td>
<td>(Davenport 1993)</td>
</tr>
<tr>
<td>with specifics</td>
<td>2. Satisfaction with the process oriented navigation structure.</td>
<td>(Maier and Lehner 2000)</td>
</tr>
<tr>
<td></td>
<td>3. Satisfaction with collaboration capabilities with other project members.</td>
<td>(Georgakopoulos et al. 1995)</td>
</tr>
<tr>
<td></td>
<td>4. Satisfaction with version handling.</td>
<td>(Gibbons et al. 1994)</td>
</tr>
<tr>
<td></td>
<td>5. Satisfaction with the process work instructions.</td>
<td>(Davenport 1993; Hammer and Stanton 1999)</td>
</tr>
<tr>
<td></td>
<td>6. Satisfaction with document control.</td>
<td>(Georgakopoulos et al. 1995)</td>
</tr>
<tr>
<td></td>
<td>7. Satisfaction with the provided documents.</td>
<td>(Saleem 1996)</td>
</tr>
<tr>
<td>Information</td>
<td>1. Satisfaction with information accessible through the system.</td>
<td>(Seddon and Kiew 1996; Saarinen 1996; Ishman 1998)</td>
</tr>
<tr>
<td>Overall satisfaction</td>
<td>1. User’s overall satisfaction rating.</td>
<td>(Lewis 1995; Saleem 1996; Chin and Lee 2000)</td>
</tr>
</tbody>
</table>
Researchers have found user satisfaction to be especially appropriate when a specific IS was involved (Ibid.). The software satisfaction variable covers aspects such as satisfaction using the (software) system (Lewis 1995; Chin and Lee 2000), satisfaction with the user interface (Lewis 1995; Saleem 1996) and satisfaction with input screens (Lewis 1995; Saleem 1996). The variable of decision-making satisfaction covers the aspect of satisfaction with the support given by the system to important decision-making (Davenport 1993; Aouad et al. 1999). The satisfaction with specifics variable covers aspects such as satisfaction with information handling capabilities (Davenport 1993), satisfaction with the process oriented navigation structure (Maier and Lehner 2000), satisfaction with collaboration capabilities with other project members (Georgakopoulos et al. 1995), satisfaction with version handling (Gibbons et al. 1994), satisfaction with process work instructions (Davenport 1993; Hammer and Stanton 1999), satisfaction with document control (Georgakopoulos et al. 1995) and satisfaction with the documents provided (Saleem 1996); in other words, evaluating the impact of information management process measures. Information satisfaction on the other hand covers the aspects of satisfaction with information accessible through the system (Seddon and Kiew 1996; Saarinen 1996; Ishman 1998) and match between information output and want (Lewis 1995; Saleem 1996; Seddon and Kiew 1996). The overall satisfaction measure finally cover the aspect of the user’s overall satisfaction rating (Lewis 1995; Saleem 1996; Chin and Lee 2000).

6.5.6 Individual impact

The individual impact dimension involves the variables of information understanding, learning, information awareness, decision effectiveness, decision quality, improved decision analysis, correctness of decision, time to make decision, improved individual productivity, change in decision, task performance, personal evaluation of IS and information management (see table 11). Thus, the individual impact variable evaluates the effect of the IS on the behaviour of the user (DeLone and McLean 1992).

The information understanding variable covers the aspect of understanding of the decision context (DeLone and McLean 1992; Malmström et al. 1998), while the variable of learning covers such aspects as learning about the process by using the system (Davenport 1993; Garvin 1993; De Michielis et al. 1998) and improvements in training and education in the process (Maier and Lehner 2000). The information awareness variable covers the aspect of improvements in access to existing sources of information (Maier and Lehner 2000). The decision effectiveness variable covers aspects such as utilisation enabling better decision to be made (Sanders 1984), ability
Table 11: Individual impact variables, measures and sources

<table>
<thead>
<tr>
<th>Variables</th>
<th>Measures</th>
<th>Sources</th>
</tr>
</thead>
<tbody>
<tr>
<td>Information</td>
<td>Understanding of the decision context.</td>
<td>1. (DeLone and McLean 1992; Malmström et al. 1998)</td>
</tr>
<tr>
<td>awareness</td>
<td>Learning about the process by using the system.</td>
<td>1. (Davenport 1993; Garvin 1993; De Michielis et al. 1998)</td>
</tr>
<tr>
<td></td>
<td>Improves training and education</td>
<td>2. (Maier and Lehner 2000)</td>
</tr>
<tr>
<td></td>
<td>Improves access to existing sources of information</td>
<td>3. (Maier and Lehner 2000)</td>
</tr>
<tr>
<td>Learning</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Utilisation enabled better decision to be made</td>
<td>1. (Sanders 1984)</td>
</tr>
<tr>
<td></td>
<td>Ability to set decision-making priorities.</td>
<td>2. (Sanders 1984)</td>
</tr>
<tr>
<td></td>
<td>Ability to present arguments more convincingly.</td>
<td>3. (Sanders 1984)</td>
</tr>
<tr>
<td>Decision</td>
<td></td>
<td></td>
</tr>
<tr>
<td>effectiveness</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Improvement of decision quality made in projects.</td>
<td>1. (Sanders 1984)</td>
</tr>
<tr>
<td></td>
<td>As a result of the system, more relevant information is available for decision-making.</td>
<td>2. (Sanders 1984)</td>
</tr>
<tr>
<td>Decision</td>
<td></td>
<td></td>
</tr>
<tr>
<td>quality</td>
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<td></td>
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<tr>
<td>Improved</td>
<td></td>
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</tr>
<tr>
<td>decision</td>
<td></td>
<td></td>
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<tr>
<td>analysis</td>
<td></td>
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<tr>
<td>Correctness</td>
<td></td>
<td></td>
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<tr>
<td>of decision</td>
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<tr>
<td>Time to make</td>
<td></td>
<td></td>
</tr>
<tr>
<td>decision</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Confidence</td>
<td></td>
<td></td>
</tr>
<tr>
<td>of decision</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Improved</td>
<td></td>
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<tr>
<td>individual</td>
<td></td>
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<tr>
<td>productivity</td>
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<tr>
<td>Change in</td>
<td></td>
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<tr>
<td>decision</td>
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</tr>
<tr>
<td>Task performance</td>
<td></td>
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<td></td>
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<td></td>
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<td></td>
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<tr>
<td>Personal valuation of IS</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Information</td>
<td></td>
<td></td>
</tr>
<tr>
<td>management</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
to set decision-making priorities (Sanders 1984) and ability to present arguments more convincingly (Sanders 1984). The decision quality variable covers aspects like improvement of decision quality made in projects (Sanders 1984) and as a result of the system, more relevant information is available for decision-making (Sanders 1984). The variables of improved decision analysis, correctness of decision and time to make decision cover the aspects of increases of analytical aids in decision-making (Sanders 1984), reductions of risk-taking (Lee et al. 2001) and increases in decision analysis speed (Sanders 1984). Confidence in decision covers the aspect of helping to feel confident in decisions made (DeLone and McLean 1992).

The improved individual productivity variable covers aspects such as increases in work productivity (Davis 1989; Malhotra and Galletta 1999; Sørebø et al. 2000), positive impact on effectiveness and productivity in my job (Davis 1989; Moore and Benbasat 1991; Goodhue 1995; Seddon and Kiew 1996; Abecker et al. 1998; Malhotra and Galletta 1999), significantly improved individual performance (Davis 1989; DeLone and McLean 1992; Seddon and Kiew 1996; Malhotra and Galletta 1999), help managing time more efficiently (Sørebø et al. 2000) and increases in job focus (Sørebø et al. 2000). The change in decision variable on the other hand covers the aspect of causing change in behaviour at work (DeLone and McLean 1992; Kock 2001).

The variable of task performance covers the aspects of accomplishing tasks more quickly (Davis 1989; Moore and Benbasat 1991; Lewis 1995; Seddon and Kiew 1996; Malhotra and Galletta 1999), improvement of work quality (Moore and Benbasat 1991; Good and Stone 2000), easier to do job (Davis 1989; Moore and Benbasat 1991; Seddon and Kiew 1996; Malhotra and Galletta 1999), improvements in work control (Moore and Benbasat 1991) and improvements in ability to handle information (DeLone and McLean 1992). The personal evaluation of IS variable covers the aspects of overall, using the system at work is advantageous (Moore and Benbasat 1991) and changes in perception of the importance or usefulness of an information system (DeLone and McLean, 1992). Finally, the information management variable covers the aspects of improvements in distribution of information (Maier and Lehner 2000), reductions of storage requirements for documents and quicker access to appropriate information (Lee et al. 2001).

6.5.7 Project (group) impact

The organisational impact variable was used for measuring project (group) impact. Ishman (1998) and Myers et al. (1998) speak of the importance of a workgroup...
dimension between the individual and organisational impact dimension. The change was necessary due to the evaluation group consisting of PMs who were unable to see the effects at an organisational level. Their perspective embraces project impact only. Based on this assumption the dimension of project group impact involves the variables of operating cost reductions, staff reductions, overall productivity gain, increased work volume, product quality, contribution to achieving goals, service effectiveness, time effectiveness, improved information management and increased profits (see table 12). Thus, the Project (group) impact variable evaluates the effect of the IS on project (group) performance.

Table 12: Project (group) impact variables, measures and sources

<table>
<thead>
<tr>
<th>Variables</th>
<th>Measures</th>
<th>Sources</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating cost reductions</td>
<td>1. Cost savings in information management</td>
<td>(Myers et al. 1997; Maier and Lehner 2000)</td>
</tr>
<tr>
<td>Staff reductions</td>
<td>1. Reduction of staff in projects</td>
<td>(Detone and McLean 1992)</td>
</tr>
<tr>
<td>Overall productivity gains</td>
<td>1. Increases in project group effectiveness due to increased information sharing capabilities.</td>
<td>(Tushman and Anderson 1997)</td>
</tr>
<tr>
<td></td>
<td>2. Enhancement of group understanding and motivation due to increased information dissemination.</td>
<td>(Myers et al. 1998)</td>
</tr>
<tr>
<td></td>
<td>3. Improvements in work participation by project members.</td>
<td>(Delone and McLean 1992; Myers et al. 1998)</td>
</tr>
<tr>
<td></td>
<td>4. Improvements in communication within the project work group.</td>
<td>(Tushman and Anderson 1997)</td>
</tr>
<tr>
<td></td>
<td>5. Improvements in productivity within the project work group.</td>
<td>(Delone and McLean 1992; Myers et al. 1998)</td>
</tr>
<tr>
<td></td>
<td>6. Quicker responses to project changes.</td>
<td>(Lee et al. 2001)</td>
</tr>
<tr>
<td>Increased work volume</td>
<td>1. Reduction in work volume for the project work group.</td>
<td>(Detone and McLean 1992)</td>
</tr>
<tr>
<td>Product quality</td>
<td>1. Reductions of rework and waste in the project.</td>
<td>(Prasad 1999; Andresen et al. 2000; Lee et al. 2001)</td>
</tr>
<tr>
<td>Contribution to achieving goals</td>
<td>1. Helps the project to achieving its goals.</td>
<td>(Boman et al. 1997; Garvin 1998; Rubenstein-Montano et al. 2001)</td>
</tr>
<tr>
<td>Service effectiveness</td>
<td>1. Increased effectiveness in serving customers.</td>
<td>(Detone and McLean 1992)</td>
</tr>
<tr>
<td>Time effectiveness</td>
<td>1. Increases in project time.</td>
<td>(Myers et al. 1998)</td>
</tr>
<tr>
<td>Improved information management</td>
<td>1. Increased informal exchange of ideas.</td>
<td>(Maier and Lehner 2000)</td>
</tr>
<tr>
<td></td>
<td>2. Improvement of communication and cooperation within the project group.</td>
<td>(Maier and Lehner 2000; Aouad et al. 1999)</td>
</tr>
<tr>
<td></td>
<td>3. Increased information availability within the project workgroup.</td>
<td>(Myers et al. 1997; Aouad et al. 1999)</td>
</tr>
<tr>
<td></td>
<td>4. Supporting education and training of newly recruited employees.</td>
<td>(Maier and Lehner 2000)</td>
</tr>
<tr>
<td></td>
<td>5. Supporting training and education of all employees.</td>
<td>(Maier and Lehner 2000)</td>
</tr>
<tr>
<td>Increased profits</td>
<td>1. User assessment of information management cost reductions and increases of company profit.</td>
<td>(Detone and McLean 1992)</td>
</tr>
</tbody>
</table>
The variables of operating cost reductions and staff reductions cover the aspects of cost savings in information management (Myers et al. 1997; Maier and Lehner 2000) and reduction of staff in projects (DeLone and McLean 1992). While, the overall productivity gain variable covers aspects of increases in project group effectiveness due to increased information sharing capabilities (Tushman and Anderson 1997), enhancement of group understanding and motivation due to increased information dissemination (Tushman and Anderson 1997), improvements in work participation by project members (Myers et al. 1998), improvements in communication within the project work group (Myers et al. 1998), improvements in productivity within the project work group (DeLone and McLean 1992; Myers et al. 1998) and quicker responses to project changes (Lee et al. 2001).

The variables of increased work volume, product quality, contribution to achieving goals, service effectiveness and time effectiveness cover the aspects of reduction in work volume for the project work group (DeLone and McLean 1992), reduction of rework and waste in the project (Prasad 1999; Andresen et al. 2000; Lee et al 2001), helping the project to achieve its goals (Boman et al. 1997; Garvin 1998; Rubenstein-Montano et al. 2001), increasing effectiveness in serving customers (DeLone and McLean 1992) and increases in project time (Myers et al. 1998). The improved information management variable covers aspects such as increased informal exchange of ideas (Maier and Lehner 2000), improvement of communication and cooperation within the project group (Maier and Lehner 2000; Aouad et al. 1999), increased information availability within the project workgroup (Myers et al. 1997; Aouad et al. 1999), supporting education and training of newly recruited employees (Maier and Lehner 2000) and supporting training and education of all employees (Maier and Lehner 2000). Finally, the increased profits variable covers the aspect of user assessment of information management cost reductions and increases of company profit (DeLone and McLean 1992).

6.6 Conclusions
This chapter has discussed the information process, the entities of data, information and knowledge, ISs in general and the assessment of ISS. This was then followed by a detailed description of the development of a hypothesised model and assessment instrument to measure the success of the developed process oriented IS. This instrument is founded on DeLone and McLean’s ISSM, but extended to include a common set of variables to measure the dimension of process quality (information (knowledge) management process). The augmented ISSM can now be used to design and perform a questionnaire survey for the purpose of test-
ing the ISSM as a construct, as well as measuring PM attitudes towards the new process oriented IS.
7. Questionnaire design and survey

7.1 Introduction
The augmented ISSM (the hypothesis model for this research) developed and presented in chapter 6 creates input for the work of designing a questionnaire survey. A questionnaire is a method for the elicitation, collection and recording of information (Kirakowski 1997). It was decided to use a questionnaire survey, for the purpose of testing the relationships within the augmented ISSM, as well as for measuring PM attitudes towards the new process oriented IS. The decision to perform a questionnaire survey was made as a consequence of the majority of previously performed research that had tested DeLone and McLean’s ISSM. By using a questionnaire approach, a statistical analysis could be performed to test the hypothesis model, but also used to compare the findings with previously published results. This chapter describes the development of a multi-item instrument for assessing project manager perceptions of ISS, and for testing the hypothesised relationships presented in the augmented ISSM in chapter 6. The first section describes the questionnaire design. The following section describes the pilot study, which was performed before the final data collection. The final two sections describe the data collection and the statistical analysis of the data collected.

7.2 Questionnaire design
A questionnaire tells only of the user’s reaction, i.e. as the user perceives the situation. Developing a questionnaire to measure a hypothesis is not a trivial affair and measuring attitudes does not make it easier. The questionnaire survey in this research was developed to measure attitudes of PMs using the newly developed process oriented IS. It was decided to investigate only PMs attitudes, excluding other professionals, so as to obtain a homogeneous and generalisable result. When
using a small sample it is advisable to select human subjects from a narrow subculture (Tweney et al. 1981). The questionnaire was developed to test the hypotheses: system quality, process quality and information quality singularly and jointly affect both system use and user satisfaction; and also, the amount of system use positively or negatively affect the degree of user satisfaction and vice versa. System use and user satisfaction directly affect individual impact, which in turn should have some impact on the project (workgroup).

7.2.1 Sample population

The chosen sample (of the) population to be investigated was PMs for housing development projects as stated in the research question. Fellows and Liu (1997) state that “it is necessary to obtain data from only a part of the total population with which the research project is concerned.” PMs at NCC Housing are responsible for the execution of all phases in the TPC process. This means managing the entire process from project idea and acquisition of the site to product delivery and post occupational commitments and services. This also means coordinating and leading the work of many different professions and trades such as surveying, design, cost estimation, purchasing, sales and construction management. During the time of the study, the total population of PMs at NCC Housing was 35. To be able to perform the questionnaire survey it was recommended that the respondents had used the new IS for a sufficient period of time to know both its advantages and disadvantages. So, based on this, a prerequisite target was established, requiring approximately one-year’s experience of using the IS to participate in the questionnaire survey. In the housing developer’s organisation, 15 PMs fitted this criterion. Of these, it was possible to achieve a 100% return (or success) rate. As it transpired, the composition of the sample was representative of the population. Of the 15 participants, 80% were male and 20% female. Their ages ranged from below 30 to above 45 and the average age of the sample was above 45 years of age. Average sector experience of 23.2 years. 27% of the participants also held a university degree while 73% did not. The response sample characteristics are shown in table 13. Equal characteristics for the sector could not be obtained. The characteristics of the 15 PMs in comparison with the same for NCC Construction Sweden AB (NCC 2002a; NCC 2002b) indicates that the sample might after all be a good representation of the Swedish construction sector. This generalisation is made in the light of the number of employees (white collar) within NCC Construction Sweden AB. Another assumption is that a PM is more likely to hold a university degree than other employ-

39) PMs at NCC Housing – Swedish operations.
40) Construction and real-estate sector.
ees in the sector, which may explain the divergent statistics in the education category.

Table 13: The general characteristics of the sample population in relation to the total number of employees at NCC Construction Sweden AB - white collar (%)

<table>
<thead>
<tr>
<th>Category</th>
<th>Study sample</th>
<th>NCC Construction Sweden</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;31</td>
<td>13</td>
<td>13</td>
</tr>
<tr>
<td>31-45</td>
<td>27</td>
<td>30</td>
</tr>
<tr>
<td>&gt;45</td>
<td>60</td>
<td>57</td>
</tr>
<tr>
<td>Average age</td>
<td>Above 45 years</td>
<td>46.6 years</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>Male</td>
<td>80</td>
<td>80</td>
</tr>
<tr>
<td>Education</td>
<td></td>
<td></td>
</tr>
<tr>
<td>University degree</td>
<td>27</td>
<td>10</td>
</tr>
<tr>
<td>Non-university degree</td>
<td>73</td>
<td>90</td>
</tr>
</tbody>
</table>

7.2.2 Measuring attitudes
As described in chapter 6, the development of the assessment instrument involved an extensive literature study of many existing survey instruments and publications in the area of process orientation and ISs. From this review, appropriate measures for the inclusion in the augmented ISSM, as well for testing the stated hypotheses, were extracted. Whenever possible, previously validated measures were adopted to ensure content validity. Details of all questions used in this study are presented in Appendix B. The main principles for measurement being (Oppenheim 1992): uni-dimensionality or homogeneity; linearity and equal intervals or equal-appearing intervals; reliability; and reproducibility. An attitude is a standpoint, more relevant to measure than an opinion, which may vary from day to day. Oppenheim (1992) states "social psychologists make a rough distinction among these different levels, calling the most superficial one opinions, the next attitudes, a deeper level, values or basic attitudes, and a still deeper level, personality" (see figure 37). Attitudes are a state of readiness to react in a certain manner when faced with certain motivation. The magnitude of attitudes becomes particularly clear when trying to change them (Ibid.).

41) The Swedish operations of the NCC Group are gathered under the name NCC Construction Sweden AB, with a total number of 3,200 employees in 2002 (white collar).
7.2.3 Measurement scales for the survey

The best method (scale) for retrieving data is the one that is most appropriate to the particular problem being studied. When it comes to measuring attitude patterns or exploring theories of attitudes, Oppenheim (1992) states that the Likert procedure is the most relevant. The Likert scale is also perhaps the most common scale for obtaining respondents' opinions (Fellows and Liu 1997). Consequently, as it was attitudes of PMs that were going to be measured, a Likert scale was chosen. Oppenheim (1992) stresses two advantages by using a Likert scale, apart from their relative ease of construction: primarily, such a scale provides more precise information about the respondents' degree of agreement or disagreement to a statement; and, secondly, it becomes possible to include items whose manifest content is not obviously related to the attitude in question. When measuring attitudes with a Likert scale, respondents are asked to position their attitudes towards a statement on a scale from strong agreement to strong disagreement. To get unambiguous responses, one must decide whether a high scale score should mean a positive or a negative attitude.

If it is decided that a high score on the scale means a positive attitude, then positive attitudes must be scored 7 for "strongly agree", down to 1 for "strongly disagree". If it is decided that a high score means a negative attitude, then the opposite system of scoring will apply. The important thing is to be consistent. Attitude statements should avoid double negatives and should be short and uncomplicated. It is also advisable to avoid double-barrelled statements. To this, Oppenheim (1992) states that difficulties arise for the respondent who agrees with one part of the statement but not with the other. A questionnaire should also be designed to provide ease of tabulation and/or interpretation (Naoum 1998). There is no purpose served by
using extreme items, which will provoke the respondents to answer in the same way (Moser and Kalton 1979). The Likert scale, used for this particular instrument, rates the responses from strongly agree (7) to neither (4) to strongly disagree (1) with no verbal labels for scale points 2-3 and 5-6. Also, five questions using a numerical rating scale were included to capture respondents’ actual usage of the IS and to obtain a perceived rating of the benefits in terms of time and cost from the use of the IS: these questions are numbered 92-94, 148 and 167 in Appendix B.

7.2.4 Question formulation

Bearing this in mind and based on the measures extracted and defined in chapter 6 to test the hypothesis model (see table 14 for the variables used in the questionnaire), questions were formulated to provide the link between theory and data, and also to ensure that the intended information was elicited.

In the beginning of the questionnaire, six questions of a descriptive nature (sample

<table>
<thead>
<tr>
<th>System quality</th>
<th>Process quality</th>
<th>Information quality</th>
<th>System use</th>
<th>User satisfaction</th>
<th>Individual impact</th>
<th>Project impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Database content</td>
<td>Information development</td>
<td>Relevance of information</td>
<td>Frequency of report request</td>
<td>Software satisfaction</td>
<td>Information understanding</td>
<td>Operating cost reductions</td>
</tr>
<tr>
<td>Ease of use</td>
<td>Information acquisition</td>
<td>Usefulness</td>
<td>Appropriate use</td>
<td>Decision-making satisfaction</td>
<td>Learning</td>
<td>Staff reductions</td>
</tr>
<tr>
<td>Ease of learning</td>
<td>Information identification</td>
<td>Usability</td>
<td>Purpose of use</td>
<td>Satisfaction with specific information</td>
<td>Awareness</td>
<td>Overall productivity</td>
</tr>
<tr>
<td>Convenience of access</td>
<td>Information preservation</td>
<td>Clarity</td>
<td>Number of reports generated</td>
<td>Overall satisfaction</td>
<td>Decision effectiveness</td>
<td>Increased productivity</td>
</tr>
<tr>
<td>Usefulness of system features and functions</td>
<td>Information dissemination</td>
<td>Understandability</td>
<td>Regulatory of use</td>
<td>Decision</td>
<td>Effectiveness</td>
<td></td>
</tr>
<tr>
<td>System flexibility</td>
<td></td>
<td>Format</td>
<td>Amount of connected time</td>
<td>Improved decision</td>
<td>Quality</td>
<td></td>
</tr>
<tr>
<td>System reliability</td>
<td></td>
<td>Content</td>
<td>Frequency of access</td>
<td>Improvement analysis</td>
<td>Analysis</td>
<td></td>
</tr>
<tr>
<td>Integration of systems</td>
<td></td>
<td>Accuracy</td>
<td></td>
<td>Correctness of decision</td>
<td></td>
<td></td>
</tr>
<tr>
<td>System efficiency</td>
<td></td>
<td>Sufficiency</td>
<td></td>
<td>Time to make decision</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Response time</td>
<td></td>
<td>Completeness</td>
<td></td>
<td>Improved decision</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Reliability</td>
<td></td>
<td>Improved individual productivity</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Timeliness</td>
<td></td>
<td>Change in decision</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Task performance</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Personal evaluation of IS</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Information management</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 14: The variables used in the augmented ISSM instrument
characteristics) were included to give a clear picture of the response sample. In accordance with recommended procedures for questionnaire development, roughly one third of the questions were worded negatively to avoid the respondents switching on the autopilot when filling out the questionnaire (Moser and Kalton 1979; Parasuraman et al. 1988). If this happens, a respondent can simply check off all the ‘agree’ without having to consider each statement carefully. Negatively worded questions are identified by [R] in Appendix B. The scale values of the negatively worded questions were reversed prior to the statistical analysis of the collected data. All questions are direct making them more uniform and the results more reliable. The questionnaire was originally developed in English and translated into Swedish. This because the majority of studies and publications where done in the English language. However, using Swedish during data collection enabled the respondents to be familiar with words and expressions, thereby reducing ambiguity. The translation may imply a risk of changed meaning, but as the questions were worded so directly, it was easy to translate word for word.

7.3 Pilot study

Before collecting the final data from the intended respondents it is advisable to perform a pilot study of the survey instrument (questionnaire). Pilot testing of question wording and question order are extremely important. If developing a questionnaire survey from scratch, it is advisable to perform two pilot studies. In the case of this questionnaire, most of the questions were reused from established instruments, rendering little need for extensive piloting. Bell (1996), cited in Naoum (1998), describes a pilot study as “getting the bugs out of the instrument (questionnaire) so that subjects in your main study will experience no difficulties in completing it and so that you can carry out a preliminary analysis to see whether the wording and format of questions will present any difficulties when the main data are analysed.” The key issue is, thus, whether the respondents’ understandings of the questions do or do not match what the researcher had in mind.

So, before the questionnaire was distributed to the intended survey population a pilot study was performed focusing on the issues of ‘construct clarity’ and question wording. The research instrument was thoroughly examined by five staff members within the housing developer’s organisation. Three of these were PMs for development projects, one was a personnel manager and the final one was the administrator of the new IS. No one from the pilot study was later included in the questionnaire survey. The feedback from the pilot study group was obtained by interviews and through reviewed questionnaires that were returned to the researcher with written comments and suggestions. Comments and suggestions from the pilot study showed the way to a number of important enhancements, especially in the
wording of questions, which were built-in into the final version (see Appendix B). It was also decided to include the housing developer’s annual system satisfaction index measures (see Table 15). The time to complete the questionnaire was also studied during the pilot work. It took roughly one hour to complete, making the decision to use two hours for the subsequent surveys adequate, i.e. leaving room for introduction and follow up.

Table 15: The variables and the question-groupings of the SSI

<table>
<thead>
<tr>
<th>Variables</th>
<th>Measure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Individual productivity</td>
<td>1. I find the information system to be useful.</td>
</tr>
<tr>
<td></td>
<td>2. The information system makes my job easier.</td>
</tr>
<tr>
<td></td>
<td>3. Due to information system I can do a better job.</td>
</tr>
<tr>
<td></td>
<td>10. The information system takes care of the needs necessary to perform my job.</td>
</tr>
<tr>
<td>Comprehensive view</td>
<td>4. Using the information system feels like a natural part of my daily work.</td>
</tr>
<tr>
<td>of process work</td>
<td>5. I find that the information system clarifies my daily work.</td>
</tr>
<tr>
<td></td>
<td>6. The information system clarifies my role within the organisation.</td>
</tr>
<tr>
<td>Information retrieval satisfaction</td>
<td>7. The information system helps me find appropriate information easier.</td>
</tr>
<tr>
<td></td>
<td>8. The information system helps me to reduce my information search time.</td>
</tr>
<tr>
<td></td>
<td>9. I find all the information necessary for me to perform my job due to the layout of the information system.</td>
</tr>
</tbody>
</table>

7.3.1 System Satisfaction Index

The system satisfaction index (SSI) is the housing developer’s annually performed survey, with the aim of measuring the attitudes of personnel relative to their work system. The inclusion of the SSI enabled a comparison between pre-implementation and post-implementation of the new IS. The SSI includes 10 Likert-scaled measures, which are grouped under three main variables: perceived individual productivity, comprehensive view of process work and perceived information retrieval satisfaction (see Appendix A). Thus, these measures were included in the questionnaire and also extracted when the survey was completed, enabling a comparison with the result from preceding year. These SSI questions were included in the individual impact instrument and marked with [SSI#] in the questionnaire (see Appendix B).

7.4 Data collection

After final adjustments arising from the pilot study, the questionnaire survey was performed and the data were gathered. Due to the amount of questions included in the questionnaire, it was felt appropriate by the researcher to sit in when the survey
respondents filled out the questionnaire. This was decided as a precaution against not receiving any answers. Every questionnaire was filled out during a two-hour appointment between the researcher and the respondent, but the researcher did not interact, intervene or influence the respondent’s answers in any way. Every session was, with the respondents, initialised by an introduction by the researcher clarifying the purpose of the questionnaire survey and some definitions (information, knowledge and process) of word usage, which were felt necessary from the pilot study. It was explained that the data would be handled confidentially and their names would not be mentioned other than being given in the list of interviewees. Besides this, it was a subjective self-report of perceived job performance with respect to the IS. The respondents were asked to indicate to what extent they agreed or disagreed with each statement. At the end of each survey, in order to avoid systematic errors, the researcher asked the respondent the following questions: were the instructions clear; were any of the questions unclear or ambiguous; did I (the researcher) affect you in any way answering the questions; did you object to answering any of the questions; and was the layout of the questionnaire clear? The respondents’ responses were that the instructions, questions and layout were regarded as clear and unambiguous, and the researcher had not influenced them.

### 7.5 Statistical analysis

The data were compiled and entered into a SPSS database for analysis. The data were then presented as descriptive statistics and analysed to test the internal reliability of the questionnaire and the correlations according to the hypothesis relationships. This included means, standard deviations and distribution of values for the major study dimensions, which are presented in table 16. The relationships in the model were tested using Kendall’s correlation coefficient, \(\tau\), and the internal reliability using the reliability coefficient of Cronbach’s \(\alpha\). This result is described in chapter 8.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>S.D.</th>
<th>Min.</th>
<th>Max.</th>
</tr>
</thead>
<tbody>
<tr>
<td>System quality</td>
<td>5.37</td>
<td>0.90</td>
<td>3.39</td>
<td>6.62</td>
</tr>
<tr>
<td>Process quality</td>
<td>5.99</td>
<td>0.38</td>
<td>5.44</td>
<td>6.69</td>
</tr>
<tr>
<td>Information quality</td>
<td>5.75</td>
<td>0.53</td>
<td>4.29</td>
<td>6.57</td>
</tr>
<tr>
<td>System use</td>
<td>6.01</td>
<td>0.39</td>
<td>5.43</td>
<td>6.79</td>
</tr>
<tr>
<td>User satisfaction</td>
<td>5.62</td>
<td>0.69</td>
<td>4.14</td>
<td>6.57</td>
</tr>
<tr>
<td>Individual impact</td>
<td>5.81</td>
<td>0.36</td>
<td>5.04</td>
<td>6.41</td>
</tr>
<tr>
<td>Project (group) impact</td>
<td>5.77</td>
<td>0.43</td>
<td>4.95</td>
<td>6.42</td>
</tr>
</tbody>
</table>

Table 16: Descriptive statistics of the perceived values of the different ISS dimensions
7.5.1 Reliability and validity

The reliability of a questionnaire is the ability of the questionnaire to give the same results when filled out by like-minded people in similar circumstances. A questionnaire’s reliability is thus its ability to give a similar result when filled out by a homogenous group of people with similar values and attitudes (Kirakowski 1997) and an adequate reliability is a prerequisite to validity (Oppenheim 1992). An important aspect of a survey instrument is consequently its reliability. Figure 38 gives a simple but helpful visual explanation of what a reliability coefficient is.

![True Measure Error](image)

Figure 38: Explanation of the reliability coefficient (Oppenheim 1992)

Theoretically, reliability is expressed on a numerical scale between the minimum of 0 and the maximum of 1. In social sciences and behavioural sciences reliabilities above 0.90 are very rare (Oppenheim 1992). When it comes to defining a threshold for acceptance scholars have varying opinions. Some say that values above 0.60 are acceptable (Heath and Martin 1997), some even go as low as 0.50 (Yoon et al. 1998), while others say that only values above 0.80 are acceptable (Oppenheim 1992). But the most agreed upon acceptance level is that of 0.70 and above (Staples et al. 2002; McGill et al. 2000b; McCormack 1999b). Kirakowski (1997) state that it is appropriate to suspect a questionnaire whose reliability falls below 0.50, but if well constructed a questionnaire should yield reliability values of 0.70 or more (Kirakowski 2001). By using the internal consistency method (associated with the Cronbach’s $\alpha$ coefficient) the reliability value can be tested (Oppenheim 1992). In order to verify the reliability of the questionnaire used in this research, a statistical reliability analysis was conducted using Cronbach’s $\alpha$. This was used on each of the ISS dimension data sets. The instruments showed good internal consistency reliability: system quality, $\alpha = 0.90$; process quality, $\alpha = 0.88$; information quality, $\alpha = 0.81$; system use, $\alpha = 0.64$; user satisfaction, $\alpha = 0.88$; individual impact, $\alpha = 0.75$; and project (group) impact, $\alpha = 0.77$. All, but the system use dimension showed an internal consistency $\alpha$ above 0.70 (see table 17).
As for validity, several precautions were taken to ensure a high validity of the augmented ISSM construct. The validity of a questionnaire is the degree to which the questionnaire is actually measuring or what is thought it should be measuring. To ensure content validity, a thorough review of the relevant literature was performed to understand the important aspects of each major variable of ISS and its measures. Content validity assumes that you have a good detailed description of the content domain. Content validity seeks to establish a well-balanced sample of content domain measures, i.e. measuring what is supposed to be measured (Saarinen 1996). Many of the measures used in this research were also chosen from well-acknowledged theoretical models. A strong reliable construct is thus a means for achieving good content validity (Oppenheim 1992). Many studies have previously addressed the relationships studied, enabling a fair test of the concurrent validity in this research. Concurrent validity explains how well the test corresponds to other test results in the same content domain and, by doing so, determining whether the measures of the variables are consistent. The final validity type is construct validity, which shows how well the collected data match up to a set of theoretical assumptions about a conceptual model. A correlation analysis is consequently performed for testing the construct validity.

### 7.5.2 Hypothesis correlation

Based on the collected data from the questionnaire survey, the underlying hypothesis, supporting the questionnaire was tested using Kendall’s correlation coefficient, tau, (see chapter 8 for more details). A correlation tells how strong the relationship is between two variables. Relationships can be either positive or negative: when one variable increases while the other increases there is a positive correlation, but when a variable decreases while another increases the correlation is negative. In correlation analysis, the aim is generally to determine whether or not two variables are interdependent, i.e. if they vary together. Correlation analysis is the proper approach when wishing to establish the degree of association between pairs of variables in a sample from a population (Moser and Kalton 1979). A correlation analysis was used in this research to test the hypothesised relationships, i.e. between
Due to the small sample and the amount of questions, it was decided that any other statistical analysis methods were inappropriate for testing. One example, a factor analysis approach, was rejected because of the rule of thumb for such an analysis, that the sample is bigger than the amount of questions (Chen et al. 2000). Testing the statistical correlation between variables in a hypothesis context enables the researcher to verify or reject a hypothesised relationship. A correlation can be two-tailed or one-tailed. In using the two-tailed tests, even if the hypothesis relationship is in one direction, there is a higher probability that the correlation is true. All probabilities reported in this research are based on two-tailed tests as each comparison had two possible directions. The conventional level by which a hypothesis correlation can be rejected is when the probability of the result being due to chance is higher than 5 percent. Thus, if the probability is less than 0.05, the relationship is significant and verifies the relationship between the research variables in the hypothesis. The significance of the test results is reported in two ways, as suggested by Coolican (1990), based on the probability level:

- Significant: $0.05 > p < 0.01$
- Highly significant: $0.01 > p < 0$

Consequently, the lower the probability, the more confident one can be that there is a significant relationship applicable to the data (Naoum 1998). The results from the correlation tests showed that 12 questions had no correlation whatsoever (see markings in Appendix B). The SSI questions were removed since they did not belong to the questionnaire instrument (see markings in Appendix B). The SSI results are presented in chapter 8 under the individual impact section. When the SSI measures had been removed the remaining measures were analysed and the overall result is shown in table 18 and figure 39.
**Correlation is significant at the 0.05 level (2-tailed)**

**Correlation is significant at the 0.01 level (2-tailed)**

### Table 18: Kendall’s tau correlation matrix (two-tailed) of the survey dimensions

<table>
<thead>
<tr>
<th>Variable</th>
<th>SQ</th>
<th>PQ</th>
<th>IQ</th>
<th>SU</th>
<th>US</th>
<th>II</th>
<th>PI</th>
</tr>
</thead>
<tbody>
<tr>
<td>System quality</td>
<td>Coef. 0.409</td>
<td>Sig. 0.112</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Process quality</td>
<td>Coef. 0.284</td>
<td>Sig. 0.039</td>
<td>0.842</td>
<td>0.395</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Information quality</td>
<td>Coef. 0.422*</td>
<td>Sig. 0.073</td>
<td>0.351</td>
<td>0.039</td>
<td>0.168</td>
<td></td>
<td></td>
</tr>
<tr>
<td>System use</td>
<td>Coef. 0.282</td>
<td>Sig. 0.001</td>
<td>0.657**</td>
<td>0.363</td>
<td>0.108</td>
<td>0.578**</td>
<td></td>
</tr>
<tr>
<td>User satisfaction</td>
<td>Coef. 0.427</td>
<td>Sig. 0.002</td>
<td>0.587**</td>
<td>0.109</td>
<td>0.578**</td>
<td>0.585**</td>
<td></td>
</tr>
<tr>
<td>Individual impact</td>
<td>Coef. 0.088</td>
<td>Sig. 0.000</td>
<td>0.347</td>
<td>0.109</td>
<td>0.578**</td>
<td>0.003</td>
<td></td>
</tr>
<tr>
<td>Project impact</td>
<td>Coef. 0.155</td>
<td>Sig. 0.002</td>
<td>0.576**</td>
<td>0.117</td>
<td>0.541**</td>
<td>0.003</td>
<td></td>
</tr>
</tbody>
</table>

*Correlation is significant at the 0.05 level (2-tailed)

**Correlation is significant at the 0.01 level (2-tailed)

---

### 7.6 Conclusions

This chapter has described the work of designing a questionnaire supporting the testing of the relationships in the augmented ISSM, as well as measuring PMs attitudes towards the new IS. It also describes measures of questionnaire design in relation to the investigated sample, aspects of measuring attitudes, measurement scales and question formulation. The inclusion of a pilot study was also described. Finally, the data collection and the statistical analysis were described covering the aspects of reliability and validity of the questionnaire instrument. Even though the sample was small, making it impossible to perform more advanced statistical tests
such as factor analysis and regression analysis, it is felt that a number of conclusions
could nonetheless be made.

The descriptive statistics shown in table 16 show that the PMs showed, on an overall
level, positive attitudes towards the new IS. By taking a closer look at the correla-
tion results shown in table 18, it is noticed that the relationships between process
quality and user satisfaction, user satisfaction and individual impact, individual
impact and project (group) impact are supported by the research. The relationship
of information quality and user satisfaction is also very close to being fully supported.
These results are described more thoroughly in the following chapter where the
main findings are included.
8. Main findings from the questionnaire survey

8.1 Introduction

The findings presented in this chapter have been collected from the questionnaire survey presented in chapter 7 (see questionnaire in Appendix B). As earlier described, the analysis applied to the collected data includes descriptive statistics, principal scale reliability testing using Cronbach’s alpha and correlation analysis using Kendall’s coefficient correlation analysis denoted by \( \tau \). The measures reported in the hypothesis figures are based on a two-tailed probability test, because each comparison can have two possible directions. The significance of test results is reported and based on their probability level. Thus, a probability between 0.05-0.01 is significant and a probability below 0.01 is highly significant. The first section presents the descriptive statistics of the questionnaire results for the seven IS success dimensions and their adjacent measures\(^{42}\). A section testing of the eleven stated hypotheses follows this. This section will show the correlations found between independent variables and measures, which verify or contradict the 11 hypotheses\(^{43}\). Even though all hypotheses were not found to show a strong correlation on a comprehensive level (see table 18), single measures in the model may show high correlations. A discussion of the findings within the context of previously performed studies found in the literature is found in the conclusions, concerning the research hypotheses covered, in the preceding chapter.

\(^{42}\) More detailed descriptions of this in Appendix D.

\(^{43}\) More detailed descriptions of this in Appendix E.
8.2 Questionnaire survey results

8.2.1 System quality

The system quality instrument receives a high internal reliability value of 0.90. From the results of the questionnaire survey the usefulness of system features and functions variable and the convenience of access variable both show highest values, ranging between 6.13 and 6.47. The response time variable and the ease of use variable on the contrary show the lowest values. The overall impression is that the system shows a fair quality, that is, all measures have received a value over 4.00 except for one. This value has to do with the amount of steps necessary to perform an operation in the IS.

The high values of convenience of access and usefulness of system features and functions can both be seen in table 19. Thus, the IS is perceived to be very important and extremely useful by the users. Two particular features that differ between the new IS and the old IS is the systems ability to connect processes and information and at the same time be accessible almost from all locations. The web-based interface enables the user to gain access through any Internet connection. The low satisfaction with the response time measure can only be explained by poor network capabilities in the studied company. The almost as low measure of ease of use was explained in the interviews with the PMs, by the number of steps necessary to save a document within the system. By the instalment of a drag and drop function in the system, the number of steps necessary to save a document was reduced from five ‘clicks’ to a single ‘click’. According to the users, the system is now “very easy to use.” The lower values of ease of use may be connected to age or it may not.

Table 19: Averages from the system quality findings (source: Appendix D)
8.2.2 Process quality

The process quality instrument receives an internal reliability measure of 0.88. In table 20 the information acquisition variable, the information utilisation variable and the information dissemination variable cover the highest values. Measures using these variables show an average value between 6.60 and 6.27.

Table 20: Averages from the process quality findings (source: Appendix D)

Among these measures is the IS’s ability to support storage of information, collaboration, communication, coordination and information exchange between project participants. Also included in the high values is the IS’s ability to visualise the process structure, which clarifies the important decision points in the process and enables a structured way of working. The answers given in the questionnaire show lower values in the information identification variable and the information preservation variable. Among the low measures, the statements on record document clarification and information search and retrieval are found. The low values can be derived from the respondents’ lack of experience of the information retrieval function and the vague description of record documents in the IS. Despite this, the values from the questionnaire survey indicate that the quality of the information management process is high. The high values of information development, information acquisition, information utilisation and information dissemination show that a process-oriented approach to information management receives a warm welcome from the respondents.

8.2.3 Information quality

The internal reliability of the information quality instrument is 0.81, which indicates a fairly high reliability. The highest values were found in the information relevance variable, the information usefulness variable and the information usableness variable, with values between 6.53 and 6.33 (see table 21). Measures found under these variables show that the IS delivers an information output that the respondent
finds useful. The information output provided by the system is also highly relevant
and helpful in the daily work situations for the users. The lowest values were found
in the information accuracy variable and the information completeness variable. Those
values were associated with the completeness and the up-to-date nature of the
information output. Since the IS is fully reliant on human effort, the quality of the
output is fully related to the quality of the input. The overall impression is that the
information output is of a high quality. The high values of information relevance, in-
formation usefulness and information usableness may thus be explained by the sudden
availability of most project information in one place. The low values of information
accuracy and information completeness can be explained by a lack of up-to-date
information in the new IS. Some of the information put into the new IS was not
updated, making some users discontent with the accuracy and content of the
output. As a result, an extensive document overview was initiated with the aim of
updating old information and excluding unwanted information.

Table 21: Averages from the information quality findings (source: Appendix D)

8.2.4 System use
The only instrument of the questionnaire survey that did not receive a high internal
reliability measure was the system use variable. The system use instrument
received an internal reliability of 0.64. The value is not catastrophic neither is it
supported by the majority of scholars, even if some remark that the acceptance
level for internal reliability is above 0.60 (Heath and Martin 1997). Based on this,
the instrument was deemed acceptable for this study only and not recommended
as a whole for other researchers to use. One reason for low internal reliability may
be due to the use of questions using the Likert-scale in combination with questions
using a numerical rating scale. The results from system use questions (see table 22)
show high values in the appropriate use variable and the purpose of use variable, with
scores between 6.53 and 6.33. The high values indicate that the system is used as
support for project development, project management and project planning. The low measure in frequency of access is however associated with how many hours the IS is being used per week. The overall impression is that the actual use of the system is high. The high values of appropriate use and purpose of use may be explained by the sudden availability of a support tool for the housing development process and the availability of an improved document control system. The low values of frequency of access may be explained by the users being unaccustomed with working with a computer-based system. It might also be connected to the use of numerical rating scale and the numbers used on the scale. From the numerical rating scale questions it can be estimated that the average user retrieves, creates, studies, alters or distributes between 21-23 documents per month, uses the system more than once a day and spends between 12-16 hours per week with a maximum of over 25 hours working with the system.

Table 22: Averages from the system use findings (source: Appendix D)

![Bar chart showing averages for system use findings](image)

8.2.5 User satisfaction
The internal reliability of the user satisfaction instrument is 0.88, which indicates high internal reliability. The highest values in table 23 are found in the information satisfaction variable and the satisfaction with specifics variable, with a score of 6.13. These include measures such as satisfaction with the document control and collaboration capabilities of the IS. Satisfaction with the information output, in that it fully matches the needs and wants of the users, is also high on the agenda. Low measures can be noted in software satisfaction and satisfaction with specifics. The overall impression however is that users’ satisfaction with the system is extremely high as no rating goes below 5.00. The high values of information satisfaction and satisfaction with specifics may be explained by the document control and collaboration capabilities with other project members; also the information output fully matches the users’ needs.
8.2.6 Individual impact

The internal reliability of the individual impact instrument is 0.75, which is a reasonable indication of internal reliability. From the questionnaire result, it can be noticed that the highest values (see table 24) are found in the variables of learning, personal evaluation of IS, improved individual performance, task performance, information awareness and decision quality, with scores between 6.40 and 6.27. Thus, the users indicate that using the IS improves process training and education improves access to existing sources of information and receives suitable conditions for improved work performance in general. The lowest value is found in the change in decision variable. The overall impression is that the IS has a large positive impact on the individual's performance. The high values found in information understanding, learning, personal evaluation of IS, improved individual performance, task performance, information awareness and decision quality may be explained by the sudden availability of information in a process context enabling a shared understanding. This is also seen in the SSI result (see the following paragraph), which indicates that the comprehensive view of process work and information retrieval capabilities has increased by 55% since the introduction of the IS. The low value of change in decision may be explained by the systems flexibility of supporting the user, not forcing him/her to change his way of working. The results also show that users estimate that the system will improve their ability to handle information by between 16 and 17% indicating a large capability of improving work productivity. This is also seen in the SSI result, which indicates that work productivity has improved by approximately 36% from the previous year.

| Table 23: Averages from the user satisfaction findings (source: Appendix D) |

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<table>
<thead>
<tr>
<th>Software satisfaction</th>
<th>Decision-making satisfaction</th>
<th>Satisfaction with specifics</th>
<th>Information satisfaction</th>
<th>Overall satisfaction</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>6</td>
</tr>
</tbody>
</table>

---

CHAPTER 8
8.2.7 Findings from the system satisfaction index (SSI)

Based on the results of the SSI parameters from the 2001 study, with results from the 2002 study, it possible to measure the PM’s changes in attitude regarding the newly implemented IS. The results as shown in table 25 show a significant increase in user satisfaction with the new IS. A comparison shows that perceived individual productivity has increased by 36% (from 3.03 to 4.10), comprehensive view of process work has increased by 44% (from 2.94 to 4.23) and information retrieval has increased by 61% (from 2.66 to 4.28).

Table 25: Averages from the SSI findings (source: Appendix D)
8.2.8 Project (group) impact

The last project impact instrument also displayed an adequate internal reliability of 0.77. The questionnaire result indicated that the PMs found that the IS had made the biggest impression (see table 26) by delivering an improved information management and overall productivity gains, with values between 6.53 and 6.00. The major areas of improvement were the ISs ability to manage information, improve workgroup communication and cooperation and support training and education of employees. Low measures can be noted in time effectiveness and increased profit.

The overall impression is that the system has a positive impact on project (group) performance. The high values found in the variables of improved information management and overall productivity gains may be explained by the sudden ability of finding and sharing information between project participants in a process context. The low value of time effectiveness and increased profit may be explained in the following way. Increases in time may be explained by the systems tougher demands on the user, i.e. what a PM has to do before an executive decision can be made. The results of the increased profit question show that the respondents’ estimate that the IS will reduce information management costs by 12-13%.

Table 26: Averages from the project (group) impact findings (source: Appendix D)
8.3 Hypothesis correlations

8.3.1 Testing the hypothesis that increases in system quality will lead to increases in system use

Based on the answers presented in the earlier section the stated hypothesis that increases in system quality will lead to increases in system use is tested here. As shown in chapter 7, the hypothesis achieves a correlation of -0.284, which is significant at the 0.148-level. The result does not support the hypothesis statement and very few variables in system quality affect system use in a positive way. Even though the instrument correlation shows a negative and low relationship between the main variables, there are a few correlations between independent measures, which show significant results. The following paragraph will show the correlations and non-correlations found between the system quality and system use measures. The following correlations were supported by this study:

- **Database content – system use**: No correlation could be found between the database content variable and system use.
- **Ease of use – system use**: The results show that increases in *ease of use* leads to increases in *frequency of report request* and reductions in *appropriate use, amount of connected and frequency of access*.
- **Ease of learning – system use**: The *ease of learning* variable shows a negative relationship with the *appropriate use* variable and the *purpose of use* variable.
- **Convenience of access – system use**: No correlation could be found between the *convenience of access* variable and system use.
- **Usefulness of system features and functions – system use**: The *usefulness of system features and function* variable, despite having negative hypothesis results, show a positive correlation with the *frequency of report request* variable and the *purpose of use* variable.
- **System flexibility – system use**: No correlation could be found between the *system flexibility* variable and system use.
- **System reliability – system use**: Increases in *system reliability* are shown to be negatively correlated to the *number of reports generated* and the *amount of connected time*.
- **Integration of systems – system use**: When it comes to *integration of systems* the questionnaire result also indicates a negative relationship with the *number of reports generated*.
- **System efficiency – system use**: The *system efficiency* variable also shows a negative relationship with the *appropriate use* variable and the *purpose of use* variable.
- **Response time – system use**: Finally, a negative relationship is found between *response time* and *number of reports generated*.
The results indicate that the IS is used to store produced documents and is, therefore, an important system for the housing developer’s organisation. However, some negative relationships were found from the survey results. The PMs spent less time using the IS as a consequence of how easy and user-friendly the IS was perceived and they spent less time using the IS as a consequence of bad hardware/software characteristics (reliability and speed).

8.3.2 Testing the hypothesis that increases in system quality will lead to increases in user satisfaction

The hypothesised positive relationship between the system quality variable and the user satisfaction variable achieves a low correlation of 0.282, which is significant at the 0.149-level. Based on this result it is advisable to reject the hypothesis. The results indicate, however, that some of the underlying variable measures show strong independent correlations. The following paragraph will show the correlations and non-correlations found between the system quality and user satisfaction measures. The following correlations were supported by this study:

- **Database Content – User Satisfaction**: Initially, no correlation was found between the database content variable and user satisfaction.
- **Ease of Use – User Satisfaction**: From the questionnaire results it can be observed that increases in ease of use lead to increases in software satisfaction and satisfaction with specifics.
- **Ease of Learning – User Satisfaction**: No correlation was found between the ease of learning variable and user satisfaction.
- **Convenience of Access – User Satisfaction**: No correlation was found between the convenience of access variable and user satisfaction.
- **Usefulness of System – User Satisfaction**: In contrast to the previous two variables the usefulness of system variable has a positive correlation with the software satisfaction variable and the information satisfaction variable.
- **System Flexibility – User Satisfaction**: The system flexibility variable exhibits no correlation with user satisfaction.
- **Integration of Systems – User Satisfaction**: The questionnaire result also indicates a positive correlation between the integration of systems variable and the satisfaction with specifics variable.
- **System Reliability – User Satisfaction**: Increases in system reliability according to the hypothesis correlation lead to increases in software satisfaction, satisfaction with specifics and information satisfaction.
- **Response Time – User Satisfaction**: No correlation was found between the system’s response time and user satisfaction.
• **SYSTEM EFFICIENCY – USER SATISFACTION:** Finally, increases in **system efficiency** is shown to lead to increases in **software satisfaction** and **satisfaction with specifics.**

The results from the questionnaire survey indicate that the PMs are very satisfied with the input screens of the IS and the information handling capabilities as a consequence of the clear organisation of information on the screen.

**8.3.3 Testing the hypothesis that increases in process quality will lead to increases in system use**

The hypothesised relationship between process quality and system use achieves, based on the questionnaire results, a low correlation of 0.039 significant at the 0.842-level (two-tailed). The result indicates that the hypothesis should be rejected: few variables in process quality affect system use in a positive way. It is therefore advisable to reject the statement as a whole. But as shown in the first section of this chapter, the system use instrument did not show a very high internal reliability causing one to think of the instruments role in the low correlations. The results show, however, strong independent correlations between measures in the process quality variable and measures within the system use variable. The following paragraph will indicate the correlations and non-correlations found between the process quality and system use measures. The following correlations were supported by this study:

• **INFORMATION DEVELOPMENT – SYSTEM USE:** For a start, it is observed that increases in the **information development** variable lead to increases in the **purpose of use** variable.

• **INFORMATION ACQUISITION – SYSTEM USE:** The questionnaire results give a more positive correlation relationship between **information acquisition** and **system use.** Here, the information acquisition variables shows a positive impact on **appropriate use, purpose of use and regulatory of use,** but also a negative impact on **appropriate use, number of reports generated and frequency of access.**

• **INFORMATION IDENTIFICATION – SYSTEM USE:** The questionnaire results indicate a stronger correlation between information identification and system use variables. Hence, **information identification** shows a high positive correlation to the **purpose of use** variable, but a negative relation to **regulatory of use.**

• **INFORMATION PRESERVATION – SYSTEM USE:** Increases in the **information preservation** measures show based on the respondents answers from the questionnaire survey increases in the **frequency of report request** variable, but in turn shows a negative impact on **amount of connected time.**
8.3.4 Testing the hypothesis that increases in process quality lead to increases in user satisfaction

The hypothesised relationship between process quality and user satisfaction, differing from the previously presented relationship correlation, achieves a high correlation of 0.657 significant at the 0.001-level. The result indicates that the hypothesis is true and that many variables in the process quality dimension affect user satisfaction in a positive way. This indicates a good fit between the instruments of process quality and user satisfaction, encouraging further use. The results also show strong independent correlations between measures in the process quality
variable and measures within the user satisfaction variable. The following paragraph will show the correlations and non-correlations found between the process quality and user satisfaction measures. The following correlations were supported by this study:

- **information development – user satisfaction**: From the questionnaire results it can be noticed that an increase in information development leads to increases in satisfaction with specifics and overall satisfaction.
- **information acquisition – user satisfaction**: It can also be gathered from the material that increases in information acquisition lead to increases in satisfaction with specifics and overall satisfaction and reductions in software satisfaction and decision-making satisfaction.
- **information identification – user satisfaction**: Looking at the information identification variable makes it clear that this is an important variable for user satisfaction. Increases in the variable lead to increases in all the user satisfaction variables, i.e. software satisfaction, decision-making satisfaction, satisfaction with specifics, information satisfaction and overall satisfaction.
- **information preservation – user satisfaction**: The information preservation variable also has a strong impact on all the variables of user satisfaction, causing increases in software satisfaction, decision-making satisfaction, satisfaction with specifics, information satisfaction and overall satisfaction.
- **information utilisation – user satisfaction**: The information utilisation variable is yet another variable instigating increases in software satisfaction, satisfaction with specifics, information satisfaction and overall satisfaction.
- **information dissemination – user satisfaction**: Finally, it is shown from the questionnaire results that increases in the information dissemination variable lead to increases software satisfaction, decision-making satisfaction, satisfaction with specifics, information satisfaction and overall satisfaction.

A highly significant relationship was found between the PMs ability to identify information (navigate) in the IS and their satisfaction with the software, the information, the collaboration capabilities with other project members, document control, information handling capabilities and the overall rating of the IS. Highly significant relationships were found between the PMs’ satisfaction with the software, document control, information handling capabilities and support in important decision-making as a result of the IS ability to organise information (documents). Another highly significant correlation was found between the PMs’ perceived satisfaction with the information handling capabilities of the IS and their ability to do a better and more effective job using the information in the IS. Finally, a strong association was found between the PMs’ satisfaction with the software, information handling capabilities, and the information accessible through the IS
and the IS ability to support communication, collaboration, coordination and information distribution between project members.

8.3.5 Testing the hypothesis that increases in information quality will lead to increases in system use

With a low correlation coefficient of 0.168 significant at the 0.395-level the hypothesised positive relationship between information quality and system use is without basis. It is therefore advisable to reject the hypothesis statement. The results however indicate that some of the underlying measures show strong independent correlations with each other. The following paragraph will show the correlations and non-correlations found between the information quality and system use measures. The following correlations were supported by this study:

- **Relevance** – **System use**: Increases in information *relevance* have a positive impact on *frequency of report request* and *purpose of use*.
- **Usefulness** – **System use**: In terms of increases in information usefulness it could be observed that it leads to increases in *purpose of use*.
- **Usability** – **System use**: The same applies to information usability compared with *purpose of use*.
- **Clarity** – **System use**: No correlation was found between the information *clarity* variable and *system use*.
- **Understandability** – **System use**: Based on the respondent answers in the questionnaire survey a positive correlation was found between *understandability* and *frequency of report request*.
- **Format** – **System use**: For the information *format* variable a negative impact was found with *purpose of use*.
- **Content** – **System use**: Increases in the information *content* variable lead to increases in *frequency of report request*.
- **Accuracy** – **System use**: No correlation was found between the information *accuracy* variable and *system use*.
- **Sufficiency** – **System use**: Information *sufficiency* was found to bring about increases in *frequency of report request* and *purpose of use* and a reduction of *regulatory of use*.
- **Completeness** – **System use**: No correlation was found between the information *Completeness* variable and *system use*.
- **Reliability** – **System use**: The results also show a positive relationship between information *reliability* and *frequency of report request* and *number of reports generated* and a negative relationship to *purpose of use*. 
Finally, it can be noticed that increases in information timeliness lead to increases in frequency of report request and reductions in amount of connected time.

One highly significant relationship was found between the reliability of information output from the IS and how often the PMs use the IS to study produced documents. This relationship expresses an obvious conclusion. If the information is not relevant to the users’ needs, they are not going to consult the IS for advice.

8.3.6 Testing the hypothesis that increases in information quality will lead to increases in user satisfaction

From the coefficient correlation result, as described in chapter 7, the relationship between information quality and user satisfaction achieves a medium correlation of 0.363 significant at the 0.065-level. Using a (one-tailed) test, i.e. testing the correlation one-way from information quality (as shown in the model) indicates that the correlation between information quality and user satisfaction is significant at the 0.05-level. The correlation is, in spite of this, not used as recognition of the stated hypothesis. The result however indicates that many hypothesis variables in information quality affect user satisfaction in a positive way. The following paragraph will show the correlations and non-correlations found between the information quality and user satisfaction measures. The following correlations were supported by this study:

- **Relevance – User Satisfaction**: When looking at the relationship between information quality and user satisfaction it could be detected, based on the survey result, that increases in information relevance leads to increase in satisfaction with specifics.
- **Usefulness – User Satisfaction**: A positive correlation between information usefulness and satisfaction with specifics was also detected.
- **Usability – User Satisfaction**: Increases in information usability were shown to have a positive impact on satisfaction with specifics and information satisfaction.
- **Clarity – User Satisfaction**: The information clarity variable showed a positive relationship with software satisfaction and information satisfaction.
- **Understandability – User Satisfaction**: The information understandability variable on the other hand only indicates a positive correlation with the software satisfaction variable.
- **Format – User Satisfaction**: An increase in the information format variable leads to an increase in software satisfaction.
Highly significant correlations were found between the IS ability to provide easy to understand information to the PMs and how satisfied they were with the user interface of the system. The information content variable was also found to have a strong relationship with the PMs’ satisfaction with the documents provided by the IS. Another highly significant relationship was found between the suitability of the information in the IS and the match with the PMs wants from such a system. The information reliability was also found to have a highly significant correlation with the PMs satisfaction with the information accessible through the system. The timeliness factor also shows a highly positive impact on the PMs satisfaction with the input screens in the IS.

8.3.7 Testing the hypothesis that increases in system use will lead to increases in user satisfaction and vice versa

For this coefficient correlation, as shown in the main study chapter, there is a low correlation of 0.108 significant at the 0.583-level for the hypothesised relationship between system use and user satisfaction. Thus, the result does not support the hypothesis and indicates that few variables in system use affect user satisfaction in a positive manner. The result however indicates that some hypothesis variables in system use affect user satisfaction in a positive way. The following paragraph will show the correlations and non-correlations found between the system use and user satisfaction measures. The following correlations were supported by this study:
• **Frequency of report request – user satisfaction:** As a start it could be observed that increases in frequency of report request bring about increases in software satisfaction, decision-making satisfaction and information satisfaction.

• **Appropriate use – user satisfaction:** The variables of appropriate use could be seen having a negative impact on software satisfaction.

• **Purpose of use – user satisfaction:** Increases in the purpose of use variable cause increases in satisfaction with specifics and overall satisfaction.

• **Number of reports generated – user satisfaction:** No correlation was found between the number of reports generated variable and user satisfaction.

• **Regulatory of use – user satisfaction:** No correlation was found between the regulatory of use variable and user satisfaction.

• **Amount of connected time – user satisfaction:** The variable of amount of connected time could be seen having a negative impact on software satisfaction.

• **Frequency of access – user satisfaction:** Finally, no correlation was found between the frequency of access variable and user satisfaction.

Some highly significant correlations were found – between the information output fully matching what the PMs want from such a system and their using the IS to study produced documents; and the PMs being satisfied with document control in the IS and using the IS for obtaining work instructions.

### 8.3.8 Testing the hypothesis that increases in system use will lead to increases in individual impact

The stated hypothesis that increases in system use will lead to increases in individual impact achieves a low correlation of 0.109 significant at the 0.582-level based on the respondents’ answers in the questionnaire survey. The result indicates that the hypothesis is poorly supported and that very few variables in the system use dimension affect individual performance in a positive way. The following paragraph will show the correlations and non-correlations found between the system use and individual impact measures. The following correlations were supported by this study:

• **Frequency of report request – individual impact:** When looking at the relationship between system use and individual impact it could be detected that increases in frequency of report request brings about increases in decision quality, time to make decision, task performance, personal evaluation of IS and information management and a reduction in decision quality.
Especially significant correlations were found between the PMs’ frequency of using the IS to locate produced documents and the perceived impact that the IS facilitates quicker access to appropriate information and an improved ability to distribute information. There was also highly significant correlations between how often they use the IS to produce documents and receiving more relevant information for decision-making, which then makes their job easier. Some other highly significant relationships were found between the PMs using the IS to support project development/management and the ability to focus on their job and their ability to make better decisions. Using the system for obtaining work instructions also had a highly significant impact on reducing the PMs’ risk-taking.

8.3.9 Testing the hypothesis that increases in user satisfaction will lead to increases in individual impact

The stated hypothesis achieves a correlation coefficient value of 0.578 significant at the 0.003-level indicating a strong relationship. The result supports the hypothesis that many variables in user satisfaction affect individual performance in a positive way. The following paragraph will show the correlations and non-correlations found between the user satisfaction and individual impact measures. The following correlations were supported by this study:
• SOFTWARE SATISFACTION – INDIVIDUAL IMPACT: When looking at the relationship between user satisfaction and individual impact it was detected that increases in software satisfaction led to increases in information awareness, decision quality, time to make decision, improved individual productivity and information management.

• DECISION-MAKING SATISFACTION – INDIVIDUAL IMPACT: The decision-making satisfaction variable also had a positive impact on time to make decision and information management.

• SATISFACTION WITH SPECIFICS – INDIVIDUAL IMPACT: Increases in satisfaction with specifics showed increases in learning, information awareness, decision quality, improved decision analysis, correctness of decision, time to make decision, improved individual productivity, task performance, personal evaluation of IS and information management.

• INFORMATION SATISFACTION – INDIVIDUAL IMPACT: Increases in information satisfaction were found to have a positive impact on information understanding, learning, information awareness, decision quality, time to make decision, improved individual productivity, task performance and information management.

• OVERALL SATISFACTION – INDIVIDUAL IMPACT: Finally, increases in overall satisfaction showed increases in learning, information awareness, improved individual productivity and task performance.

Among these variables were a number of measures that were found to have highly significant relationships. The PMs were very satisfied with the software supporting the IS, with the effect of more relevant information being available to them for decision-making. A highly significant correlation was also found between the input screens in the IS and the support that the IS gives the PMs in important decision-making, with their ability to access appropriate information quickly.

Highly significant relationships were also found between the PMs satisfaction with specifics and the IS ability to: facilitate quicker access to appropriate information; improve PM work effectiveness and productivity; improve the PM’s ability to distribute information; give greater control over own work; reduce storage requirements for documents/information; reduce the PM’s risk-taking; make the PM more focused on the job he/she performs; and the PM’s ability to improve information handling. A strong correlation was also found between the IS making it easier for the PM to do his/her job (presenting more relevant information for decision-making) and the IS ability to present information that fully matches what

44) Satisfaction with information handling capabilities, process oriented navigation structure, collaboration capabilities with other project members, document control, version handling and documents provided by the IS.
the PM wants from such a system. Finally, a highly significant correlation was found between the PMs’ satisfaction with the information, which is accessible through the IS, and their perceived decision quality, time to make decision, individual productivity and individual performance.

8.3.10 Testing the hypothesis that increases in individual impact will lead to increases in project (group) impact

The last stated hypothesis shows a high correlation from the questionnaire survey results. From the coefficient correlation, as shown in the chapter 7, the hypothesis achieves a value of 0.585 significant at the 0.003-level. The result supports the hypothesis and indicates that most variables of individual impact affect project (group) impact in a positive way. The following paragraph will show the correlations and non-correlations found between the individual impact and project (group) impact measures. The following correlations were supported by this study:

- **Information understanding – Project impact**: Increases in information understanding were found to cause increases in staff reductions and increased profits.
- **Learning – Project impact**: The learning variable showed to have a positive impact on staff reduction, improved information management and increased profit.
- **Information awareness – Project impact**: For information awareness a clear, positive correlation was found with staff reduction, overall productivity gains and improved information management.
- **Decision effectiveness – Project impact**: Increases in decision effectiveness showed intensification in overall productivity gains and increased work volume.
- **Decision quality – Project impact**: When looking at decision quality it was noticed that increases here lead to increases in overall productivity gains, contributing to achieving goals, service effectiveness and improved information management.
- **Improved decision analysis – Project impact**: Increases in improved decision analysis lead to increases in overall productivity gains and improved information management.
- **Correctness of decision – Project impact**: It can also be discerned from the results that increases in correctness of decision bring about increases in improved information management.
- **Time to make decision – Project impact**: Increases in the time to make decision variable have a positive impact on staff reduction, overall productivity.
gains and improved information management, product quality, contributing to achieving goals and improved information management.

- **Confidence in Decision – Project Impact:** Increases in the confidence in decision variable bring about increases in overall productivity gains.

- **Improved Individual Productivity – Project Impact:** An increase in the improved individual productivity variable brings about increases in staff reduction, overall productivity gains, product quality, time effectiveness and improved information management.

- **Task Performance – Project Impact:** Task performance has a positive impact on staff reduction, overall productivity gains, product quality, time effectiveness and improved information management.

- **Change in Decision – Project Impact:** For the change in decision variable there is a negative impact on overall productivity gains.

- **Personal Evaluation of Information System – Project Impact:** Personal valuation of IS causes both increases and reductions in overall productivity gains.

- **Information Management – Project Impact:** Finally, increases in information management bring about increases in operating cost reductions, staff reduction, overall productivity gains, product quality, improved information management and reductions in increased work volume.

Between the dimensions of individual impact and project (group) impact a great number of highly significant correlations were found. The PMs felt that the project group could function more effectively, as a consequence of the IS, through better access to existing sources of information and an increased information sharing capability. A highly significant relationship was also found between the availability of relevant information for decision-making and the project group’s ability to increase information sharing, improve communication and improve cooperation (i.e. function more effectively). More availability of relevant information also supports training and education of newly recruited employees. The relationship between the PMs ability to reduce time spent with decision-making and the IS’s ability to facilitate quicker responses to project changes, reductions of rework and waste, reductions of staff in projects and improved communication within the project group was also found to be highly significant.

The IS has a large impact on PM effectiveness, productivity and performance, and correlates well with the project groups productivity and work participation. This also affects the project group’s ability to communicate and cooperate. Many of

\[45\] Also the number of needed project group participants.
these correlations stress the relationship between the individual having free time to interact with the project group, thus leaving room for improved teamwork. Thus, the PM values the support that the IS gives him/her in controlling and leading the project group. He/she also values the support the system gives when it comes to creating a team feeling among project group members, clarifying project goals and handing over more responsibility to the individuals in the project group. It is thus important that the IS both supports individual work, but also trains and educates the members of the project group. Some other highly significant relationships were found between the PMs’ ability, in using the IS, to improve their task performance and the ability to reduce staff on projects. A strong correlation was also found between the PMs’ ease in performing their jobs and the project groups’ increase in informal information exchange and information sharing. Finally, a highly significant relationship was found between the PMs’ ability to access/distribute information and the project group’s ability to communicate with one another. The PMs’ ability to access/distribute information also supports staff reductions.

8.4 Conclusions

A closer look at the results reveals that only one value is measured below four in the answers. This value is found under system quality and refers to the statement that the number of steps taken in the system is too many. This might seem like the scale has been misapplied and is inappropriate for this particular questionnaire survey. The reason why this type of scale was used derives from the results gathered in the previous year in the SSI survey. The average for the SSI survey that year ended below three on a five-item Likert scale. For the purpose of being able to distinguish between the low values it was decided to include a more detailed measurement scale, i.e. in this case an seven-item scale. From the main findings, the following variables and adherent measures are supported by some relationship in the tested hypothesis displaying a somewhat altered ISSM (see table 27). The following measures may be suggested, based on the main findings in this thesis, as appropriate variables to use when measuring ISS. The low number of correlations between the system use dimension and all other dimensions indicates that this dimension could be excluded from the ISSM. The final results of this work are concluded and generalised in the next chapter.

46) Task performance includes time to accomplishing task, work quality and work control.
Table 27: Variables and measures that are supported by the findings of this study

<table>
<thead>
<tr>
<th>System quality</th>
<th>User satisfaction</th>
<th>Process quality</th>
<th>Individual impact</th>
<th>Information quality</th>
<th>Project (group) impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Ease of use • Usefulness of system features and functions • System reliability • Integration of systems • System efficiency</td>
<td>• Software satisfaction • Decision-making satisfaction • Satisfaction with specifics • Information satisfaction • Overall satisfaction Individual impact</td>
<td>• Information development • Information acquisition • Information identification • Information preservation • Information utilisation • Information dissemination</td>
<td>• Information understanding • Learning • Information awareness • Decision effectiveness • Decision quality • Improved decision analysis • Correctness of decision • Time to make decision • Improved individual productivity • Task performance • Personal evaluation of IS • Information management</td>
<td>• Relevance • Usefulness • Usability • Clarity • Understandability • Format • Content • Accuracy • Sufficiency • Completeness • Reliability • Timeliness</td>
<td>• Operating cost reductions • Staff reductions • Overall productivity gains • Increased work volume • Product quality • Contribution to achieving goals • Service effectiveness • Time effectiveness • Improved information management • Increased profit</td>
</tr>
</tbody>
</table>
9. Conclusions and implications

9.1 Introduction
This thesis describes a process orientation initiative within a housing development company, linking the importance of both processes and ISs to eventual PM performance and to the success of project delivery. The underlying study combines research in the areas of operations management, construction management, construction IT and ISs. Of central importance is the concept of process orientation, where a description of the housing development process is developed and improved until it is considered to be sufficient for the purpose of managing projects. In addition, this thesis has proposed a comprehensive process, focusing on the use of ISs as one promising solution to previously stated problems in the construction sector.

The unique aspects of this study are: the full description of a process orientation procedure evaluated in a real situation by means of action research; the development of an assessment instrument (hypothesis model) for measuring IS success including the additional measure of process quality (information management process); and empirically testing the stated relationships of the hypothesis model enabling a validation and enhancement of the existing ISSM developed by DeLone and McLean (1992). Empirical links between process orientation initiatives, including IS developments, and project outcome have been limited, but this research empirically supports a positive relationship between PM performance and project success. Furthermore, the study shows the positive impact of PM performance on project outcome indicating that good information management is an essential component of project success. The purpose of this final chapter is to

47) There is a lack of continuity (repetitive behavior) in housing development projects.
summarise the key conclusions with reference to the specific research questions, research objectives, research hypothesis and implications for theory, policy and practice, limitations and future research.

9.2 Conclusions about the research questions
To summarise the introductory parts of this thesis, the research set out to try to answer two research questions, re-stated below, as a consequence of a perceived lack of continuity (repetitive behaviour) in projects within the construction sector.

1) Will a process oriented information system positively impact on the performance of project managers and in particular on the performance of project groups?
2) How important is a process oriented information management process for the success of the information system?

The two primary research areas of process orientation and ISs, recognised by the ITC community, were subsequently studied and, in particular, the relationship between ISs and holistic process approaches. To assess how successful the newly developed IS was, a hypothesis was developed leading ultimately to the development of an assessment instrument measuring IS success. The remaining part of this section addresses the research questions.

9.2.1 Research question 1
The impact of the process oriented IS is positively related to the performance of the studied PMs and the performance of their projects. As seen in Chapter 8, the housing developer’s PMs placed a high value on the IS’s ability to contribute to learning, improve information awareness, improve information understanding, improve individual performance, improve task performance and improve decision quality. Undoubtedly, many of these features could have been accomplished with a traditional IS. However, the process focus contributes to the availability of information in a process context enabling a shared understanding. The overall impression is that the IS has a large positive impact on an individual’s performance. The housing developer’s two SSI surveys’ (2001-2002) also show, as a consequence of the new IS, an increase of 44% in getting a more comprehensive view of process work. The SSI results also demonstrate that the PMs perceived the new IS as improving their individual productivity by 36% and their ability to retrieve information by 61%.
Of central importance, to this perceived success, is the elucidation of the housing development process. By arranging information according to the activities in a comprehensive process map, the user feels that he/she spends less time understanding the obvious and more time performing tasks that generate value for the customer and enhance internal efficiency. This quality also contributes to the user’s individual training and education in terms of managing projects. Consequently, by improving access to the correct, existing sources of information, suitable conditions for improved work performance in general can be achieved. An improved ability to handle information by as much as 16-17% was perceived by the PMs, which indicate a large potential for increasing work productivity.

The new IS also appears to offer improved performance when it comes to project delivery. The PMs place high value on the ISs ability to deliver improved information management and overall productivity gains. The general impression is that the IS has a positive impact on project (group) performance. Undoubtedly, many of these features could also have been accomplished with a traditional IS. However, the process focus contributes to the ability to share information between project participants in a process context. The process context is perceived to improve the ISs’ ability to manage information, improve workgroup communication and cooperation and support the training and education of employees. Thus, learning and communication among project participants seem to be especially important parameters. These indicate that the ability to share information with internal as well as external project participants is a vital parameter of an IS. The ability to secure support for the work process enables effective teamwork as well as contributeing to project learning. The IS is perceived to reduce information management cost by as much as 12-13%, which means a profit increase (alternatively, a product cost decrease) equal to 3.0-3.3% of the total revenue in a housing development project.

9.2.2 Research question 2

The hypothesis testing presented in Chapter 7 and 8 found a correlation, with high significance, between process quality and user satisfaction (H4). User satisfaction in turn was also found to have a highly significant relationship with individual impact (H10), which in turn was found to have a highly significant relationship with project (group) impact (H11). This in turn indicates that the process quality measure (measures of the information management process) have a high influence on user satisfaction and indirectly also on individual impact and project (group) impact. This shows the importance of a process quality dimension when measuring the success of an IS. The conclusions from the hypothesis testing are described more thoroughly in the following section.
9.3 Summary and conclusions about the research objectives

Prior to describing how the five research objectives were dealt with in this study and what can be concluded from them, it is considered appropriate to re-state the objectives as previously presented in chapter one:

1) To identify and define activities and events that constitutes the housing development process, so that deficiencies in the flow of information and resources can be highlighted and excluded.
2) To propose an improved housing development process and instantiate it in every day work, by developing an information system that visualises the correct work procedures in a process-oriented manner.
3) To establish measures, in an assessment instrument, that will reveal the various dimensions of information system success, including qualities of the information management process.
4) To evaluate how project managers using the information system perceive information system success.
5) To explore the relationships, based on the evaluation, between the derived process qualities and the dimensions of information system success enabling a validation and enhancement of the assessment instrument.

In broad terms, the structure of this thesis has followed that of the above listed objectives. The first three objectives were addressed, each in turn, by chapters 3-6. The fourth and fifth objectives were addressed in chapters 7-9.

9.3.1 Objective 1

The first objective was accomplished through an extensive investigation of a housing developer’s processes. The investigation started with a thorough review of descriptive company specific system documentation. This review contributed to an understanding of the generally accepted activities in the housing development process and the creation of an activity list. It also achieved a clear understanding of the different existing control and support systems available in the organisation. This stage made beneficial use of individual views expressed by interviewees to capture as-is conditions and increase the researcher’s understanding of the process context. With this as a foundation, more extensive interviews and more structured surveys were performed to capture perspectives not described by the systems.

The understanding that a process model is less complicated than reality, and hence easier to use for research purposes, enabled the process to be formalised in a model. Based on a review of process modelling techniques it was decided to use the
IDEFO technique. Especially useful was the syntax of the IDEFO technique, which captured a number of different perspectives of the process. Two matrices, based on the document review, were also developed to support the gathering of process information. The matrices were then sent out through a postal questionnaire to process actors and later collected. Based on the empirical data captured in the interviews and surveys an as-is process model was created, displaying activities, inputs, outputs, dependencies, resources and support and control systems. Based on the experience from the study a recommended order of actions was established including the following steps.

- Establish aims and objectives.
- Review system documentation.
- Create an activity list and compile existing control/support documents.
- Create an activity-resource matrix and a DSM matrix.
- Distribute the matrices to relevant key personnel together with user-instructions.
- Collect completed matrices and compile the result.
- Create a process model based on the information gathered.

Based on this initial part of the study, a number of conclusions can be drawn. One is that a representation of a process, in any form, offers immense support for a company wishing to improve its performance. During the process of enquiry it was noticed that understanding and insights into the entire process was lacking even by the most successful managers. Thus, their process knowledge was drawn from, and limited by, their own project experience and not from some collective knowledge supplied by the company. This situation leaves process actors with incomplete knowledge of the common goals of the project, increasing the occurrence of sub-optimisation. The fragmentation nature of the construction sector can, consequently, be observed inside large construction companies. Instead of the sector’s many islands of different actors, companies have islands of professions and trades, e.g. purchasing, marketing, design and sales. By achieving an accurate representation of process information and making it more accessible, the potential gains for the company and the wider sector could be considerable.

Many tools are available for the purpose of process modelling and it is up to the user to decide if the method is suitable for the intended purpose or not. From the use of process models for the identification and definition of the housing development process a number of conclusions could be drawn. It was noticed that process models are invaluable for the purpose of structuring information about processes, but less valuable when introducing the result or educating personnel. The latter do not often have the time to take a closer look at the complex diagrams (arrows and
boxes) in order to filter information. It is therefore easier to start by describing the processes on a more comprehensive level and then introduce detailed information later. This is, more or less, like building up a framework and then filling it with substance. For displaying the resulting as-is processes, it was found to be more useful to use PowerPoint™ than the complex process models, which are better suited to researchers and process engineers.

9.3.2 Objective 2
The second objective was fulfilled through the performance of a thorough literature review and the carrying over of an extensive development effort resulting in an improved to-be housing development process and a supporting new IS. As little was known about the concept of process orientation an exploratory approach was chosen. The literature review was then summarised under the eight management principles of the ISO family to highlight similarities and focus on the essentials in the process orientation effort. An initial eight-day workshop with cross-functional participation was carried out to clarify vital dependencies between activities in the process. This also led to a clarification of external and internal resources in the process activities. Based on the resulting information from the workshop a DSM algorithm was applied, helping the researcher to generate modest changes in the sequence of process activities from the initial as-is process definition.

With the main principles of process orientation and the gathered process material in hand, an extensive development effort was initiated within the subject company to develop a to-be housing development process. People in the organisation were assigned to focus groups and a development organisation structure was established. During one year of frequent focus group sessions a new process structure emerged. The result was a description of a work system describing the processes, inputs, outputs (record documents), control/support documentation (procedures, knowledge documents, checklists and templates) and resources (people and IT). Based on the process models a process oriented navigation structure was incorporated into a new IS (based on a Domino.doc, Teamroom™ and Dols platform). The IS was developed to help project staff coordinate, communicate, document, and inform each other in an easy manner. The developed IS supported a shared workspace and document management, i.e. it allowed communication, collaboration, and coordination between project participants; also, general document management characteristics such as version handling, template storage and document storage were incorporated. This enabled the housing developer to store all its information in an activity (process) context. The IS serves as a process-oriented perspective of a single project. Thus, each project has a temporary IS, which consists of its own information and is available for everyone involved in the project.
The natural owners of these are the project managers, who control the access properties.

It can be concluded, from this work, that the involvement of people is necessary to achieve strong support and empathy among personnel when developing and implementing new procedures. It was noticed that it did not matter how right the system was theoretically if it was not accepted by the personnel in the company. Thus, it was important to involve people to gain the support for the new procedures. Even the discussions contributed to a larger understanding among those who participated in the development work. But, as a consequence of using people’s opinions, it was necessary for the researcher to act as a moderator to capture those opinions from everyone in the groups. Without a uniting individual the discussions tended to wonder away from the subject. By adopting the principles of customer focus, leadership, involvement and commitment of people, process approach, system approach to management, continual improvement, factual decision-making and mutually beneficial supplier relationships it became easier to focus on the important aspects of the development work. An example is the inclusion of decision-points (toll gates) between different process phases, which made factual decisions on investments possible and, with that, the ability to abort a project before incurring a loss for the company.

Since the first complete model was introduced in the summer of 2000, processes have been on everyone’s lips in the company. Executives, middle management and other staff functions are being involved in development efforts to improve processes. Thus, processes bring organisations together to perform against a common goal. Since, construction companies have a tendency to focus on quantities, processes will force them to think about quality, an area that is lacking in the sector. Consequently, one can conclude that one of the main prerequisites for a significant improvement in an organisation is to understand the bigger picture. Focusing on the details might well cause problems elsewhere in the organisation. Another conclusion is that without the use of IT, the instantiation of the new process procedures would have been harder to accomplish. The new IS made it possible to integrate and structure company specific systems and, at the same time, partitioning information among activities. Any paper-based system would have been too complex and difficult to manage over time.

9.3.3 Objective 3

The third objective was fulfilled through a comprehensive literature review, complementary to the review of process orientation literature, aimed at gathering information on how to evaluate the success of the newly created IS and supported
processes. Concurrently with the literature review, the IS was implemented in the organisation. The literature review identified existing theoretical frameworks and clarified issues of importance. It was found that the ISSM developed by DeLone and McLean (1992) was the most cited, acknowledged and widely used assessment model within the ISs research community. DeLone and McLean’s (1992) ISSM claim that system quality and information quality singularly and jointly affect both system use and user satisfaction. Also, the amount of system use – positively or negatively – affects the degree of user satisfaction and vice versa. System use and user satisfaction directly affect individual impact, which in turn should have some effect on the organisation.

A closer look at the model revealed the lack of a measure to assess the qualities of the information management process and how this measure impacted on the success of the IS. Based on a review of existing information (knowledge) management process frameworks the dimension of process quality was developed. Abecker et al.’s (1998) information (knowledge) management process framework was chosen due to its all-embracing nature. Based on the Abecker et al. (1998) nomenclature, the following common set of variables was used to structure the process quality measure.

- Information development
- Information acquisition
- Information identification
- Information preservation
- Information utilisation
- Information dissemination

More detailed and useful measures were then extracted from the literature and organised according to the main variables of Abecker et al.’s (1998) information management process framework. Using the ISSM as the foundation, the seventh perspective of process quality was added. Since, DeLone and McLean’s (1992) ISSM was presented on a comprehensive level, it lacked detailed measures, which also had to be extracted from the literature and existing instruments. The result was formulated in the augmented ISSM. Based on the model the following hypothesis was formulated: system quality, process quality and information quality singularly and jointly affect both system use and user satisfaction. Also, the amount of system use – positively or negatively – affects the degree of user satisfaction and vice versa. System use and user satisfaction direct affect individual impact, which in turn should have some impact on the project (workgroup).

48) More about this in Chapter 6.
The augmented ISSM (hypothesis model) combines both measures of ISs and processes and enables an evaluation of the relationship between an IS and a holistic process approach, thus combining the concepts of work systems and information systems. The hypothesis model enables the theoretical establishment of a process quality measure, but also a validation and enhancement of DeLone and McLean’s (1992) ISSM. Consequently, the result can be used to create an assessment instrument, which measures both process and ISS. Since construction work relies heavily on the performance of the information management process it seems important to include this seventh perspective of ISS. It has the potential to reveal if an IT investment is likely to generate value for money.

9.3.4 Objective 4

The fourth objective was fulfilled through a questionnaire survey with 15 PMs within the studied housing company. The questionnaire survey was carried out to measure PMs’ attitudes towards the new IS and to test the research hypotheses model empirically. The questionnaire was thus built up around the developed hypothesis model, but also included the housing developer’s system satisfaction index (SSI) measures. By including the SSI measures a ‘before and after’ comparison of PM attitudes was possible. Attitude scaling was applied in the survey, more precisely the Likert scaling method. The Likert scale used for this particular questionnaire survey rated the responses from strongly agree (7) to neither (4) to strongly disagree (1) with no verbal labels for scale points 2-3 and 5-6. Five numerical rating scale questions were also included to capture quantitative measures for actual usage and perceived benefits in time and cost from using the IS. The questionnaire results show that the characteristics of response sample, despite its small size, revealed surprisingly good consistency with the population of the Swedish operations. All of the seven dimensions of information success were given high ratings by the respondents. Overall, the respondents showed high satisfaction with the new IS with only one measure below 4. When looking at the questionnaire results it is quite noticeable that the respondents seem to perceive the new IS as more than acceptable. The main findings revealed that the system quality dimension received especially high value.

The respondents’ answers highlighting such parameters as: it is an important IS for the organisation; the IS is extremely convenient to access; the IS is extremely useful; and the user personally benefit from the existence of the IS. The respondents’ answers give the impression that the ability to gather all project-related informa-

49) More about this in Chapter 7 and 8.
tion in one place is highly appreciated. The ability to access the information through the Internet was also appreciated as it eliminates the need for costly client-based applications, but it also makes it possible to access the information from anywhere in the world. These parameters do not emphasise any advanced technical solutions; they just highlight the need for an IS to be easy to use in daily work. Except for mostly high values, two measures achieved lower values. These related to the speed of the system, i.e. whether or not it was fast enough and if the number of steps per task in the system was too many. The speed problem could be traced back to the company’s technical platform, which at times could be quite slow and had little to do with the new IS. The second low value had to do with an unnecessarily difficult procedure when importing documents into the IS database. This problem was later corrected by reducing the number of steps taken for the procedure from six to two steps. The process quality dimension showed high values in all variables with especially high values in the following variables.

- Information development
- Information acquisition
- Information utilisation
- Information dissemination

The most distinguishing parameters were the IS ability to facilitate or support: collaboration between project members; communication between members of the project team; communicating information between various members of the project team; storing of project information; and information exchange between project members. It also stressed parameters such as: making the job easier by using a process structure for information management; giving greater understanding of process procedures; facilitating more structured project management work; and clarifies the most important decision points in the process. In conformity with the system quality result, the respondents’ answers give the impression that the ability to gather all project-related information in one place is highly appreciated.

The new common set of process procedures was highly appreciated as previously diverging procedures in the different regional organisations were hurting the external appearance of the developer. This consequently led to a perceived feeling among the respondents that the quality of the operations had improved significantly. Especially appreciated is the support the IS gives the users to manage project information among the various members of the project team. The use of a process structure was also appreciated as it clarifies the work procedures giving users a greater process understanding enabling him/her to do a better job. The results thus indicate that there is much to gain from the establishment of a good process model and then building an IS around it. This gives the user a greater understanding of
his/her contribution to achieving the project goal, which is a finished product handed over to a customer. In the case of the information quality dimension the respondents’ answers showed high values in the following variables.

- Information relevance
- Information usefulness
- Information usableness

The answers concerning information quality stress such parameters as: the IS provides, for the users job, relevant information; the information output is as useful for an experienced user as it is for an inexperienced user; the output information is useful; and the information in the IS is useful in helping the user complete his/her tasks. These answers indicate that users appreciate that the information is structured according to the process both for educational and operational purposes. The IS is however not immune to inaccurate information as it relies heavily on people supplying the correct information. The system use dimension showed especially high values in the following variables.

- Appropriate use
- Purpose of use
- Number of report generated
- Regulatory of use

Measures that were given high values stated: using the IS for storing information; using the IS as project planning support; using the IS as project development (management) support; and using the IS to control projects. Moreover emphasising parameters such as: how many documents the user produces, stores, reads, alters and distributes per month in the IS; and how many times the user would say he/she uses the IS during a week. It can be concluded that by storing all information at one place has improved the information accessibility significantly within the housing developer organisation. The respondents’ answers indicate that such an IS is appropriate for managing projects, especially in construction where numerous actors have to work together and plenty of information is exchanged. Such an IS also simplifies the PM’s workload and displays what has to be done and what has not been done. The following variables achieved high values in the user satisfaction dimension from the questionnaire results.

- Satisfaction with specifics
- Information satisfaction
- Overall satisfaction
The result relates to issues such as: the user being satisfied with the collaboration capabilities with other project members; user satisfaction with document control in the IS; the information output fully matches what the user wants from such a system; and how the user rates his/her overall satisfaction with the IS. The results also indicate that there are three important characteristics for the user, where the first is collaboration, the second is document control and the third is appropriate information supplied by the IS. These characteristics reflect process quality and information quality measures, indicating that system quality is not the most important feature of a successful IS. The individual impact dimension showed high values in the following variables.

- Learning
- Decision quality
- Improved individual productivity
- Task performance
- Personal valuation of IS
- Information management

The results stress such parameters as: improving the user’s process training and education; the user finds using the IS advantageous in his/her job; using the system makes the user more focused on the job he/she performs; using the IS gives the user greater control over his/her work; improving access to existing sources of information; making more relevant information for decision-making available for the user; and facilitating quicker access to appropriate information. Consequently, by improving the quality of work the IS improves what is needed to save both time and money. This conclusion is also strengthened by the SSI result, which indicates large improvements in individual productivity, increased comprehensive view of process work and improved information retrieval. The results also show that the users estimate that the system will improve their ability to handle information by 16-17%. The last, but not the least, dimension – project (group) impact – revealed high values in the following variables.

- Overall productivity gain
- Improved information management

The respondents’ answers highlight such issues as: increased information availability within the project group; using the IS supports training and education of inexperienced as well as experienced users; the IS improves work participation by project members; the IS improves communication and cooperation within the project group; and the project group can function more effectively due to the increased information sharing capability. The respondents’ answers give the impression that
sharing access to a process-oriented IS among project members will improve information management and increase overall productivity of projects. The new IS also permits, due to the ability to authorise external participation in the system, improved sharing of information with customers, contractors, suppliers and subcontractors. Learning and communication seem to be especially important parameters. The questionnaire results also show that users estimate that the system will reduce information management cost by 12-13\%. Based on the general definition that information management cost is sales + general + administrative + research + development costs (Strassmann 1999), this would mean a profit increase or cost reduction of 3.0-3.3\% on total revenue.

9.3.5 Objective 5
The fifth and final objective was fulfilled through the performance of a statistical analysis on the data collected from the questionnaire survey\(^{50}\). After making sure that the instrument’s internal reliability was acceptable, a statistical correlation test was performed, enabling a confirmation or rejection of the hypothesised relationships. The attitudinal responses on the individual questions were statistically analysed and tested using a Kendall’s tau correlation coefficient analysis (two-tailed). The correlation results found that only three, out of the 11 tested hypotheses, were supported by the collected data. The result from the questionnaire study (see figure 40) shows support for the relationships of (H4) process quality and user satisfaction, (H10) user satisfaction and individual impact and (H11) individual impact and project (group) impact. System use and system quality show no relationship with any variable at all, supporting their exclusion. The relationship between information quality and user satisfaction, however, is almost supported by the questionnaire survey result.

\(^{50}\) See Chapter 7 and 8 for more details.
The absence of a relationship between ‘information quality and system quality’ and system use is also supported by McGill et al. (2000b). Based on the survey results it can be concluded that the process quality measure is appropriate in the context of ISS. The process quality measure shows a strong relationship with user satisfaction, individual impact and project (group) impact. For the individual user of the IS, the results in this study provide considerable support/dismissal of DeLone and McLean’s ISSM. The conclusions about the relationships of the hypothesis model are more fully described in the following section. To assess how successful the newly developed IS was, a hypothesis was developed and lead ultimately to the development of an assessment instrument measuring IS success. The result and main findings from the questionnaire survey were then used to test the hypotheses empirically. The remaining part of this section will attempt to show support or disagreement with the hypothesised relationships and compare them with results found in the literature.

**Hypothesis 1: Increases in system quality will lead to increases in system use**

This research found no immediate support\(^{51}\) for a relationship between system quality and system use. Out of the 17 variables included in this relationship only four were found to have any significant association whatsoever. This result corresponds to those of McGill et al. (2000b), who found no direct influence of system quality on system use. If there are any variables supporting the hypothesised relationship these are: **ease of use** and **usefulness of system features and functions** from the system quality variable; and **frequency of report request** and **purpose of use** from the system use variable. One conclusion, why this non-relationship exists, might be that different users have various time needs when using the IS. Thus, system quality might have varying influence on different individuals. A small part of this result might also be caused by the inclusion of three questions using a numerical rating scale.

**Hypothesis 2: Increases in system quality will lead to increases in user satisfaction**

The second hypothesis states that perceived system quality has a significant positive influence on user satisfaction. This relationship was not directly supported\(^{52}\) by the survey result of this study. Out of the 15 variables included in the hypothesis, eight were found to have a number of significant correlations. This result does not correspond to that of Seddon and Yip (1992), Seddon and Kiew (1996) and

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\(^{51}\) See Appendix E for more details about the correlations.

\(^{52}\) See Appendix E for more details about the correlations.
McGill et al. (2000b) who found that perceived system quality had a significant positive influence on user satisfaction. However, the results from the questionnaire survey indicate that the following variables were found to support the hypothesised relationship: ease of use, usefulness of system features and functions, system reliability, integration of systems and system efficiency from the system quality variable; and software satisfaction, satisfaction with specifics and information satisfaction from the user satisfaction variable.

The negative correlation between earlier performed empirical investigations and this study, however, does not contradict the results. Previously performed studies, which have investigated the relationship between system quality and user satisfaction, have not included the same number of variables from DeLone and McLean’s (1992) ISSM as in this study. One reason why the result here differs from those of Seddon and Yip (1992), Seddon and Kiew (1996) and McGill et al. (2000b) is that they included only measures of: ease of use and ease of learning in their system quality variable; and software satisfaction, system efficiency/effectiveness and overall satisfaction in their user satisfaction variable. To some extent, this explains why this study does not support a relationship, which has been revealed by several other investigations. Ease of use, system efficiency and software satisfaction are also supported by this study. Consequently, the conclusions from this research are that in addition to those variables supported by previous research, the variables of usefulness of system features and functions, system reliability, integration of systems, satisfaction with specifics and information satisfaction seem to have a valid case for inclusion in the ISSM.

**Hypothesis 3: Increases in process quality will lead to increases in system use**

The first test of the process quality dimension’s affiliation with ISS indicates no support for the relationship between process quality and system use. However, a closer look at the results from the questionnaire survey indicates that the following variables were found to support the hypothesised relationship: information development, information acquisition, information identification, information preservation, and information utilisation from the process quality variable; and frequency of report request, appropriate use, purpose of use and regulatory of use from the system use variable. As a whole, the result of this research does not however support the relationship between process quality and system use. One conclusion, similar to that between system quality and system use, is that it is difficult to create any conclusions of ISS on system use. Users usually have different time needs, using an IS with vary-

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53) See Appendix E for more details about the correlations.
ing competence and personal commitment. A small part of this result might also be caused by the inclusion of three questions using a numerical rating scale.

**Hypothesis 4: Increases in process quality will lead to increases in user satisfaction**

The second test of the process quality dimension’s affiliation with ISS indicates a very highly significant relationship between process quality and user satisfaction. All variables of the process quality dimension were found to have positive correlations with all variables of user satisfaction. Highly significant correlations were found between: information identification, information preservation, and information utilisation and information dissemination from the process quality variable; and software satisfaction, decision-making satisfaction, satisfaction with specifics, information satisfaction and overall satisfaction from the user satisfaction variable. The result of this survey indicates that it is an appropriate instrument for the purpose of measuring the impact of process quality on user satisfaction. The results indicate that process quality is an appropriate dimension of ISS. These two dimensions indicate that they are highly relevant when measuring ISS.

**Hypothesis 5: Increases in information quality will lead to increases in system use**

This study does not support the assertion that perceived information quality directly influenced system use. Out of the 19 variables included in this relationship only 11 were found to have any significant correlation whatsoever. This result corresponds to the results of McGill et al. (2000b), who found no direct influence of information quality on system use. The results however indicate that some of the underlying variables show support for this hypothesis. Variables that, in spite of the overall correlation result, support the stated hypothesis are: relevance, usefulness, usableness, understandability, content, sufficiency, reliability and timeliness from the information quality variable; and frequency of report request, purpose of use and number of reports generated from the system use variable. One conclusion, similar to that between process quality and system use, is that it is difficult to create any conclusions on ISS in regard to system use. Users usually have different time needs for using an IS, and as a consequence have varying competence and personal commitment. A user may need, or may not need, to spend a longer time using the IS if the information quality is low. A small part of this result might also be caused by the inclusion of questions using a numerical rating scale.

**Hypothesis 6: Increases in information quality will lead to increases in user satisfaction**

The sixth hypothesis is insufficiently supported by this study. However, this study has found numerous significant relationships between variables and measures of in-
formation quality and variables of user satisfaction. The findings are somewhat inconsistent with the results found in other research. The findings of Seddon and Kiew (1996), Teo and Wong (1998) and McGill et al. (2000b) indicate that perceived information quality has a large positive influence on user satisfaction. The results from the questionnaire survey indicate that the following variables were found to support the hypothesised relationship, they are: relevance, usefulness, usableness, clarity, understandability, format, content, accuracy, sufficiency, completeness, reliability, and timeliness from the information quality dimension; and software satisfaction, satisfaction with specifics and information satisfaction from the user satisfaction dimension.

The reasons for the inconsistency between this study and previously performed studies appear to be two-fold. The first reason seems to be a divergent approach when it comes to what variables to include in the different dimensions and the second is the amount of variables and measures included in the survey instrument. Teo and Wong (1998) used relevance, accuracy and timeliness and valuableness (not included in this study) for the information quality dimension and hardware/software satisfaction and satisfaction with consultant and vendor support (not included in this study). Seddon and Kiew (1996) and McGill et al. (2000b) used clarity, format, content, accuracy, sufficiency, completeness, timeliness, and exactliness in the information quality dimension and overall satisfaction with the IS, IS adequacy (used in system quality in this study), IS efficiency (not included in this study) and IS effectiveness (not included in this study) in the user satisfaction dimension. Thus, the findings from this study support the results from Teo and Wong (1988) and extend the number of applicable variables. To compare the result with Seddon and Kiew (1996) and McGill et al. (2000b) is not appropriate, as the variables do not correspond with the ones used in this study. This result however indicates that it is not enough for an IS to deliver high information quality as it is not the only factor affecting user satisfaction as seen in chapter 7.

**HYPOTHESIS 7-8: Increases in system use will lead to increases in user satisfaction (and vice versa)**

This research found very little support for a relationship between system use and user satisfaction or vice versa. Gelderman (1998) found no support for this hypothesised relationship. Igbaria and Tan (1997), however, found that user satisfaction has a very strong effect on system use. Even though the survey results do not

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54) See Appendix E for more details about the correlations.
support the stated hypothesis, a number of correlations were found between the variables of: frequency of report request and purpose of use from the system use variable; and software satisfaction, decision-making satisfaction, satisfaction with specifics, information satisfaction and overall satisfaction from the user satisfaction variable. The results of this study, which appear contradictory against previously performed investigations, are essentially not comparable. The different studies have used different variables to measure user satisfaction and system use. For instance, Igbaria and Tan (1997) and Gelderman (1998) have used content, accuracy, timeliness, format and ease of use to measure user satisfaction. All these measures are grouped under the system quality and information quality variables in DeLone and McLean’s (1992) ISSM. This is also were they are found in this study. Gelderman (1998) used hours of use and frequency of use, whilst Igbaria and Tan (1997) used number of computerised applications used by the employees and number of business tasks for which the system is used for the system use dimension. The variables used in this study correspond to those of DeLone and McLean’s (1992) ISSM indicating a more reliable study of the relationship between system use and user satisfaction.

**HYPOTHESIS 9: Increases in system use will lead to increases in individual impact**

No significant relationship was found between system use and perceived individual impact in this study. This is consistent with Gelderman’s (1998) observations in the organisational field, but inconsistent with the findings of Yuthas and Young (1998) who suggest that system use is a good indicator of individual performance. Igbaria and Tan (1997) also acknowledge the positive relationship between system use and individual impact, but stress that it has a small effect. Even though the survey results do not support the stated hypothesis, a number of correlations were found between the variables of: frequency in report request, appropriate use and purpose of use in the system use dimension; and learning, decision effectiveness, decision quality, improved decision analysis, correctness of decision, time to make decision, improved individual productivity, change in decision, task performance, personal evaluation of IS and information management in the individual impact dimension.

Even though there are a number of highly significant correlations between system use and individual impact, this study does, nonetheless, add weight to the doubts that already exist about the validity of usage as a success criterion for ISs. The conflicting results between Igbaria and Tan’s (1997) and Yuthas and Young’s (1998) investigations and this study may be caused by differing variables of system use and individual impact. Igbaria and Tan (1997) used number of computerised applications used by the employees and number of business tasks for which the system is used for the system use dimension and decision-making quality, performance, productivity, and effectiveness of the job for the individual impact variable. Whilst, Yuthas and Young
(1998) used *number of minutes a subject spent accessing computerised reports using the IS* and *the total number of reports accessed* for the system use variable and the individual's ability to minimise the combined product, holding and stock out cost for individual impact. Igbaria and Tan’s (1997) individual impact variables correspond with those showing high significant relationships in this study, but this is where the similarities end. This study has used the variables included in DeLone and McLean’s (1992) ISSM. The results from this study indicate that the relationship between system use and individual impact proposed by DeLone and McLean may not exist, at least not to its full extent.

**Hypothesis 10:** Increases in user satisfaction will lead to increases in individual impact

The declaration that user satisfaction has a highly significant influence on individual impact is encouraged by the results of this study55. Seddon and Kiew (1996), Igbaria and Tan (1997), Yoon et al. (1998), Yuthas and Young (1998) and McGill et al. (2000b) also found a strong support for this hypothesised relationship in their studies. The investigated variables supporting this relationship are: *software satisfaction*, *decision-making satisfaction*, *satisfaction with specifics*, *information satisfaction* and *overall satisfaction* in the user satisfaction dimension; and *information understanding*, *learning*, *information awareness*, *decision effectiveness*, *decision quality*, *improved decision analysis*, *correctness of decision*, *time to make decision*, *improved individual productivity*, *task performance*, *personal evaluation of IS* and *information management* in the individual impact dimension. User satisfaction displays a highly significant influence on individual impact. Again, this finding is consistent with the results of studies conducted with organisational systems (McGill et al. 2000b). In accordance with the result presented by Igbaria and Tan (1997), this study shows that user satisfaction helps individuals to accomplish tasks more effectively and increases their productivity. Thus, users who are satisfied with the IS were more likely to report a greater level of individual impact. The finding that user satisfaction had a highly significant influence on individual impact is encouraging as it suggests that the reliance of organisations on end user satisfaction with the applications may not be misplaced. Again, this finding is consistent with the results of studies conducted with ISs (Seddon and Kiew 1996; McGill et al. 2000b). It can therefore be concluded that user satisfaction is an important factor affecting individual impact.

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55) See Appendix E for more details about the correlations.
HYPOTHESIS 11: Increases in individual impact will lead to increases in project (group) impact

This result provides support for a positive relationship between individual impact and project (group) impact, which is also supported by Jurison (1996), but rejected by McGill et al. (2000). Both these studies were using organisational impact as a substitute for project (group) impact making these unfit for comparison. The relationship between individual impact and project impact has been recognised to be complex, therefore has never been studied in detail. Scholars have discussed the broad concept of organisational impact but little attention has been given to the project (group) impact level. This study, however, suggests that impact on the individual precedes that of the project (group). Variables which support the hypothesised relationship are: learning, information awareness, decision effectiveness, decision quality, improved decision analysis, correctness of decision, time to make decisions, improved individual productivity, task performance, personal evaluation of IS and information management from the individual impact dimension; and operating cost reductions, staff reductions, overall productivity gains, increased work volume, product quality, contribution to achieving goals, service effectiveness, time effectiveness, improved information management and improved profit from the project (group) impact dimension. This result indicates that the IS by itself does not improve project performance but rather that the method of its implementation and use of individuals determine the improvements that will occur. Consequently, this study supports an ISSM, which consists of a relationship that says that improvements in individual impact will lead to improvements in project (group) impact.

9.4 Implications for theory

This research presents a study in an important area which should be of interest to corporate executive and IT professionals within the construction sector, as well as the IS community in general. This is one of the more comprehensive tests of DeLone and McLean’s ISSM and gives a broad perspective of the entire ISS construct. This study has examined the ISSM for the purpose of testing the core assumptions, testing for improved accuracy and testing a broader scope. The ISSM model has not been fully tested in this way and few variables included in DeLone and McLean’s original ISS synthesis have been tested simultaneously. This research tries to discover the specific variables and measures that support the phenomena of ISS. Beach and Alvager (1992) state that “being specific is often the only thing that distinguishes the scientist’s prediction from common sense predictions.”

The characteristics of the 15 investigated PMs correspond to those found in NCC
Construction Sweden AB\textsuperscript{56}. Equal characteristics for the sector cannot be obtained, but the large number of employees within NCC Construction Sweden AB indicates that the sample is representative\textsuperscript{57} for the Swedish construction sector. The only divergent statistics were that of a university degree, which could be linked to the position/level. The result of the questionnaire study shows support for the relationships of process quality and user satisfaction, user satisfaction and individual impact, and individual impact and project (group) impact. An almost significant relationship is also found between information quality and user satisfaction (see figure 41). Insignificant correlations were found between system quality and system use, system quality and user satisfaction, process quality and system use, information quality and system use, system use and user satisfaction (and vice versa), and system use and individual impact.

This study does not claim generalisability, but gives an indication that process quality is an important dimension affecting ISS. By combining the results of this study with earlier empirical research some generalisations can be made about the concept of ISS. In conformity with a large number of other studies mentioned in the earlier sections of this chapter, this study finds the dimension of system use to be an inappropriate measure for ISS. Based on this finding it is advisable to exclude the system use variable from the ISSM. ISS is not only dependent on system quality and information quality, but also on process quality, which is a vitally important characteristic for a successful IS. The data show that perceived user satisfaction has a strong direct effect on individual impact. The finding that user satisfaction has a highly significant influence on individual impact is encouraging as it suggests that the reliance of organisations on end user satisfaction with the applications may not be misplaced. Again, this finding is consistent with the results of studies conducted with ISs (Seddon and Kiew, 1996; Igbaria and Tan, 1997; McGill et al., 2000b).

The investigation and enhancement of the ISSM offers support for a process quality dimension. By adding this dimension and removing measures with no correlation or with negative correlation, the augmented instrument might just improve IS assessment quality and capabilities. This might also provide the information research community with an improved tool for measuring IS success in the future. By studying the supported correlations it is noticeable that the process quality instrument can be used to measure ISS as it directly affects user satisfaction and indirectly affects individual impact and project (group) impact. The comprehensive correlations of the seven dimensions of ISS indicate that process quality may also have a direct rela-

\textsuperscript{56} The Swedish operations of the NCC Group are gathered under the name NCC Construction Sweden AB, with a total number of 3 200 employees in 2002 (white collar).

\textsuperscript{57} This item is more thoroughly described in chapter 7.
relationship with individual impact and project (group) impact. These relationships are however not investigated in this study. It seems that the success of the IS is coupled to the ability to support the user’s actual work process. The quality of the system and the information output are secondary qualities when speaking of user satisfaction.

The result implies that it does not matter how theoretically good the system quality and information quality are as long as the process quality is low. Hence, if the IS supports the information management process of the user and the information output/supporting system is of high quality, an IS could become extremely successful for a project. Thus, if the IS does not support the user’s actual work process the user will not be satisfied and consequently not improve project performance. As the information management process is synonymous with the knowledge management process this aspect becomes very interesting for theory. This provides support for knowledge being a critical enabler within a project. That knowledge is one of the most important assets of construction companies today is therefore supported by the results found in this study. ISs that allow PMs to identify how their projects develop, acquire, identify, preserve, utilise and disseminate knowledge will consequently improve many aspects of project management and, in the long run, generate profit for the business.

9.5 Implications for policy and practice
The suggested implications of this research for policy and practice are divided into two parts. The first one has to with how an organisation carries through a process orientation (organisational development). Based on the findings and on experience gained from the process orientation work described in chapters 3-5, this section presents an action plan for a process orientation. This action plan suggests a path to follow, a course of action, which will help managers to incorporate the research.
findings in their organisations. The second implication has to do with the procedure of IS development. Based on the research result this section presents a principle of how to pursue successful IS development. The following paragraphs give a clearer picture of the implications, from the research findings, for policy and practice.

9.5.1 Organisational development
During the study a number of highly relevant steps and suggestions for performing a process orientation have emerged. The following activities are gathered from the experience captured during the process development work and give a rough picture of the general procedure.

- Establish aim and objectives for the development work
- Establish a development organisation
- Identify and define the as-is processes
- Implement a process oriented information system
- Continually improve process performance

The first step is to establish aims and objectives for the development work. This is as important for a process orientation as it is when performing research. The scope should be limited to prevent digressions and sharpen the focus on issues of importance as these initiatives otherwise have tendencies to become cumbersome. Thus, the purpose should be clarified to make the implementation strategy clear for all participants. It is especially important to clarify the relationship between the actions of the process orientation and the company’s overall strategy. This makes it more acceptable to the organisation as well as clarifying the overall goal for the actions. Before engaging in the development work, it is important to generate a comprehensive process map, covering the main phases of the process under study. This general process view is later used to create the development organisation and to elucidate to which phase the process activities belong.

Establishing a development organisation is a prerequisite and the next step of a process orientation. A development effort of this magnitude needs an organisation that has the right to make decisions. It is also important to gain the involvement and commitment of people within the organisation to identify and define their work processes. Necessary units of the development organisation are a steering group, project management and process development groups. The steering group should have full execution authorisation to be able to carry out necessary changes within the organisation. A good composition of such a group is preferably senior executives or members of the management group of the company. The task of the project management should be to coordinate, moderate and participate in the work
of the process development groups. It is the project management’s responsibility to compile the results from the development groups as well as providing the steering group with information and decision-support. Development groups should be appointed for a particular part of the process and given full authority over their particular assigned process(es). The total number of development groups is decided upon the complexity of the process under study. Each development group should be heterogeneously put together with representation from different skills active in the examined process. Thus, it is important create a competency profile of the desirable participants before deciding on who should be picked out for a development group to enable different views to be expressed.

Identifying and defining the as-is processes is consequently the next step for the development organisation. A time schedule should be established that include dates for running meetings and special events such as when the key activities should have been identified. A good start in the identification process is to have a kick-off meeting for those involved in the development work. Here, it is important to stress the importance of the work and let all participants ask questions and discuss the work being planned ahead. A good kick-off makes it easier to coordinate the work as all people involved have a common goal. After the kick-off meeting when the groups hold their first separate meetings it is appropriate for the development groups to start studying company specific documentation to establish an understanding of what constitutes key activities in the process under study. Particularly important for the success of the process orientation work is that the participants start to discuss how things really may be working in a holistic (cross-functional) way. When the key activities have been identified it is appropriate to map the dependencies among them. When doing so, it is highly appropriate to use some kind of graphical modelling technique to visualise the dependencies more easily. The next step is to identify the particular information needs for the key activities in form of inputs, controls and support and their particular outputs. Finally, the support mechanisms are identified in the form of competences need to perform a particular activity and IT applications. The process descriptions are just a small part of the advantages of a process orientation.

Implementing a process oriented information system is equally important as identifying and defining the as-is processes. The next step is to instantiate the process descriptions in an IS that supports the user’s daily work procedures. This is where the development work becomes useful for everyone in the company. The IS is struc-

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38 Representation by the CEO and the members of the steering group is preferable to add weight to the importance of the work, as well as the participation of the project management and the members of the development groups.
tured after the information from the process description, which makes the flows more clearly described and more accessible. By using the IS in this particular way it acts as guide to daily work for the benefit of users.

*Continually improve the process performance* should be a permanent objective of an organisation wanting to stay one step ahead of the competition. It is therefore important to have a systematic way of working with continual improvement even after a large process initiative has been launched. It is also important to use both preventive and corrective actions in this work. Measuring process performance through regular self-assessment is one way of enabling corrective actions to be taken. Another way is to measure customer satisfaction and, based on this evidence, take corrective actions to improve the internal operations. Another way to work with continual improvement is to take preventive action. It is suggested that the steering group and development groups used in the process identification work become permanent. Each representative from the steering group takes on the responsibility of process owner and chairman of one development group. The participants in the development groups should not be permanent and preferably be moved out each year to enable fresh ideas and new insights to be introduced. It is these groups’ responsibility to perform extensive analysis of external and internal data and information to prevent surprises and eliminate risk. This should then form a large part of the strategic planning for the company as well as for the implementation of strategies.

### 9.5.2 Information system development

Companies often encounter problems when introducing a new IS with respect to user satisfaction and user acceptance. Often, this has nothing to do with usability, but rather how the IS supports users’ regular working processes. An IS can be theoretically accurate and cover all possible perspectives of the information need but, in reality, could be very wrong for end users with respect to usefulness and user satisfaction. Developers of ISs too often focus on theoretical models and technology but very little on trying to understand the needs and wishes of users. This research supports, in conformity with other research, the proposition that IS by itself does not create opportunities for organisational change, but that the method of its development and implementation determine the changes that will occur. Thus, by this logic it is very hard to change a work process just by developing a new IS. This reasoning presupposes a number of changes in the way ISs are being developed. As suggested in articles on user participation development, users should be involved in the development work and help the developers to define clearly the necessary characteristics of the end product.

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59) Technology is used synonymous with software and hardware in this paragraph.
According to the findings of this research, the most needed characteristics for users are process quality followed by information quality and eventually system quality. Consequently, a large effort should be put on the process quality attribute in the early phases of the development process, followed by the identification of the information needs of the users/process and, finally, the technical realisation of them. Covering these steps and in this order will have a positive effect on the users’ perceptions of the benefits of actually using the IS. An IS, which has been developed according to these steps, can generate valuable support for users in their daily work and consequently saving a lot of money for the business in the long run. Thus, in order to minimise problems with the implementation of the IS, definition of the metrics that contribute to IS success should be taken into consideration at the start of any IS development.

So, in common with the earlier described procedure for organisational development, IS development should start with the identification and definition of working processes supporting users in their work. In addition to the IS developer, this work needs the participation of the intended users as well as the involvement of someone with organisational development skills. By understanding the working process, which the new IS should support, it is possible to identify the information needs of the work process. Unlike most IS development, where the focus is placed on the technology and how it can support the business, this approach ignores the technology until the process and relevant information needs are clearly known. This is especially important, as most users are unaware of the level of technology that is standard for the type of IS being developed. Thus, before deciding on the technology it is important to understand the information need of the users and the process to be supported.

Finally, the result of the process and information identification should be translated into an information model supporting the development of the technology part of the IS. In this last phase, the IS professionals can use a great deal of their creativity to the development of an appropriate technology with a useful interface for the end user. This phase might require new knowledge to be gained by the IS professionals in order to realise the characteristics defined in the earlier development work. This sequence of steps for IS development prevents IS professionals spending too much effort on areas that are less important to users. This increased focus on processes does not however lower the need for high quality technological solutions or high quality information output. It only emphasises that for the technology and information to be more useful for the end user, it is important that it supports his/her actual work process. Once a final product is delivered users may be able to evaluate the IS according to agreed characteristics and measures of IS success.
This new focus on IS development will have a definite impact on training and education of IS professionals. This new course of action will need a combination of competences, that of organisational development as well as that of IS development. This combination of skills could lay the foundations for new IS educational programmes. In the absence of IS professionals possessing this combination of skills it is advisable to include both professions when developing ISs. The process and information identification should preferably be performed by the organisational development professional with a change over to the IS professional to realise the technical characteristics. There should be dialogue between both professions during all phases to secure a satisfactory end product. The knowledge differences between the two competences are in this way set aside. As a final precaution, before launching the IS, a number of pilot tests should be performed. The users should then evaluate the ISS using the ISSM to get a feeling for how well the IS lives up to expectations.

9.6 Limitations
The research has a number of limitations, which do not invalidate the results, but have to be considered and properly understood in order to interpret the results and conclusions correctly. It is undoubtedly probable that these limitations could restrict the generalisability of the results; however, this also provides substance for future research as described in the subsequent section. One limitation of this research can be attributed to the chosen method, the questionnaire survey technique. Perceived lack of rigour and subjectivity were addressed in the research design phase of this study. A carefully crafted methodology outlining the use of reliability and validity measures, triangulation and a definition of a questionnaire survey instrument before the data collection phase was performed as a response to these concerns. As discussed earlier in chapter 2, other research methods could have been used. The survey method was chosen to improve generalisability as the majority of studies investigating the ISS construct have used this particular method. This was also done to support a study with a larger scope of the phenomena than had been performed previously. This broad scope limits the richness of the information that can be collected and may leave out important details about the final causes. However, this should not significantly impact the conclusions of this study.

The results of this study must be considered in conjunction with the limitations of the sample and hypothesis model. As seen in the comprehensive correlation results in chapter 7, the process quality variable seems to have a strong correlation with both individual impact and project (group) impact. The study, however, is limited to investigating the relationships stated by the hypothesis. Looking at all relationships between the variables may consequently create additional insight. Another limitation has to do with the sample investigated. The small sample size and the
organisational identity of the sample population may have influenced some conclusions. The decision to use a single organisation and a single profession did, however, avoid contradictory results that might arise from an inter-company study involving far more variables than would be sensible.

The scope is limited to the project level and it does not attempt to make any conclusions about the impact of ISS on the organisation as a whole. Despite this, the result may be applicable to an organisational or industrial setting that, in common with the construction sector, is project-based. For practical reasons, it was not possible to wait two more years to perform the study with a redoubling of the sample size. It is also arguable whether or not the inclusion of further questionnaires would have provided any additional insights, as the total amount of possible respondents would have been too few for a factor analysis to be performed anyway. However, it must be noted that a larger response rate would minimise concerns about population generalisations. Findings based on comparisons with similar research across investigating organisations and groups using different IS and in different industrial settings have been shown to present similar results. Nevertheless, the findings of this research should be seen as descriptive and preliminary. They depend on confirmation from further empirical studies to validate proposed changes in theory.

9.7 Implications for further research

Further research refers to the topics of both ISs research and process orientation research as well as to methodological issues. Due to the comprehensive scope of the results of this research, this section offers many propositions and brings up research issues for future research.

To begin with, this research provides an extensive investigation of the relationships of DeLone and McLean’s (1992) ISSM as well as an extension of the model by the inclusion of a process quality dimension. The theoretical model is presented as a comprehensive model that applies to ISS. This study indicates that the process quality dimension is an essential ingredient in the way that users perceive ISS. If the result were confirmed by additional empirical results it would be possible to foresee the success of a new IS by measuring the process quality. Thus, measuring process quality could prevent many expensive developments being carried through and expensive implementation processes taking place. In common with other studies in testing the relationships of the ISSM, this research supports the rejection of the system use dimension as a part of ISS. Based on the findings of this study an augmented ISSM is presented which includes numerous measures to be taken into consideration when measuring ISS. However, further empirical research will be necessary to examine the content validity of this assumption. The instrument should also be
tested in a larger population in another environment so as to assure its general
validity. A larger population would enable more comprehensive and complemen-
tary statistical tests to be performed, allowing a generalisation of the relationships.
The results show that additional studies need to be performed with other populations
to solidify and verify the relationships found in this study. The research only tests the
model on one specific IS (web-based project document management system).

Further studies are needed to investigate the applicability of the model to other ISs
various categories of different users. This includes populations other than PMs in
housing development organisations. The survey research method employed in this
study was used to gain a broad understanding of the general phenomena surround-
ing ISS. Such a broad approach, however, has the potential to overlook particular
facts of importance. To further generalise the findings different types of empirical
investigation such as case studies, field studies and field experiments could be
performed to strengthen the conclusions achieved in this study.

Within the specific field of process orientation and IS research, there is need for
further research into the possible application of the proposed method to perform
process orientation work. This course of action should therefore be evaluated in other
organisational settings as well as in different organisations. Another possible direction
for further research would be to test the method in different countries and different
industrial sectors for cultural implications. Currently, NCC Construction Sweden AB
as a whole is engaging in process orientation work according to the actions suggested
for a process orientation and will consequently be evaluated after completion to
strengthen the procedure. A test of the procedure in another company or industrial
sector would be necessary to give further validation of the method. Process measure-
ment is another field, which needs further attention as this research has created only
a foundation for comprehensive process measurement. Finding those measures that
reveal what went wrong and where improvement work is needed is high on the
research agenda for the entire sector. Further research is also required to clarify the
relationship of the results of this study with objective measures of organisational suc-
cess such as cost, time consumption and product/service quality.

Through this research and continued research on the topics discussed above,
significant contributions will be made to the development of ISs and organisations.
The literature suggests that ISS is directly linked to dimensions such as system
quality and system use. This theory-building research indicates that the ISS
construct is more complex than the literature suggests and sets a foundation for
further research about the phenomenon.
10. References and Interviewees

10.1 References


References


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Koskela, L. 1992. Application of the new production philosophy to construction. CIFE Technical Report no. 72, Stanford University, California, USA.


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10.2 Interviewees


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EKMAN, A. (Spring 2002) Project Manager, NCC Housing Sweden, Malmoe, Sweden, questionnaire survey.

ERIKSSON, G. (Fall 1999) Project Manager, NCC Housing Sweden, Stockholm, Sweden, interview.


HOLGERSSON, S. (Fall 1999) Senior vice President Business Development, NCC Housing, Stockholm, Sweden, interview.

HOLMQVIST, A. (Fall 1999 – Fall 2000) Project Manager, NCC Housing Sweden, Stockholm, Sweden, interview.

JOHANSSON, A. (Spring 2002) Project Manager, NCC Housing Sweden, Gothenburg, Sweden, questionnaire survey.

KRISTENSSON, B. (Spring 2002) Project Manager, NCC Housing Sweden, Gothenburg, Sweden, questionnaire survey.

LINDGREN, P. (Spring 2002) Project Manager, NCC Housing Sweden, Umeå, Sweden, questionnaire survey.


LYSEDAHL, A. (Fall 1999) Project Manager, NCC Housing Sweden, Stockholm, Sweden, interview.


MATTSSON, T. (Spring 2002) Project Manager, NCC Housing Sweden, Uppsala, Sweden, questionnaire survey.


NORDEBORG, U. (Fall 1999) Quality Manager, NCC Housing Sweden, Malmoe, Sweden, interview.

NORDSTRÖM, A. (Spring 2002) Project Manager, NCC Housing Sweden, Uppsala, Sweden, questionnaire survey.


PAULSEN, L. (Fall 2000) Project Economy, NCC Housing Sweden, Stockholm, Sweden, interview.

PETERSSON, L-G. (Spring 2002) Project Manager, NCC Housing Sweden, Gothenburg, Sweden, questionnaire survey.

ROHMAN, L. (Spring 2002) Project Manager, NCC Housing Sweden, Gothenburg, Sweden, questionnaire survey.

SEDIN, E. (Fall 1999) Site Manager, NCC Housing Sweden, Gothenburg, Sweden, interview.

SJÖÖ, L-G. (Spring 2002) Project Manager, NCC Housing Sweden, Uppsala, Sweden, questionnaire survey.


STÅLBACK, K. (Spring 2002) Project Manager, NCC Housing Sweden, Gothenburg, Sweden, questionnaire survey.


WIDELL, B. (Spring 2002) Project Manager, NCC Housing Sweden, Gothenburg, Sweden, questionnaire survey.

ZEIGLER, T. (Fall 2000) Manager of Sales and Housing Development, NCC Housing Sweden, Stockholm, Sweden, interview.
Appendix A

– NCC Housing’s SSI questionnaire

1. How long have you been working in the construction
   and real-estate sector? Approximately ___ years
2. Sex?
   – Female
   – Male
3. Age?
   – Under 31 years
   – 31 – 45 years
   – Over 45 years
4. Education?
   – Engineering Degree
   – University education 0 - 79 credits
   – University education 80 - 179 credits
   – University education ≥ 180 credits

System satisfaction Index

The questions, under this title, deal with questions concerning the management
information system, e.g. questions concerning perceived individual productivity,
comprehensive view of process work and information retrieval due to the management
information system.

1. I find the management information system to be useful.
2. PDS makes my job easier.
3. Due to PDS I can do a better job.
4. PDS takes care of the needs necessary to perform my job.
5. Using PDS feels like a natural part of my daily work.
6. I find that PDS clarifies my daily work.
7. PDS clarifies my role within the organisation.
8. PDS helps me find appropriate information easier.
9. PDS helps me to reduce my information search time.
10. I find all the information necessary for me to perform my job due to the layout of PDS.
Appendix B

– Hypothesis questionnaire

In the questionnaire the variables that are included in the SSI index are marked with green and the variables that had no correlation are marked with red.

Included in SSI, therefore removed from the final questionnaire.

No correlation found with any other measure.

1. How long have you been working in the construction and real-estate sector? Approximately ___ years

2. Sex?
   – Female
   – Male

3. Age?
   – Under 31 years
   – 31 – 45 years
   – Over 45 years

4. Education?
   – High School or Engineering Degree
   – University education 0 - 79 credits
   – University education 80 - 179 credits
   – University education ≥ 180 credits

5. Regional belonging?
   – Middle and North
   – Gothenburg
   – South

6. What are your main responsibilities?
   – Project development
   – Project management

System Quality

The questions, under this title, deal with issues concerning the software/hardware supporting the system, e.g. if there are any “bugs” in the system etc.

<table>
<thead>
<tr>
<th></th>
<th>Strongly agree</th>
<th>Neither</th>
<th>Strongly disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.</td>
<td>PDS information content meets my needs.</td>
<td></td>
<td></td>
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<tr>
<td>8.</td>
<td>Remembering usage of features in PDS is easy.</td>
<td></td>
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<tr>
<td>9.</td>
<td>Number of steps per task in PDS are too many. [R]</td>
<td></td>
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<tr>
<td>10.</td>
<td>Steps to complete a task in PDS rarely follow a logic sequence. [R]</td>
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<tr>
<td>11.</td>
<td>It is easy to get PDS to do what I want it to do.</td>
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<tr>
<td>12.</td>
<td>PDS is user friendly.</td>
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<tr>
<td>13.</td>
<td>It is easy to learn how to use PDS.</td>
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</tbody>
</table>

210
14. Compared to other computer software, PDS is not easy to learn. [R]
15. I find PDS extremely convenient to access.
16. PDS is not an important system for this organisation. [R]
17. PDS is extremely useful.
18. I personally benefit from the existence of PDS in this organisation.
19. The functions in PDS allows individual work procedures.
20. Performing an operation in PDS never leads to a predicted result. [R]
21. I can count on PDS to be “up” and available when I need it.
22. PDS integrates different soft systems within the organisation well.
23. The organisation of information on the system screens by PDS is clear.
24. PDS makes it easy to find the information I need.
25. General system speed is fast enough.

### Information Quality

The questions, under this title, deal with issues concerning the information in PDS, e.g. what is possible to read out from the system.

<table>
<thead>
<tr>
<th></th>
<th>Strongly agree</th>
<th>Neither</th>
<th>Strongly disagree</th>
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<tbody>
<tr>
<td>26.</td>
<td>PDS provides for my job relevant information.</td>
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<tr>
<td>27.</td>
<td>The output information from PDS is not useful. [R]</td>
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<tr>
<td>28.</td>
<td>The information output in PDS is as useful for experienced as well as inexperienced users.</td>
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<td>29.</td>
<td>The information in PDS is effective in helping me complete my tasks.</td>
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<tr>
<td>30.</td>
<td>The information output from PDS is not clear. [R]</td>
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<tr>
<td>31.</td>
<td>PDS does not provide easy to understand information. [R]</td>
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<tr>
<td>32.</td>
<td>PDS presents the information in an appropriate format.</td>
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<tr>
<td>33.</td>
<td>The information content in PDS is very good.</td>
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<tr>
<td>34.</td>
<td>The information output from PDS is up to date enough for my purposes.</td>
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<tr>
<td>35.</td>
<td>The information that PDS delivers is sufficient enough for my purposes.</td>
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<tr>
<td>36.</td>
<td>The completeness of output information that PDS delivers is not sufficient for my purposes. [R]</td>
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<tr>
<td>37.</td>
<td>The completeness of the output information is adequate enough for my purposes.</td>
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<tr>
<td>38.</td>
<td>The reliability of output information from PDS is high.</td>
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<tr>
<td>39.</td>
<td>The reliability of output information in PDS is superior to other information systems.</td>
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<td>40.</td>
<td>PDS provides the information I need in time.</td>
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</table>

### Process Quality

The questions, under this title, deal with issues concerning the information management in PDS, e.g. how the information management process works.

<table>
<thead>
<tr>
<th></th>
<th>Strongly agree</th>
<th>Neither</th>
<th>Strongly disagree</th>
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<tbody>
<tr>
<td>41.</td>
<td>PDS does not support me when creating new information/documentation. [R]</td>
<td></td>
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<tr>
<td>42.</td>
<td>PDS does not support information retrieval for decision-making. [R]</td>
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<td>43.</td>
<td>The level of detail in the activity structure in PDS is not sufficient enough. [R]</td>
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<td>44.</td>
<td>I find the information I need under the appropriate activity in PDS.</td>
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<tr>
<td>45.</td>
<td>Using a process structure for information management in PDS makes my job easier.</td>
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<td>46.</td>
<td><strong>The housing development process in PDS is sufficiently defined.</strong></td>
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<td>47.</td>
<td>PDS is good at structuring information.</td>
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<td></td>
<td>Strongly agree</td>
<td>Neither</td>
<td>Strongly disagree</td>
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<td>48.</td>
<td>PDS clarifies the most important decision points in the housing development process.</td>
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<td>49.</td>
<td>PDS clarifies the workflow of the housing development process.</td>
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<tr>
<td>50.</td>
<td>Information search and retrieval in PDS does not function satisfactorily. (\text{[R]})</td>
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<tr>
<td>51.</td>
<td>The retrieval function (Get information) in PDS functions satisfactorily.</td>
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<tr>
<td>52.</td>
<td>I find PDS easy to navigate.</td>
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<td>53.</td>
<td>PDS clarifies the documents which are necessary to create in an activity.</td>
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<tr>
<td>54.</td>
<td>PDS clarifies the documents that are record documents.</td>
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<tr>
<td>55.</td>
<td>PDS organises information in a sufficient manner.</td>
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<td>56.</td>
<td>The version handling function in PDS works well.</td>
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<td>58.</td>
<td>My personal information feels secure in PDS.</td>
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<td>59.</td>
<td>PDS is good at publishing information.</td>
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<td>60.</td>
<td>PDS facilitates storing of project information.</td>
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<td>61.</td>
<td>PDS presents relevant information that helps me do my job better and more effectively.</td>
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<td>62.</td>
<td>PDS supports communication between members of the project team.</td>
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<td>63.</td>
<td>PDS supports collaboration and coordination in projects.</td>
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<tr>
<td>64.</td>
<td>PDS is good at supporting individual learning.</td>
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<tr>
<td>65.</td>
<td>PDS clarifies performance expectations in projects.</td>
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<tr>
<td>66.</td>
<td>PDS visualises logical work routines for the housing development process.</td>
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<tr>
<td>67.</td>
<td>PDS describes the company’s standard procedure for the housing development process.</td>
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<td>68.</td>
<td>PDS facilitates a more structured project management work.</td>
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<tr>
<td>69.</td>
<td>PDS facilitates collaboration between project members.</td>
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<tr>
<td>70.</td>
<td>Information exchange between project members in PDS is good.</td>
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<tr>
<td>71.</td>
<td>Using PDS gives a greater understanding of the housing development process procedures.</td>
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<tr>
<td>72.</td>
<td>Availability of information in PDS is very good.</td>
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<tr>
<td>73.</td>
<td>Effective information retrieval in PDS is very poor. (\text{[R]})</td>
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<td>74.</td>
<td>PDS helps me with resource control.</td>
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<tr>
<td>75.</td>
<td>Document control in PDS is good.</td>
<td></td>
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<tr>
<td>76.</td>
<td>The information in PDS does not support me in decision-making. (\text{[R]})</td>
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<tr>
<td>77.</td>
<td>PDS does not support me with the formal planning of project activities. (\text{[R]})</td>
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<tr>
<td>78.</td>
<td>PDS is good at distributing information to project participants.</td>
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<tr>
<td>79.</td>
<td>PDS facilitates communicating information between various members of the project team.</td>
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<tr>
<td>80.</td>
<td>PDS makes it easier to communicate with the project organisation.</td>
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<tr>
<td>81.</td>
<td>PDS facilitates effective communication between project members.</td>
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</table>

## System use

The questions, under this title, deal with issues concerning the use of the system, e.g. how frequent the system is used.

<table>
<thead>
<tr>
<th></th>
<th>Strongly agree</th>
<th>Neither</th>
<th>Strongly disagree</th>
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</thead>
<tbody>
<tr>
<td>82.</td>
<td>I frequently use PDS to access support documents.</td>
<td></td>
<td></td>
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<tr>
<td>83.</td>
<td>I seldom use PDS to store produced documents. (\text{[R]})</td>
<td></td>
<td></td>
</tr>
<tr>
<td>84.</td>
<td>I frequently use PDS to locate produced documents.</td>
<td></td>
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<tr>
<td>85.</td>
<td>I often use PDS to study produced documents.</td>
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<tr>
<td>86.</td>
<td>I use PDS as project development support.</td>
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<tr>
<td>87.</td>
<td>I use PDS as project management support.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>88.</td>
<td>I do not use PDS as project planning support. (\text{[R]})</td>
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</tr>
<tr>
<td>89.</td>
<td>I use PDS for getting work instruction.</td>
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</table>
User satisfaction

The questions, under this title, deal with issues concerning the users satisfaction with PDS, thus how satisfied the user is with the system.

<table>
<thead>
<tr>
<th>Strongly agree</th>
<th>Neither</th>
<th>Strongly disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>96. I am very satisfied with using the software that supports PDS.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>97. I am very satisfied with the user interface of PDS.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>98. I am very satisfied with the input screens in PDS.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>99. I am very satisfied with the support that PDS gives me in important decision making.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>100. I am very satisfied with the information handling capabilities in PDS.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>101. I am very satisfied with the process oriented navigation structure in PDS.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>102. I am not satisfied with the collaboration capabilities with other project members in PDS.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>103. I am very satisfied with the version handling in PDS.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>104. I am very satisfied with the process work instructions in PDS.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>105. I am not satisfied with the document control in PDS.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>106. I am very satisfied with the documents provided by PDS.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>107. The information output from PDS fully matches what I want from such a system.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>108. I am satisfied with the information, which is accessible through PDS.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>109. How would you rate your overall satisfaction with PDS?</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Individual impact

The questions, under this title, deal with issues concerning how the use of the system affects the individual performance.

<table>
<thead>
<tr>
<th>Strongly agree</th>
<th>Neither</th>
<th>Strongly disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>110. PDS has given me a better understanding of the decision context in a housing development project.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>111. By using the PDS I have learned a lot about the housing development process.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>112. PDS improves my training and education of the housing development process.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>113. PDS improves access to existing sources of information.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>114. PDS helps me find appropriate information easier.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>115. PDS helps me to reduce my information search time.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>116. I find all the information necessary for me to perform my job due to the layout of PDS.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>117. Utilisation of PDS has not enabled me to make better decision.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>118. As a result of PDS, I am better able to set my priorities in decision making.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>119. Using information in PDS has enabled me to present my arguments more convincingly.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>120. PDS has improved the quality of decisions I make in projects.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>121. As a result of PDS, more relevant information has been available to me for decision making.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### APPENDIX B

#### Strongly agree

- 122. PDS has led me to greater use of analytical aids in my decision-making.
- 123. PDS have not reduced my risk-taking. [R]
- 124. As a result of PDS, the speed at which I analyze decisions has increased.
- 125. PDS helps me feel confident in the decisions made.
- 126. I find the management information system to be useful [SSI1]
- 127. PDS makes my job easier [SSI2]
- 128. Due to PDS I can do a better job [SSI3]
- 129. PDS takes care of the needs necessary to perform my job [SSI10]
- 129. Using PDS increases my work productivity.
- 130. The PDS environment has a large positive impact on my effectiveness and productivity in my job.
- 131. PDS makes my job easier.
- 132. Using PDS has improved my individual performance significantly.
- 133. Using PDS helps me manage my work time in a more efficient manner.
- 134. Using PDS makes me less focused on the job I perform [R]
- 136. Using PDS facilitates quicker access to appropriate information.
- 137. Using PDS helps me manage my work time in a more efficient manner.
- 138. Using PDS makes it easier to do my job.
- 139. Using PDS gives me greater control over my work.
- 140. Overall I find using PDS to be advantageous in my job.
- 141. Using PDS has changed my perception of the importance and usefulness of an information system.
- 142. Using PDS facilitates cost savings in information management.
- 143. Due to increased information dissemination in projects the group understanding and motivation is enhanced.
- 144. Using PDS helps achieve the project's goals.
- 145. Using PDS facilitates quicker responses to project changes.
- 146. Using PDS facilitates quicker access to appropriate information.
- 147. Using PDS helps me manage my work time in a more efficient manner.
- 148. I value that PDS improves my ability to handle information with: [R] 3-0%, 6-4%, 9-7%, 12-10%, 15-13%, 18-16%, ≥19%

#### Neither

- 120. PDS have led me to greater use of analytical aids in my decision-making.
- 121. PDS have not reduced my risk-taking.
- 122. As a result of PDS, the speed at which I analyze decisions has increased.
- 123. PDS helps me feel confident in the decisions made.
- 124. I find the management information system to be useful.
- 125. PDS makes my job easier.
- 126. Due to PDS I can do a better job.
- 127. PDS takes care of the needs necessary to perform my job.
- 128. Using PDS increases my work productivity.
- 129. The PDS environment has a large positive impact on my effectiveness and productivity in my job.
- 130. PDS makes my job easier.
- 131. Using PDS has improved my individual performance significantly.
- 132. Using PDS helps me manage my work time in a more efficient manner.
- 133. Using PDS makes me less focused on the job I perform.
- 134. Using PDS reduces storage requirements for documents/information.
- 135. Using PDS facilitates quicker access to appropriate information.
- 136. Using PDS helps me manage my work time in a more efficient manner.
- 137. Using PDS makes it easier to do my job.
- 138. Using PDS gives me greater control over my work.
- 139. Overall I find using PDS to be advantageous in my job.
- 140. Using PDS has changed my perception of the importance and usefulness of an information system.
- 141. Using PDS facilitates cost savings in information management.
- 142. Due to increased information dissemination in projects the group understanding and motivation is enhanced.
- 143. Using PDS helps achieve the project's goals.
- 144. Using PDS facilitates quicker responses to project changes.
- 145. Using PDS facilitates quicker access to appropriate information.
- 146. Using PDS helps me manage my work time in a more efficient manner.
- 147. I value that PDS improves my ability to handle information with: 3-0%, 6-4%, 9-7%, 12-10%, 15-13%, 18-16%, ≥19%

#### Strongly disagree

- 120. PDS have led me to greater use of analytical aids in my decision-making.
- 121. PDS have not reduced my risk-taking.
- 122. As a result of PDS, the speed at which I analyze decisions has increased.
- 123. PDS helps me feel confident in the decisions made.
- 124. I find the management information system to be useful.
- 125. PDS makes my job easier.
- 126. Due to PDS I can do a better job.
- 127. PDS takes care of the needs necessary to perform my job.
- 128. Using PDS increases my work productivity.
- 129. The PDS environment has a large positive impact on my effectiveness and productivity in my job.
- 130. PDS makes my job easier.
- 131. Using PDS has improved my individual performance significantly.
- 132. Using PDS helps me manage my work time in a more efficient manner.
- 133. Using PDS makes me less focused on the job I perform.
- 134. Using PDS reduces storage requirements for documents/information.
- 135. Using PDS facilitates quicker access to appropriate information.
- 136. Using PDS helps me manage my work time in a more efficient manner.
- 137. Using PDS makes it easier to do my job.
- 138. Using PDS gives me greater control over my work.
- 139. Overall I find using PDS to be advantageous in my job.
- 140. Using PDS has changed my perception of the importance and usefulness of an information system.
- 141. Using PDS facilitates cost savings in information management.
- 142. Due to increased information dissemination in projects the group understanding and motivation is enhanced.
- 143. Using PDS helps achieve the project's goals.
- 144. Using PDS facilitates quicker responses to project changes.
- 145. Using PDS facilitates quicker access to appropriate information.
- 146. Using PDS helps me manage my work time in a more efficient manner.
- 147. I value that PDS improves my ability to handle information with: 3-0%, 6-4%, 9-7%, 12-10%, 15-13%, 18-16%, ≥19%

### Project (group) impact

**The questions, under this title, deal with issues concerning how the use of the system affects the project group performance.**

<table>
<thead>
<tr>
<th>Strongly agree</th>
<th>Neither</th>
<th>Strongly disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>149. PDS facilitates cost-saving in information management.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>150. PDS do not facilitate staff reduction in projects. [R]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>151. Due to the increased information sharing capability the project workgroup can function more effectively.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>152. Due to increased information dissemination in projects the group understanding and motivation is enhanced.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>153. PDS improves work participation by project members.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>154. PDS improves communication within the project workgroup.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>155. PDS facilitates quicker responses to project changes.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>157. PDS does not increase the work volume for the project workgroup.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>158. PDS reduce rework and waste in the project.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>159. PDS helps the project to achieve its goals.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>160. PDS does not offer an increased effectiveness in serving customers. [R]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>161. Using PDS has increased project time.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>162. PDS increased informal exchange of ideas within the project group.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>163. PDS improves communication and cooperation within the project group.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Strongly agree</td>
<td>Neither</td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>164.</td>
<td>PDS increases information availability within the project workgroup.</td>
<td></td>
</tr>
<tr>
<td>165.</td>
<td>Using PDS supports education and training of newly recruited employees.</td>
<td></td>
</tr>
<tr>
<td>166.</td>
<td>Using PDS supports training and education of all employees.</td>
<td></td>
</tr>
<tr>
<td>167.</td>
<td>How much do you assess that PDS reduces information management cost and increases company profit? [R]</td>
<td>3.0-6.4%, 6-9.7%, 9.7-12.0%, 12-15.3%, 15.3-18.6%, ≥19%</td>
</tr>
</tbody>
</table>
Appendix C
– Variables and measure groupings

System quality variables and adjacent measure numbers

<table>
<thead>
<tr>
<th>Variable</th>
<th>Measure No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Database content</td>
<td>7</td>
</tr>
<tr>
<td>2. Ease of use</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>11</td>
</tr>
<tr>
<td></td>
<td>12</td>
</tr>
<tr>
<td>3. Ease of learning</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td>14</td>
</tr>
<tr>
<td>4. Convenience of access</td>
<td>15</td>
</tr>
<tr>
<td>5. Usefulness of system features and functions</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td>17</td>
</tr>
<tr>
<td></td>
<td>18</td>
</tr>
<tr>
<td>6. System flexibility</td>
<td>19</td>
</tr>
<tr>
<td>7. System reliability</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>21</td>
</tr>
<tr>
<td>8. Integration of systems</td>
<td>22</td>
</tr>
<tr>
<td>9. System efficiency</td>
<td>23</td>
</tr>
<tr>
<td></td>
<td>24</td>
</tr>
<tr>
<td>10. Response time</td>
<td>25</td>
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</tbody>
</table>

Information quality variables and adjacent measure numbers

<table>
<thead>
<tr>
<th>Variable</th>
<th>Measure No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>11. Relevance</td>
<td>26</td>
</tr>
<tr>
<td>12. Usefulness</td>
<td>27</td>
</tr>
<tr>
<td>13. Usableness</td>
<td>29</td>
</tr>
<tr>
<td>14. Clarity</td>
<td>30</td>
</tr>
<tr>
<td>15. Understandability</td>
<td>31</td>
</tr>
<tr>
<td>16. Format</td>
<td>32</td>
</tr>
<tr>
<td>17. Content</td>
<td>33</td>
</tr>
<tr>
<td>18. Accuracy</td>
<td>34</td>
</tr>
<tr>
<td>19. Sufficiency</td>
<td>35</td>
</tr>
<tr>
<td>20. Completeness</td>
<td>36</td>
</tr>
<tr>
<td></td>
<td>37</td>
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</tbody>
</table>
## Variable and Measure Numbers

**Process quality variables and adjacent measure numbers**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Measure No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>21. Reliability</td>
<td>38, 39</td>
</tr>
<tr>
<td>22. Timeliness</td>
<td>40</td>
</tr>
<tr>
<td>23. Development (Create)</td>
<td>41, 42, 43, 44, 45, 46, 48, 49, 65, 66, 67</td>
</tr>
<tr>
<td>24. Acquisition (Capture)</td>
<td>44, 45, 46, 48, 49, 50, 51, 52, 59, 65, 66, 67</td>
</tr>
<tr>
<td>25. Identification (Access)</td>
<td>42, 50, 51, 52, 59, 72, 73</td>
</tr>
<tr>
<td>26. Preservation (Store and organise)</td>
<td>47, 53, 54, 55, 56, 57, 58, 69, 70, 71, 74, 75, 76, 77</td>
</tr>
<tr>
<td>27. Utilisation (Use)</td>
<td>61, 62, 63, 64, 65, 68, 71, 74, 75, 76, 77</td>
</tr>
<tr>
<td>28. Dissemination (Distribute)</td>
<td>62, 63, 69, 70, 78, 79, 80, 81</td>
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</tbody>
</table>
### System use variables and adjacent measure numbers

<table>
<thead>
<tr>
<th>Variable</th>
<th>Measure No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>34. Frequency of report request</td>
<td>82</td>
</tr>
<tr>
<td>35. Appropriate use</td>
<td>86</td>
</tr>
<tr>
<td>36. Purpose of use</td>
<td>87</td>
</tr>
<tr>
<td>37. Number of reports generated</td>
<td>88</td>
</tr>
<tr>
<td>38. Regulatory of use</td>
<td>89</td>
</tr>
<tr>
<td>39. Amount of connect time</td>
<td>90</td>
</tr>
<tr>
<td>40. Frequency of access</td>
<td>91</td>
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</table>

### User satisfaction variables and adjacent measure numbers

<table>
<thead>
<tr>
<th>Variable</th>
<th>Measure No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>29. Software satisfaction</td>
<td>96</td>
</tr>
<tr>
<td>30. Decision-making satisfaction</td>
<td>97</td>
</tr>
<tr>
<td>31. Satisfaction with specifics</td>
<td>98</td>
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<tr>
<td>32. Information satisfaction</td>
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</tr>
<tr>
<td>33. Overall satisfaction</td>
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### Individual impact variables and adjacent measure numbers

<table>
<thead>
<tr>
<th>Variable</th>
<th>Measure No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>41. Information understanding</td>
<td>10</td>
</tr>
<tr>
<td>42. Learning</td>
<td>11</td>
</tr>
<tr>
<td>43. Information awareness</td>
<td>12</td>
</tr>
<tr>
<td>44. Decision effectiveness</td>
<td>13</td>
</tr>
<tr>
<td>45. Decision quality</td>
<td>14</td>
</tr>
<tr>
<td>46. Improved decision analysis</td>
<td>15</td>
</tr>
<tr>
<td>47. Correctness of decision</td>
<td>16</td>
</tr>
<tr>
<td>48. Time to make decision</td>
<td>17</td>
</tr>
<tr>
<td>49. Confidence in decision</td>
<td>18</td>
</tr>
<tr>
<td>50. Improved individual productivity</td>
<td>19</td>
</tr>
</tbody>
</table>

### Project (group) impact variables and adjacent measure numbers

<table>
<thead>
<tr>
<th>Variable</th>
<th>Measure No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>55. Operating cost reductions</td>
<td>149</td>
</tr>
<tr>
<td>56. Staff reductions</td>
<td>150</td>
</tr>
<tr>
<td>57. Overall productivity gains</td>
<td>151</td>
</tr>
<tr>
<td></td>
<td>152</td>
</tr>
<tr>
<td></td>
<td>153</td>
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<tr>
<td></td>
<td>155</td>
</tr>
<tr>
<td></td>
<td>156</td>
</tr>
<tr>
<td>58. Increased work volume</td>
<td>157</td>
</tr>
<tr>
<td>59. Product quality</td>
<td>158</td>
</tr>
<tr>
<td>60. Contribution to achieving goals</td>
<td>159</td>
</tr>
<tr>
<td>61. Service effectiveness</td>
<td>160</td>
</tr>
<tr>
<td>62. Time effectiveness</td>
<td>161</td>
</tr>
<tr>
<td>63. Improved information management</td>
<td>162</td>
</tr>
<tr>
<td></td>
<td>163</td>
</tr>
<tr>
<td></td>
<td>164</td>
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<tr>
<td></td>
<td>165</td>
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<tr>
<td></td>
<td>166</td>
</tr>
<tr>
<td>64. Increased profits</td>
<td>167</td>
</tr>
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</table>
Appendix D
– means and standard deviations from the survey

### Perceptions of system quality by project managers

<table>
<thead>
<tr>
<th>Measure</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>16. PDS is not an important system for this organisation. [R]</td>
<td>6.67</td>
<td>1.30</td>
</tr>
<tr>
<td>15. I find PDS extremely convenient to access.</td>
<td>6.33</td>
<td>0.82</td>
</tr>
<tr>
<td>17. PDS is extremely useful.</td>
<td>6.20</td>
<td>0.86</td>
</tr>
<tr>
<td>18. I personally benefit from the existence of PDS in this organisation.</td>
<td>6.13</td>
<td>0.99</td>
</tr>
<tr>
<td>20. Performing an operation in PDS never leads to a predicted result. [R]</td>
<td>5.87</td>
<td>1.06</td>
</tr>
<tr>
<td>13. It is easy to learn how to use PDS.</td>
<td>5.80</td>
<td>1.01</td>
</tr>
<tr>
<td>22. PDS integrates different soft systems within the organisation well.</td>
<td>5.80</td>
<td>1.01</td>
</tr>
<tr>
<td>23. The organisation of information on the system screens by PDS is clear.</td>
<td>5.53</td>
<td>1.25</td>
</tr>
<tr>
<td>24. PDS makes it easy to find the information I need.</td>
<td>5.47</td>
<td>1.19</td>
</tr>
<tr>
<td>7. PDS information content meets my needs.</td>
<td>5.33</td>
<td>1.12</td>
</tr>
<tr>
<td>14. Compared to other computer software, PDS is not easy to learn. [R]</td>
<td>5.33</td>
<td>1.29</td>
</tr>
<tr>
<td>10. Steps to complete a task in PDS rarely follow a logic sequence. [R]</td>
<td>5.20</td>
<td>1.21</td>
</tr>
<tr>
<td>11. I find it easy to get PDS to do what I want it to do.</td>
<td>5.20</td>
<td>1.27</td>
</tr>
<tr>
<td>21. I can count on PDS to be “up” and available when I need it.</td>
<td>5.20</td>
<td>1.70</td>
</tr>
<tr>
<td>8. Remembering usage of features in PDS is easy.</td>
<td>5.07</td>
<td>1.39</td>
</tr>
<tr>
<td>12. PDS is user friendly.</td>
<td>4.87</td>
<td>1.85</td>
</tr>
<tr>
<td>19. The functions in PDS allow individual work procedures.</td>
<td>4.87</td>
<td>1.69</td>
</tr>
<tr>
<td>25. General system speed is fast enough.</td>
<td>4.27</td>
<td>1.62</td>
</tr>
<tr>
<td>9. Number of steps per task in PDS are too many. [R]</td>
<td>3.80</td>
<td>1.86</td>
</tr>
</tbody>
</table>

### Perceptions of process quality by project managers

<table>
<thead>
<tr>
<th>Measure</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>69. PDS facilitates collaboration between project members.</td>
<td>6.60</td>
<td>0.51</td>
</tr>
<tr>
<td>45. Using a process structure for information management in PDS makes my job easier.</td>
<td>6.53</td>
<td>0.52</td>
</tr>
<tr>
<td>48. PDS clarifies the most important decision points in the housing development process.</td>
<td>6.47</td>
<td>0.52</td>
</tr>
<tr>
<td>60. PDS facilitates storing of project information.</td>
<td>6.40</td>
<td>0.51</td>
</tr>
<tr>
<td>62. PDS supports communication between members of the project team.</td>
<td>6.40</td>
<td>0.83</td>
</tr>
<tr>
<td>68. PDS facilitates a more structured project management work.</td>
<td>6.40</td>
<td>0.63</td>
</tr>
<tr>
<td>71. Using PDS gives a greater understanding of the housing development process procedures.</td>
<td>6.40</td>
<td>0.63</td>
</tr>
<tr>
<td>79. PDS facilitates communicating information between various members of the project team.</td>
<td>6.40</td>
<td>0.63</td>
</tr>
<tr>
<td>70. Information exchange between project members in PDS is good.</td>
<td>6.33</td>
<td>0.49</td>
</tr>
</tbody>
</table>
### Perceptions of information quality by project managers

<table>
<thead>
<tr>
<th>Measure</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>26. PDS provides for my job relevant information.</td>
<td>6.33</td>
<td>0.32</td>
</tr>
<tr>
<td>28. The information output in PDS is as useful for experienced as well as inexperienced users.</td>
<td>6.40</td>
<td>0.74</td>
</tr>
<tr>
<td>27. The output information from PDS is not useful.</td>
<td>6.33</td>
<td>0.82</td>
</tr>
<tr>
<td>29. The information in PDS is effective in helping me complete my tasks.</td>
<td>6.33</td>
<td>0.62</td>
</tr>
<tr>
<td>30. The Information output from PDS is not clear.</td>
<td>5.80</td>
<td>1.01</td>
</tr>
<tr>
<td>40. PDS provides the information I need in time.</td>
<td>5.67</td>
<td>0.98</td>
</tr>
<tr>
<td>32. PDS presents the information in an appropriate format.</td>
<td>5.53</td>
<td>0.92</td>
</tr>
<tr>
<td>33. The information content in PDS is very good.</td>
<td>5.53</td>
<td>1.06</td>
</tr>
<tr>
<td>39. The reliability of output information in PDS is superior to other information systems.</td>
<td>5.47</td>
<td>1.13</td>
</tr>
<tr>
<td>31. PDS provide easy to understand information.</td>
<td>5.40</td>
<td>0.99</td>
</tr>
<tr>
<td>34. The information output from PDS is up to date enough for my purposes.</td>
<td>4.80</td>
<td>1.21</td>
</tr>
<tr>
<td>36. The completeness of output information that PDS delivers is not sufficient for my purposes.</td>
<td>4.80</td>
<td>1.21</td>
</tr>
<tr>
<td>37. The completeness of the output information is adequate enough for my purposes.</td>
<td>4.80</td>
<td>1.74</td>
</tr>
</tbody>
</table>
### Perceptions of system use by project managers

<table>
<thead>
<tr>
<th>Measure</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>90. I do not use PDS for storing information.</td>
<td>6.53</td>
<td>0.52</td>
</tr>
<tr>
<td>88. I do not use PDS as project planning support.</td>
<td>6.40</td>
<td>0.51</td>
</tr>
<tr>
<td>86. I use PDS as project development support.</td>
<td>6.33</td>
<td>0.82</td>
</tr>
<tr>
<td>87. I use PDS as project management support.</td>
<td>6.33</td>
<td>0.62</td>
</tr>
<tr>
<td>92. How many documents do you produce/store/read/alter and distribute per month in PDS?</td>
<td>6.27</td>
<td>1.03</td>
</tr>
<tr>
<td>93. How many times would you say that you use PDS during a week?</td>
<td>6.27</td>
<td>0.96</td>
</tr>
<tr>
<td>91. I use PDS to control projects.</td>
<td>6.20</td>
<td>0.41</td>
</tr>
<tr>
<td>85. I often use PDS to study produced documents.</td>
<td>6.13</td>
<td>0.83</td>
</tr>
<tr>
<td>83. I seldom use PDS to store produced documents.</td>
<td>6.07</td>
<td>0.70</td>
</tr>
<tr>
<td>84. I frequently use PDS to locate produced documents.</td>
<td>6.00</td>
<td>0.85</td>
</tr>
<tr>
<td>89. I use PDS for getting work instructions.</td>
<td>5.80</td>
<td>0.86</td>
</tr>
<tr>
<td>82. I frequently use PDS to access support documents.</td>
<td>5.73</td>
<td>0.80</td>
</tr>
<tr>
<td>95. How often would you say that you use PDS?</td>
<td>5.67</td>
<td>1.40</td>
</tr>
<tr>
<td>94. How many hours do you believe you use PDS every week?</td>
<td>4.47</td>
<td>1.73</td>
</tr>
</tbody>
</table>

### Perceptions of user satisfaction by project managers

<table>
<thead>
<tr>
<th>Measure</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>102. I am not satisfied with the collaboration capabilities with other project members in PDS.</td>
<td>6.13</td>
<td>0.74</td>
</tr>
<tr>
<td>105. I am not satisfied with the document control in PDS.</td>
<td>6.13</td>
<td>0.64</td>
</tr>
<tr>
<td>107. The information output from PDS fully matches what I want from such a system.</td>
<td>6.13</td>
<td>0.52</td>
</tr>
<tr>
<td>109. How would you rate your overall satisfaction with PDS?</td>
<td>5.87</td>
<td>0.92</td>
</tr>
<tr>
<td>101. I am very satisfied with the process oriented navigation structure in PDS.</td>
<td>5.73</td>
<td>1.03</td>
</tr>
<tr>
<td>99. I am very satisfied with the support that PDS gives me in important decision making.</td>
<td>5.67</td>
<td>1.11</td>
</tr>
<tr>
<td>100. I am very satisfied with the information handling capabilities in PDS.</td>
<td>5.67</td>
<td>0.82</td>
</tr>
<tr>
<td>104. I am very satisfied with the process work instructions in PDS.</td>
<td>5.67</td>
<td>0.82</td>
</tr>
<tr>
<td>108. I am satisfied with the information, which is accessible through PDS.</td>
<td>5.67</td>
<td>0.72</td>
</tr>
<tr>
<td>96. I am very satisfied with using the software that supports PDS.</td>
<td>5.33</td>
<td>1.54</td>
</tr>
<tr>
<td>106. I am very satisfied with the documents provided by PDS.</td>
<td>5.27</td>
<td>0.88</td>
</tr>
<tr>
<td>97. I am very satisfied with the user interface of PDS.</td>
<td>5.20</td>
<td>1.21</td>
</tr>
<tr>
<td>98. I am very satisfied with the input screens in PDS.</td>
<td>5.20</td>
<td>1.21</td>
</tr>
<tr>
<td>103. I am very satisfied with the version handling in PDS.</td>
<td>5.00</td>
<td>2.04</td>
</tr>
</tbody>
</table>

### Perceptions of individual impact by project managers

<table>
<thead>
<tr>
<th>Measure</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>112. PDS improves my training and education of the housing development process.</td>
<td>6.40</td>
<td>0.74</td>
</tr>
<tr>
<td>142. Overall, I find using PDS to be advantageous in my job.</td>
<td>6.40</td>
<td>0.63</td>
</tr>
<tr>
<td>134. Using PDS makes me less focused on the job I perform.</td>
<td>6.33</td>
<td>0.72</td>
</tr>
<tr>
<td>141. Using PDS gives me greater control over my work.</td>
<td>6.33</td>
<td>0.62</td>
</tr>
<tr>
<td>113. PDS improves access to existing sources of information.</td>
<td>6.27</td>
<td>0.70</td>
</tr>
<tr>
<td>121. As a result of PDS, more relevant information has been available to me for decision-making.</td>
<td>6.27</td>
<td>0.59</td>
</tr>
<tr>
<td>146. PDS facilitates quicker access to appropriate information.</td>
<td>6.20</td>
<td>0.68</td>
</tr>
<tr>
<td>140. Using PDS makes it easier to do my job.</td>
<td>6.13</td>
<td>0.52</td>
</tr>
<tr>
<td>110. PDS has given me a better understanding of the decision context in a housing development project.</td>
<td>6.07</td>
<td>0.96</td>
</tr>
<tr>
<td>131. The PDS environment has a large, positive impact on my effectiveness and productivity in my job.</td>
<td>6.00</td>
<td>0.66</td>
</tr>
<tr>
<td>148. I value that PDS improves my ability to handle information with.</td>
<td>6.00</td>
<td>1.36</td>
</tr>
<tr>
<td>117. Utilisation of PDS has not enabled me to make better decisions.</td>
<td>5.87</td>
<td>1.06</td>
</tr>
</tbody>
</table>
### Measure | Mean | SD
--- | --- | ---
122. PDS has led me to greater use of analytical aids in my decision-making. | 5.87 | 0.74
123. PDS helps me feel confident in the decisions made. | 5.87 | 0.64
124. By using the PDS I have learned a lot about the housing development process. | 5.80 | 0.86
125. Using PDS increases my work productivity. | 5.80 | 0.86
126. PDS have not reduced my risk-taking. | 5.73 | 0.88
127. As a result of PDS, I am better able to set my priorities in decision-making. | 5.67 | 0.72
128. PDS has improved the quality of decisions I make in projects. | 5.67 | 0.62
129. Using PDS enables me to accomplish tasks more quickly. | 5.67 | 1.05
130. Using PDS does not improve the quality of work I do. | 5.67 | 1.23
131. As a result of PDS, I am better able to set my priorities in decision-making. | 5.53 | 0.83
132. PDS has improved my individual performance significantly. | 5.53 | 0.99
133. Using information in PDS has enabled me to present my arguments more convincingly. | 5.47 | 0.83
134. PDS has changed my perception of the importance and usefulness of an information system. | 5.40 | 1.45
135. Due to PDS I can do a better job. | 5.33 | 1.35
136. Using PDS feels like a natural part of my daily work. | 5.20 | 0.56
137. PDS clarifies my role within the organisation. | 5.13 | 0.64
138. Using PDS does not improve the quality of work I do. | 5.13 | 0.83
139. I find that PDS clarifies my role within the organisation. | 5.07 | 0.74
140. PDS improves work participation by project members. | 5.07 | 0.74
141. PDS reduces storage requirements for documents/information. | 5.00 | 0.83
142. Using PDS helps me manage my work time in a more efficient manner. | 4.87 | 0.83
143. PDS reduces rework and waste in the project. | 4.80 | 1.01
144. PDS has improved my ability to distribute information. | 4.80 | 2.19
145. PDS reduces storage requirements for documents/information. | 4.80 | 1.01
146. PDS has improved my ability to distribute information. | 4.80 | 2.19
147. PDS does not offer an increased effectiveness in serving customers. | 4.80 | 2.19
148. PDS facilitates quicker responses to project changes. | 4.73 | 0.70
149. PDS facilitates cost savings in information management. | 4.73 | 0.70
150. PDS does not facilitate staff reduction in projects. | 4.73 | 1.06
151. PDS facilitates quicker responses to project changes. | 4.73 | 0.70
152. PDS improves communication and cooperation within the project group. | 4.73 | 0.70
153. Using PDS does not facilitate staff reduction in projects. | 4.73 | 1.06
154. PDS reduces rework and waste in the project. | 4.73 | 0.70
155. PDS does not improve the quality of work I do. | 4.73 | 1.06
156. PDS reduces rework and waste in the project. | 4.73 | 0.70
157. PDS does not improve the quality of work I do. | 4.73 | 1.06
158. PDS reduces rework and waste in the project. | 4.73 | 0.70
159. PDS reduces rework and waste in the project. | 4.73 | 1.06
160. PDS increases information availability within the project workgroup. | 4.73 | 1.06
161. Using PDS supports training and education of all employees. | 4.73 | 1.06
162. Using PDS supports education and training of newly recruited employees. | 4.73 | 1.06
163. PDS improves work participation by project members. | 4.73 | 1.06
164. PDS improves communication and cooperation within the project group. | 4.73 | 1.06
165. Due to the increased information sharing capability the project group can function more effectively. | 4.73 | 1.06
166. PDS reduces storage requirements for documents/information. | 4.73 | 1.06
167. Due to increased information dissemination in projects the group understanding and motivation is enhanced. | 4.73 | 1.06
168. PDS helps the project to achieve its goals. | 4.73 | 1.06
169. PDS facilitates cost savings in information management. | 4.73 | 1.06
170. PDS does not offer an increased effectiveness in serving customers. | 4.73 | 1.06
171. PDS improves productivity within the project work group. | 4.73 | 1.06
172. PDS does not facilitate staff reduction in projects. | 4.73 | 1.06
173. PDS facilitates quicker responses to project changes. | 4.73 | 1.06
174. PDS reduces rework and waste in the project. | 4.73 | 1.06
175. PDS does not improve the quality of work I do. | 4.73 | 1.06
176. PDS increases informal exchange of ideas within the project group. | 4.73 | 1.06
177. Using PDS has increased project time. | 4.73 | 1.06
178. How much do you assess that PDS reduces information management cost and increases company profit? | 4.73 | 1.06

### System satisfaction index results 2002

| Measure | Mean | SD |
--- | --- | --- |
126. I find the management information system to be useful. | 6.53 | 0.52 |
127. PDS makes my job easier. | 6.47 | 0.52 |
128. PDS helps me find appropriate information easier. | 6.27 | 0.59 |
129. Due to PDS I can do a better job. | 6.20 | 0.56 |
130. Using PDS feels like a natural part of my daily work. | 6.13 | 0.64 |
131. I find that PDS clarifies my daily work. | 5.87 | 0.83 |
132. PDS helps me find appropriate information easier. | 5.73 | 0.70 |
133. PDS clarifies my role within the organisation. | 5.60 | 1.06 |
134. I find all the information necessary for me to perform my job due to the layout of PDS. | 5.53 | 0.52 |

### Perceptions of project (group) impact by project managers

| Measure | Mean | SD |
--- | --- | --- |
164. PDS increases information availability within the project workgroup. | 6.53 | 0.64 |
165. Using PDS supports training and education of all employees. | 6.47 | 0.52 |
166. Using PDS supports education and training of newly recruited employees. | 6.40 | 0.51 |
167. PDS improves work participation by project members. | 6.20 | 0.41 |
168. PDS improves communication and cooperation within the project group. | 6.20 | 0.78 |
169. Due to the increased information sharing capability the project group can function more effectively. | 6.13 | 0.74 |
170. PDS improves communication within the project work group. | 6.13 | 0.74 |
171. Due to increased information dissemination in projects the group understanding and motivation is enhanced. | 6.00 | 0.76 |
172. PDS helps the project to achieve its goals. | 5.87 | 0.52 |
173. PDS facilitates cost savings in information management. | 5.80 | 0.78 |
174. PDS does not offer an increased effectiveness in serving customers. | 5.80 | 0.78 |
175. PDS improves productivity within the project work group. | 5.73 | 0.70 |
176. PDS does not facilitate staff reduction in projects. | 5.47 | 1.06 |
177. PDS facilitates quicker responses to project changes. | 5.47 | 0.99 |
178. PDS reduce rework and waste in the project. | 5.40 | 0.74 |
179. PDS does not increase the work volume for the project work group. | 5.33 | 1.63 |
180. PDS increased informal exchange of ideas within the project group. | 5.27 | 1.39 |
181. Using PDS has increased project time. | 4.80 | 1.01 |
182. How much do you assess that PDS reduces information management cost and increases company profit? | 4.53 | 2.10 |
Appendix E
– Supported question correlations

Correlation above 0.6 shows a highly significant relationship between the questions.

**H1: Increases in system quality will lead to increases in system use**

*Database content – System use*
- No correlation

*Ease of use - System use*

- Remembering usage of features in the IS is easy
  - 0.485
- The IS is user friendly
  - -0.469
- How many hours per week the IS is being used
  - -0.457
- No. of steps per task are too many
  - -0.559
- I use the IS to study produced documents
  - -0.499

*Ease of learning – System use*

- It is easy to learn how to use the IS
  - -0.595
- I use the IS as a project planning support
  - -0.619
- I use the IS to control projects

*Convenience of access – System use*
- No correlation
Usefulness of system features and functions – System use

The IS is an important system for this organisation

The IS is extremely useful

I personally benefit from the existence of the IS in this organisation

System flexibility – System use

– No correlation

System reliability – System use

I can count in the IS to be “up” and available when I need it to be

System efficiency – System use

The IS makes it easy to find the information I need

Response time – System use

General system speed is fast enough

APPENDIX E
H2: Increases in system quality will lead to increases in user satisfaction

Database content – User satisfaction
- No correlation

Ease of use – User satisfaction

- I find it easy to get the IS to do what I want it to do
- No. Of steps per task are not too many
- The IS is user friendly

I am very satisfied with the information handling capabilities of the IS
I am very satisfied with the input screens in the IS
I am very satisfied with the user interface of the IS

Ease of learning – User satisfaction
- No correlation

Convenience of access – User satisfaction
- No correlation

Usefulness of system – User satisfaction

The IS is extremely useful
I personally benefit from the existence of the IS in this organisation

I am very satisfied with the input screens in the IS
The information output from the IS fully matches what I want from such an IS

System flexibility – User satisfaction
- No correlation
Integration of systems – User satisfaction

The IS integrates different soft systems within the organisation well!

0.469

I am satisfied with the process oriented navigation structure of the IS

System reliability – User satisfaction

I can count on the IS to be “up” and available when I need it to be

0.481

0.458

0.489

I am very satisfied with using the software that supports the IS

I am very satisfied with the information handling capabilities of the IS

The information output from the IS fully matches what I want from such an IS

Response time – User satisfaction

– No correlation

System efficiency – User satisfaction

The organisation of information on the IS screens is clear

0.458

0.471

0.654

I am very satisfied with the user interface of the IS

I am very satisfied with the input screens in the IS

I am very satisfied with the information handling capabilities of the IS
H3: Increases in process quality will lead to increases in system use

**Information development – System use**

- The IS supports me when creating new information/documentation
  - I use the IS for getting work instructions

**Information acquisition – System use**

- The level of detail in the activity structure in the IS is sufficient enough
  - I use the IS as project planning support
  - How many times would you say that you use the IS during a week
  - I use the IS for getting work instructions

- Using a process structure for information management in the IS makes my job easier
  - I use the IS for getting work instructions

- I find the information I need under the appropriate activity in the IS
  - How many documents that are produced - stored - altered and distributed per month

**Information identification – System use**

- Effective information retrieval in the IS is very good
  - I use the IS to control projects

- The IS support information retrieval for decision-making
  - I use the IS for getting work instructions

- Availability of information in the IS is very good
  - I use the IS to store produced documents
  - How many times would you say that you use the IS during a week

The IS visualises logical work routines for the process

The IS clarifies the most important decision points in the process

The IS describes the company’s standard procedures for the process

The IS visualises logical work routines for the process

The IS clarifies the most important decision points in the process

The IS describes the company’s standard procedures for the process

How many times would you say that you use the IS during a week

How many documents that are produced - stored - altered and distributed per month

How many times would you say that you use the IS during a week

How many documents that are produced - stored - altered and distributed per month
Information preservation – System use

The IS is good at documenting existing information 0.490
The IS is good at structuring information 0.515

I frequently use the IS to locate produced documents
The IS clarifies the documents, which are necessary to create in an activity -0.499
I use the IS to store produced documents 0.509
The IS clarifies the documents that are record documents

Information utilisation – System use

The IS is good at supporting individual learning -0.477
Using the IS gives greater understanding of process procedures 0.524

How many hours per week the IS is being used -0.543
I use the IS to get work instructions 0.464
The IS presents relevant information that helps me do my job better and more effectively
The information in The IS supports me in decision-making

The IS helps me with resource control 0.532

I use the IS to control projects 0.748
The IS supports me with the formal planning of project activities

I use the IS for project management/development support
I use the system to store produced documents
I frequently use the IS to locate produced documents
Information dissemination – System use

- Information exchange between project members in the IS is good
- The IS makes it easier to communicate with the project organisation
- The IS is good at distributing information to project participants
- I use the IS for getting work instructions
- I use the IS for project management/development support
- How many documents that are produced, stored, altered and distributed per month
- I frequently use the IS to locate produced documents
- I often use the IS to locate produced documents
- The IS supports collaboration and coordination in projects
- The IS facilitates effective communication between project members
- The IS facilitates communicating information between various members of the project team
- The IS supports collaboration and coordination in projects
- The IS facilitates effective communication between project members
- The IS facilitates communicating information between various members of the project team
H4: Increases in process quality lead to increases in user satisfaction

Information development – User satisfaction

The IS supports me when creating new information/documentation

I am satisfied with the collaboration capabilities with other project members

How would you rate your overall satisfaction with the IS

Information acquisition – User satisfaction

The level of detail in the activity structure in the IS is sufficient enough

I am satisfied with the document control in the IS

I am very satisfied with the user interface of the IS

I am satisfied with the support that the IS gives me in important decision-making

How would you rate your overall satisfaction with the IS

Information identification – User satisfaction

The information retrieval function in the IS functions satisfactorily

I am very satisfied with the software that supports the IS

I am satisfied with the collaboration capabilities with other project members

How would you rate your overall satisfaction with the IS

Effective information retrieval in the IS is very good

I am satisfied with the collaboration capabilities with other project members

The IS is good at publishing information

I am very satisfied with the information handling capabilities in the IS

The IS is good at publishing information

I am very satisfied with the information, which is accessible through the IS

I am very satisfied with the input screens in the IS

The IS clarifies the workflow of the process

The IS clarifies the most important decision points in the process

I am satisfied with the collaboration capabilities with other project members

I am very satisfied with the document control in the IS

How would you rate your overall satisfaction with the IS

Availability of the information in the IS is very good

I am very satisfied with the process oriented navigation in the IS

I am satisfied with the support that the IS gives me in important decision-making

I am very satisfied with the version handling in the IS

I am very satisfied with the information handling capabilities in the IS

The IS support information retrieval for decision-making

I am very satisfied with the information handling capabilities in the IS

The IS is good at publishing information

I am very satisfied with the input screens in the IS

The IS is good at publishing information

I am very satisfied with the version handling in the IS
Information preservation – User satisfaction

The IS is good at documenting existing information
The version handling function in the IS works well
I am very satisfied with the version handling in the IS

Information utilisation – User satisfaction

The IS presents relevant information that helps me do my job better and more effectively
I am very satisfied with the software that supports the IS
The IS facilitates a more structured project management work
The IS helps me with resource control

How would you rate your overall satisfaction with the IS?

I am very satisfied with the software that supports the IS
I am very satisfied with the input screens in the IS
I am very satisfied with the information handling capabilities in the IS
I am satisfied with the support that the IS gives me in important decision-making
I am very satisfied with the process oriented navigation in the IS
I am satisfied with the collaboration capabilities with other project members
I am satisfied with the document control in the IS

The IS clarifies the documents, which are necessary to create in an activity
The IS organises information in a sufficient manner

I am very satisfied with the user interface of the IS

Document control in the IS is good
The information in the IS supports me in decision-making
The IS supports me with the formal planning of project activities
Using the IS gives greater understanding of process procedures

How would you rate your overall satisfaction with the IS?

0,507

0,636

0,489

0,614

0,651

0,541

0,622

0,532

0,639

0,500

0,590

0,611

0,628

0,527

0,579

0,547

0,509

0,516

0,518

0,499

0,583

0,502

0,449

0,562

0,635

0,752

0,558

0,501

0,507

0,501

0,501
Information dissemination – User satisfaction

- The IS facilitates effective communication between project members.
- Information exchange between project members is good.
- I am very satisfied with the process oriented navigation in the IS.
- The IS is good at distributing information to project participants.
- I am satisfied with the support that the IS gives me in important decision-making.
- The IS facilitates effective communication between project members.
- The IS supports collaboration and coordination in projects.
- The IS makes it easier to communicate with the project organisation.
- I am very satisfied with the software that supports the IS.
- I am very satisfied with the information handling capabilities in the IS.
- I am satisfied with the collaboration capabilities with other project members.
- The information output fully matches what I want from such a system.
- I am very satisfied with the information, which is accessible through the IS.
- I am satisfied with the document control in the IS.
- I am very satisfied with the document work instructions in the IS.
- I am very satisfied with the process work instructions in the IS.
- I am very satisfied with the user interface of the IS.
- The IS facilitates communicating information between various members of the project team.

How would you rate your overall satisfaction with the IS?

I am very satisfied with the user interface of the IS.

I am very satisfied with the information handling capabilities in the IS.

I am satisfied with the collaboration capabilities with other project members.

The information output fully matches what I want from such a system.

I am very satisfied with the information, which is accessible through the IS.

I am satisfied with the document control in the IS.

The IS facilitates communicating information between various members of the project team.

How would you rate your overall satisfaction with the IS?
H5: Increases in information quality will lead to increases in system use

Relevance – System use

The IS provides for my job relevant information

I often use the IS to study produced documents

I use the IS to store produced documents

Usefulness – System use

The output information from the IS is useful for experienced as well as inexperienced users

I use the IS for getting work instructions

Usability – System use

The information in the IS is effective in helping me complete my tasks

I use the IS for getting work instructions

Clarity – System use

– No correlation

Understandability – System use

The IS provides easy to understand information

I often use the IS to study produced documents

Format – System use

The IS presents the information in an appropriate format

I use the IS to store produced documents
Content – System use

The information content in the IS is very good

I frequently use the IS to access support documents

Accuracy – System use
- No correlation

Sufficiency – System use

The IS provides for my job relevant information

I use the IS to store produced documents

Completeness – System use
- No correlation

Reliability – System use

The reliability of the output information from the IS is high

I often use the IS to study produced documents

How many documents that are produced, stored, altered and distributed per month

-0.474

The reliability of the output information from the IS is superior to other ISs

I use the IS for getting work instructions

Timeliness – System use

The IS provides the information I need in time

I often use the IS to study produced documents

How many times would you say that you use the IS during a week

-0.522
H6: Increases in information quality will lead to increases in user satisfaction

Relevance – User satisfaction

The IS provides for my job relevant information

I am satisfied with the collaboration capabilities with other project members

Usefulness – User satisfaction

The output information from the IS is useful for experienced as well as inexperienced users

I am satisfied with the collaboration capabilities with other project members

Usableness – User satisfaction

The information in the IS is effective in helping me complete my tasks

I am very satisfied with the information handling capabilities in the IS

I am satisfied with the collaboration capabilities with other project members

I am very satisfied with the information, which is accessible through the IS

The information output fully matches what I want from such a system

Clarity – User satisfaction

The information output from the IS is clear

I am very satisfied with the information, which is accessible through the IS

I am satisfied with the user interface of the IS

The information output fully matches what I want from such a system

Understandability – User satisfaction

The IS provides easy to understand information

I am satisfied with the user interface of the IS
Format – User satisfaction

The IS presents the information in an appropriate format 0.464
I am satisfied with the user interface of the IS

Content – User satisfaction

The information content in the IS is very good 0.729
I am satisfied with the documents provided by the IS
The information output fully matches what I want from such a system 0.565

Accuracy – User satisfaction

The information output from the IS is up to date enough for my purposes 0.483
I am satisfied with the documents provided by the IS

Sufficiency – User satisfaction

The information that the IS delivers is sufficient enough for my purposes 0.667
The information output fully matches what I want from such a system

Completeness – User satisfaction

The completeness of the output information is adequate enough for my purposes 0.485
The information output fully matches what I want from such a system
Reliability – User satisfaction

The reliability of the output information from the IS is high

- I am very satisfied with the software that supports the IS (0.472)
- The information output fully matches what I want from such a system (0.540)
- I am very satisfied with the information, which is accessible through the IS (0.696)
- I am satisfied with the collaboration capabilities with other project members (0.468)

Timeliness – User satisfaction

The IS provides the information I need in time

- I am very satisfied with the input screens in the IS (0.679)
- I am very satisfied with the information, which is accessible through the IS (0.538)
- I am very satisfied with the information handling capabilities in the IS (0.476)
- I am satisfied with the collaboration capabilities with other project members (0.539)
H7-H8: Increases in system use will lead to increases in user satisfaction and vice versa

**Frequency of report request – User satisfaction**

- I frequently use the IS to access support documents
- I often use the IS to study produced documents

**Appropriate use – User satisfaction**

- I use the IS as project planning support

**Purpose of use – User satisfaction**

- I use the IS for getting work instruction

**Number of reports generated – User satisfaction**

- No correlation

**Regulatory use – User satisfaction**

- No correlation
Amount of connected time – User satisfaction

How many hours do you believe you use the IS every week

I am very satisfied with the input screens in the IS

Frequency of access – User satisfaction

– No correlation
**H9: Increases in system use will lead to increases in individual impact**

*Frequency of report request – Individual impact*

- I frequently use the IS to locate produced documents
  - As a result of the IS, the speed which I analyse decisions has increased
  - Using the IS enables me to accomplish tasks more quickly
  - The IS facilitates quicker access to appropriate information
  - Overall, I find using the IS to be advantageous in my job
  - The IS has improved my ability to distribute information

- I often use the IS to study produced documents
  - As a result of the IS, more relevant information has been available to me for decision-making
  - Using the IS makes it easier to do my job
  - The IS has improved the quality of decisions I make in projects

*Appropriate use – Individual impact*

- I use the IS for project management support
  - Using the IS does improve the quality of work I do
  - Using the IS makes me more focused on the job I perform
  - Utilisation of the IS has enabled me to make better decisions
  - Using the IS makes it easier to do my job
  - The IS reduces storage for documents/information

- I use the IS for project development support
  - Using the IS does improve the quality of work I do
  - Using the IS makes me more focused on the job I perform
  - Utilisation of the IS has enabled me to make better decisions
  - Using the IS makes it easier to do my job
  - The IS reduces storage for documents/information
Purpose of use – Individual impact

I use the IS for getting work instructions

Using the IS enables me to accomplish tasks more quickly

I use the IS for storing information

The IS has reduced my risk-taking

The IS has led me to a greater use of analytical aids in my decision-making

The IS environment has a large, positive impact on my effectiveness and productivity in my job

Using the IS gives me greater control over my work

By using the IS I have learned a lot about the process

Using the IS causes me to change my behaviour at work

Using the IS does improve the quality of work I do

The IS has improved the quality of work I do in my job

Using the IS makes it easier to do my job

Number of reports generated – Individual impact

– No correlation

Regulatory of use – Individual impact

How many times would you say that you use the IS during a week

The IS has changed my perception of the importance and usefulness of an IS

Amount of connected time – Individual impact

How many hours per week the IS is being used

The IS improves access to existing sources of information

Frequency of access – Individual impact

How often would you say that you use the IS

The IS helps me feel confident in the decision made

The IS has changed my perception of the importance and usefulness of an IS

I value that the IS improves my ability to handle information with x %
H10: Increases in user satisfaction will lead to increases in individual impact

Software satisfaction – Individual impact

I am very satisfied with the user interface of the IS

As a result of the IS, more relevant information has been available to me for decision-making

As a result of the IS, the speed at which I analyze decisions has increased

The IS environment has a large, positive impact on my effectiveness and productivity in my job

The IS has improved my ability to distribute information

The IS facilitates quicker access to appropriate information

The IS improves access to existing sources of information

I am very satisfied with using the software that supports the IS

0.651

0.462

0.600

0.503

0.544

0.522

Using the IS increases my work productivity

Decision-making satisfaction – Individual impact

I am very satisfied with the support that the IS gives me in important decision-making

As a result of the IS, the speed at which I analyze decisions has increased

The IS facilitates quicker access to appropriate information

0.550

0.651

0.544

0.493

0.533

0.473

0.647

0.559

I am very satisfied with the input screens in the IS

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Satisfaction with specifics – Individual impact

I am very satisfied with the version handling in the IS

I am very satisfied with the process work instructions in the IS

I am very satisfied with the collaboration capabilities with other project members in the IS

I am very satisfied with the documents provided by the IS

Using the IS enables me to accomplish tasks more quickly

The IS has improved my ability to distribute information

The IS reduces storage for documents/information

The IS facilitates quicker access to appropriate information

As a result of the IS, the speed which I analyse decisions has increased

The IS improves access to existing sources of information

The IS improves training and education of the process

Using the IS gives me greater control over my work

The IS improves access to existing sources of information

The IS improves training and education of the process

Using the IS gives me greater control over my work

The IS improves access to existing sources of information

Using the IS gives me greater control over my work

The IS environment has a large, positive impact on my effectiveness and productivity in my job

Using the IS does improve the quality of work I do

As a result of the IS, more relevant information has been available to me for decision-making

Overall, I find using the IS to be advantageous in my job

Using the IS makes me more focused on the job I perform

By using the IS I have learned a lot about the process

The IS has led me to a greater use of analytical aids in my decision-making

I value that the IS improves my ability to handle information with x%
Information satisfaction – Individual impact

The IS has given me better understanding of the decision context in a project
As a result of the IS, my knowledge which I analyze decisions has increased
The IS improves access to existing sources of information
The IS improves training and education of the process
The IS facilitates quicker access to appropriate information
Using the IS enables me to accomplish tasks more quickly
Using the IS increases my work productivity
The information output from the IS fully matches what I want from such an IS
Using the IS gives me greater control over my work
I am very satisfied with the information, which is accessible through the IS
Using the IS has improved my individual performance significantly
The IS environment has a large, positive impact on my effectiveness and productivity in my job
Using the IS increases my work productivity
I value that the IS improves my ability to handle information with x% (0.610)
I am very satisfied with the information, which is accessible through the IS
Using the IS has improved my individual performance significantly
The IS helps me to do my job
The IS makes it easier to do my job
The IS has given me better understanding of the decision context in a project
The IS improves access to existing sources of information
As a result of the IS, more relevant information has been available to me for decision-making
As a result of the IS, the speed at which I analyze decisions has increased
Using the IS increases my work productivity
I value that the IS improves my ability to handle information with x% (0.610)
I am very satisfied with the information, which is accessible through the IS
Using the IS has improved my individual performance significantly
The IS environment has a large, positive impact on my effectiveness and productivity in my job
Using the IS increases my work productivity
I value that the IS improves my ability to handle information with x% (0.610)
I am very satisfied with the information, which is accessible through the IS
Using the IS has improved my individual performance significantly
The IS environment has a large, positive impact on my effectiveness and productivity in my job

Overall satisfaction – Individual impact

How would you rate your overall satisfaction
Using the IS gives me greater control over my work
Using the IS does improve the quality of work I do
The IS improves training and education of the process
The IS improves access to existing sources of information
Using the IS increases my work productivity
The IS environment has a large, positive impact on my effectiveness and productivity in my job
Using the IS has improved my individual performance significantly
H11: Increases in individual impact will lead to increases in project (group) impact

Information understanding – Project impact

The IS has given me better understanding of the decision context in a project

Learning – Project impact

The IS improves training and education of the process

Information awareness – Project impact

The IS improves access to existing sources of information

Decision effectiveness – Project impact

As a result of the IS, more relevant information has been available to me for decision-making

Using information in the IS has enabled me to present my arguments more convincingly

The IS facilitates quicker responses to project changes

The IS does not increase the work volume for the project workgroup
Decision quality – Project impact

- The IS offers an increased effectiveness in serving customers
- The IS helps the project to achieve its goals
- The IS improves work participation by project members
- The IS improves communication within the project group
- Due to the increased information sharing capability, the project group can function more effectively

Using the IS supports training and education of newly recruited employees
Using the IS supports training and education of all employees
The IS improves communication and cooperation within the project group
As a result of the IS, more relevant information has been available to me for decision-making
The IS offers an increased effectiveness in serving customers

Improved decision analysis – Project impact

- The IS has led me to a greater use of analytical aids in my decision-making
- The IS facilitates quicker responses to project changes
- The IS increases informal exchange of ideas within the project group

Correctness of decision – Project impact

- The IS has reduced my risk taking
- Using the IS supports training and education of newly recruited employees
- Using the IS supports training and education of all employees

Time to make decision – Project impact

- The IS helps the project to achieve its goals
- The IS facilitates staff reductions
- The IS improves work participation by project members
- The IS improves communication within the project group
- Due to the increased information sharing capability, the project group can function more effectively

As a result of the IS, the speed at which I analyse decisions has increased
The IS increases informal exchange of ideas within the project group
The IS reduces rework and waste in the project

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Confidence in decision – project impact

The IS helps me feel confident in the decisions made

The IS improves productivity within the project workgroup

Improved individual productivity – Project impact

The IS environment has a large, positive impact on my effectiveness and productivity in my job

The IS improves communication and cooperation within the project group

The IS improves work participation by project members

Due to the increased information sharing capability the project group can function more effectively

The IS facilitates staff reductions

The IS improves communication within the project workgroup

Using the IS reduces rework and waste in the project

Using the IS has improved my individual performance significantly

Using the IS increases my work productivity

Using the IS supports training and education of newly recruited employees

Using the IS supports training and education of all employees

Using the IS has increased project time

Using the IS improves productivity within the project workgroup
Task performance – Project impact

Using the IS supports training and education of all employees
The IS improves communication and cooperation within the project group
The IS facilitates staff reductions
Due to the increased information sharing capability, the project group can function more effectively
The IS improves work participation by project members
The IS facilitates quicker responses to project changes
The IS improves communication and cooperation within the project group
The IS reduces rework and waste in the project
Using the IS has increased project time
The IS increases informal exchange of ideas within the project group
Using the IS supports me to accomplish tasks more quickly
Using the IS enables me to accomplish tasks more quickly
Using the IS makes it easier to do my job
Using the IS does improve the quality of work I do
I value that the IS improves my ability to handle information with %

Change in decision – Project impact

The IS causes me to change my behaviour at work
The IS facilitates quicker responses to project changes

Personal evaluation of information system – Project impact

Overall, I find using the IS to be advantageous in my job
Due to the increased information sharing capability, the project group can function more effectively
The IS has changed my perception of the importance and usefulness of an IS
Due to the increased information dissemination in projects, the workgroup understanding and motivation is enhanced

APPENDIX E

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Information management – Project impact

The IS facilitates staff reductions
Due to the increased information sharing capability the project group can function more effectively
The IS improves work participation by project members
The IS improves communication within the project workgroup
The IS reduces rework and waste in the project
The IS increases information availability within the project workgroup
The IS improves communication and cooperation within the project group
The IS facilitates cost savings in information management

The IS improves my ability to distribute information

The IS facilitates quicker access to appropriate information
0.703
0.526
0.615
0.628
0.561
0.529
0.493

The IS reduces storage for documents/information -0.510

The IS does not increase the work volume for the project group
0.570
0.477
0.466
0.493
0.526
0.615
0.628
0.561
0.529
0.493