Software Process Asset Management and Deployment in a Multi-Site Organization

TIMO KALTIO

Nokia Mobile Phones
P.O.Box 407
FIN-00045 NOKIA GROUP
Finland

Dissertation for the degree of Doctor of Science in Technology to be presented with due permission for public examination and criticism in the Auditorium T2 of the Helsinki University of Technology on the 26th January 2001, at 12 o'clock noon.

HELSINKI 2001

Kaltio, T., **Software Process Asset Management and Deployment in a Multi-Site Organization.** Acta Polytechnica Scandinavica, Mathematics and Computing Series No. 112, Espoo 2001, 182 pp. Published by the Finnish Academies of Technology. ISBN 951-666-562-4, ISSN 1456-9418.

Keywords: software process improvement, process asset management, process deployment, process asset, process modeling, process definition

Abstract

During the 1990's, Software Process Improvement gained increasing popularity as a means of improving the quality and efficiency of software engineering. Huge numbers of software process improvement projects started with a successful process assessment, but many of them died during, or soon after, the action planning phase. Organizations were not ready to use the assessment findings. There has to be an existing infrastructure that is capable of carrying out the improvement actions, of packaging and managing the process knowledge, and also of reusing the knowledge through successful process deployment.

SW Process Assets represent Software Engineering Process knowledge in a reusable form. The purpose of SW Process Asset Management is to capture the existing processes, as well as the improvements and changes to these processes, into a set of assets (tools, methods, and process representations) that can be reused in future process instances, to store and maintain these assets, and to make them available for process engineering purposes. The activation of organizational learning is realized through Software Process Deployment. Without success in Process Deployment, other Software Process Improvement activities are of almost no value.

This research studies a case in which the SW Process Asset Management and Deployment system was successfully re-constructed and continuously maintained over a period of more than five years in a large multi-site telecommunications company.

This study report contains a comprehensive description of the system elements. The system consists of three process models and infrastructure elements, which are organization, people, knowledge and technology. The first of the processes is about establishing, maintaining, and managing the system itself. This was found critical for the success of continuous activities. The other two process models are Software Process Asset Management and Software Process Deployment. The activities in these processes are linked to roles in the organization, and people filling those roles need suitable abilities, standing, motivation and time allocation in order to be successful in the task in hand. They use knowledge and technology to perform their activities.

Foreword

This dissertation has allowed me to reach the peak of my academic aspirations - and has enabled me to leave the lessons learned as my legacy to others experiencing similar challenges.

This study is based on the work I performed during the years 1995-2000 as a Global SW Process Asset Manager in Nokia Mobile Phones and as a consultant for two other Nokia business units. During this period of nearly six years, I had the pleasure of becoming acquainted with, and working with, a huge number of outstanding people in Nokia Mobile Phones and in other parts of Nokia. Many of these people played an important role in this story. Thank you all. Special thanks are due to all of you who acted as key informants and reviewers of this study. Although I had my role in Nokia Mobile Phones, I was employed by the Nokia Research Center from January 1995 until March 2000. I want to thank all my colleagues and friends in the Nokia Research Center.

To one friend in Nokia Mobile Phones, I owe the biggest debt of gratitude; you set an excellent example of what do and indicated what mistakes I should avoid in the study process, you reviewed the manuscript several times, encouraging me all the way through.

I also wish to thank the following people: Prof. Reijo Sulonen, the supervisor of this dissertation, for encouraging me to begin this huge exercise - and to carry it through to its conclusion; Prof. Dewayne Perry and Dr. Marc Kellner for reviewing the original research plan; and Dr. Markku Oivo and Ph.D. Atte Kinnula for the preliminary examination.

I express my deepest gratitude to my wife Virpi for her encouragement and support. I would like to remember all my dear friends as well. They understand the real value of all this effort…i.e. it gives a good reason to organize a party for them!

This work is dedicated to all those persistent people working hard to improve the way in which software is developed in Nokia Mobile Phones and in the software industry overall.

Helsinki, November 2000 Timo Kaltio

Contents

1 Introduction

Software (henceforth SW) is everywhere. It influences our daily life increasingly every day. The use of the internet, computers, mobile phones, teller machines (ATMs) and so forth is growing rapidly. Also, most household appliances, like washing machines, televisions and even toasters, although once implemented totally without SW, now contain an ever-increasing amount of embedded SW. The near future will bring SW to things and places that we could not even imagine to have anything to do with SW. The size of an average SW solution has been multiplying rapidly. This has lead not only to more complex SW, but also to more complex settings for the SW development projects.

In most cases, it is not possible anymore for a small independent team to develop commercial SW - not to mention solely by an individual SW engineer. The increasing size and complexity of SW, together with time-to-market pressure, have led to large SW development projects, and to networks of projects that are often also geographically distributed to different sites, which may even be located in different continents. This in turn increases the complexity of the project's internal, and inter-project, co-operation.

During the 1990's, SW Process Improvement gained increasing popularity as a means of coping with the challenges of this increasing complexity and the need to improve the efficiency and quality of SW engineering.

SW Process Engineering, "i.e. an disciplined approach for managing and further developing processes and process assets" (Kinnula 1999), includes activities like measurement, process assessment, process definition, process asset management, and process deployment. All these activities measure, develop, improve, manage or use SW Process Assets. The technologies that are in company-wide use and are being actively managed, and the knowledge that has been captured and turned into process representations are collectively known as ‘Process Assets’; the intellectual and technical property that the company actively manages and reuses (Kaltio & Kinnula 2000). The purpose of SW Process Asset Management is to capture the existing processes - and also the improvements and changes to these processes - into a set of assets (tools, methods, and process representations) that can be reused in future process instances; to store and maintain these assets; and to make them available for process engineering purposes.

In a small, single-site SW development organization, it is possible to transfer SW engineering knowledge even without actively managed SW Process Assets. However, when the size of organization and number of sites grows, the role of SW Process Assets in SW Process Improvement becomes correspondingly more central. Especially when the projects are inter-related, it is not acceptable to have totally diverse SW engineering practices within different teams in the organization. The SW Process Assets can be used to establish process commonality across the organization’s SW projects in order to support co-operation, communication, learning, process continuity, and process improvement and maintenance.

The activation of organizational learning is realized through SW Process Deployment. Without success in deployment, all the SW Process Engineering effort comes to naught. It is the last and often the biggest hurdle in successful SW Process Improvement.

Several successful SW Process Improvement programs have been reported in literature. However, probably at least as many unsuccessful programs exist that organizations are not so keen to report. One possible reason for failing improvement programs is that the improvement infrastructure in those organizations has not been ready for the effort required to carry out these improvement activities.

A well-organized and institutionalized infrastructure is necessary for SW Process Asset Management and Process Deployment, as well for the other SW Process Engineering activities. Not only does the infrastructure need to include clearly defined activities, roles and responsibilities, but also the skills of the people have to be planned for and increased. Support tools and relevant knowledge have to be available for carrying out the activities. With a culturally diverse and geographically distributed environment, a decentralized approach is necessary, and this presents its own requirements for managing the said infrastructure.

2 Background

This chapter describes the background of the study case, establishes the reasons for this research, defines the scope of the study, and details the structure of the study report.

2.1 Case background

Nokia Mobile Phones (henceforth NMP) has a long history of organizational SW process representation; at least since 1983. This process representation had a major update in 1992-3 aiming to fulfil ISO 9000 requirements. The nature of SW development projects in terms of size, complexity, amount of reuse, and amount of interrelationships between projects, started to evolve rapidly in the early nineties. (Artifacts.)

In 1995, the NMP SW process improvement program evaluated the status and use of the company's existing SW process documentation. The documentation was found to be outdated, difficult to access and use, lacking in coverage and having contradictory instructions. In addition, the support infrastructure for the enactment of the defined process was clearly inadequate. For these reasons, the guidelines were not used for the most part. In essence, the defined process was not deployed and working practices in SW development projects had started to diverge. (Artifacts.)

The decision was made to improve the status of SW Process Asset Management and Process Deployment. A new SW process definition and approach for supporting deployment were developed and carried out. These have been in use and evolving since September 1996. The approach to treating SW Process Asset Management and Deployment as a system, consisting of related processes and infrastructures, has proven to be successful in establishing and continuously maintaining the said system. (Artifacts.)

2.2 Scope of the study

This study will focus on the subject of SW Process Asset Management and Deployment as part of the SW Process Engineering process, exploring and describing the issues that help to sustain continuous SW Process Asset Management and Deployment in a multi-site organization.

The study takes both a multi-site (global) and a single-site (local) viewpoint and approaches the subject mostly from the perspective of the operative management, and partially from the perspective of process engineer, who aim to establish and institutionalize the SW Process Asset Management and Deployment activities in a multi-site organization.

The thesis will not study other areas of SW Process Engineering, for example process assessments and measurement. When those are discussed, it is done with the purpose of providing context and of aiming to understand the issues related to SW Process Asset

Management and Deployment. The SW engineering processes, such as testing, configuration management and so forth, are also beyond the scope of this study.

This study does not include detailed discussion about all factors influencing the success of SW Process Asset Management and Deployment, for instance management commitment and the alignment of SW Process Engineering goals with business strategy and goals (ProSci 1998, Zahran 1998). Those are often related to the SW Process Engineering overall, rather than specifically to SW Process Asset Management and Deployment.

2.3 Motivation

A literature study reveals that most of the research done in the area of SW Process Asset Management has concentrated on developing and describing specific methods, notations, models and tools for defining processes and process-centered SW engineering environments. Little research has been done about what it actually takes to maintain, deploy and re-deploy these SW Process Assets. These issues are partially covered in many papers taking a wider view of SW process improvement.

Although the way in which SW Process Assets are described (that is, process modeling) and accessed (for instance how an on-line process guideline has been implemented) has influenced the success of process deployment, I suggest that more research should be focused on the infrastructure needs for continuous SW Process Asset management and deployment in real-life settings.

My personal motivation for this report comes from experiences as an operational manager responsible for establishing, improving and managing SW Process Asset Management and Deployment system in NMP globally during the period of January 1995 – March 2000. Throughout the period, I studied all the available well-known models for SW Process Improvement and found them to be inadequate for building and maintaining such a system. My wish is that others tackling similar challenges can benefit from this study report.

2.4 Structure of study report

This study report contains the following major parts:

- Introduction: chapters 1 and 2
- Research plan: chapters 3 and 4
- Related work: chapter 5, and partially also in chapters 7 and 8
- Case presentation: chapter 6, and partially also in chapters 7 and 8
- Analysis and synthesis: chapters 7, 8 and 9, and appendices 2 - 5
- Conclusions: chapter 10

The structure of this study report is illustrated in Fig. 1. **Introduction** depicts the research subject, case background, scope of the study, and motivation for the research (chapters 1 and 2).

In the **Research plan**, the reader is first introduced to the applied research approach (chapter 3), including the research statement, the research problem under investigation, working assumptions, research methodology and research phases. After that, case study design (chapter 4) defines research constructs, research goals and questions, and applied data collection techniques. Chapter 4 also discusses validity risks and the tactics applied to control them. The definition of research approach and case study design were influenced by work prior notion of research and related work, which is depicted with arrows in Fig. 1.

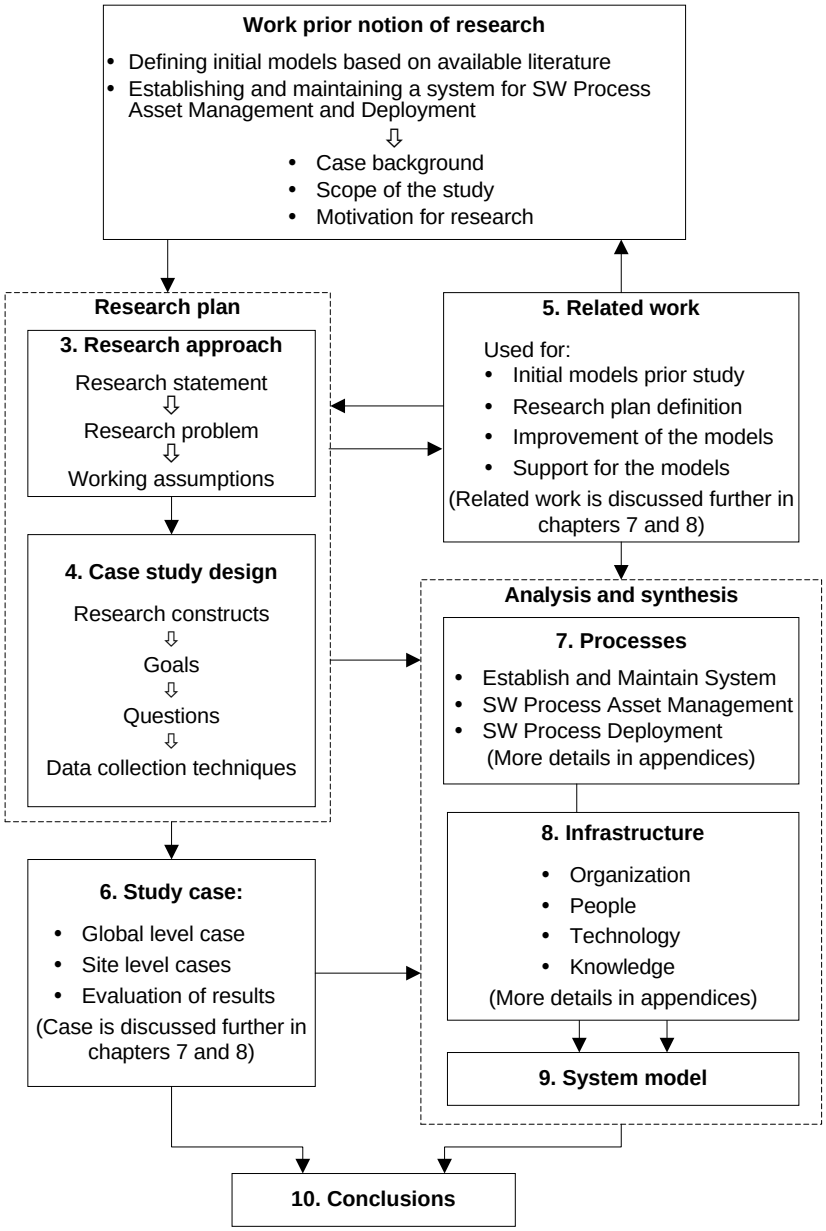

Fig. 1. Structure of study report (numbers refer to chapters)

Related work establishes the theoretical background for the thesis, and links the results to previous research done in the scope of this study. The related work is summarized in chapter 5. A more detailed discussion is included in the context of each infrastructure element and process model, in the analysis and synthesis part of the study, and in chapters 7 and 8, in order to compare the observations in the case organization to the findings in the literature. The content of related work chapter was derived from research plan, which is depicted with an arrow in Fig. 1.

Case presentation (chapter 6) starts with a description of the case organization. Then follows a chronological description of how the system for SW Process Asset Management and

Deployment in a multi-site environment has evolved during the period of this case study. This is followed by five local level embedded cases that concisely present how the local infrastructure has evolved in different sites. Finally, this chapter summarizes the results of SW Process Asset Management and Deployment activities. Many of the case findings are presented in chapters 7 and 8 because detailed findings are an essential part of the analysis. The case presentation was influenced by research plan, which is illustrated with an arrow in Fig. 1.

Analysis and synthesis gives answers to the research problem under study. Firstly, defined processes are presented in chapter 7. Secondly, the infrastructure model and each infrastructure element are described in chapter 8. Finally, chapter 9 summarizes the study results as a system model. Appendices 2-5 contain more detailed descriptions of some relevant system elements in the form of a formal process representation. The analysis and synthesis of the research was influenced by research plan, study case and related work, which is depicted with arrows in Fig. 1.

Conclusions (chapter 10) presents the final summary of this study. It describes the results, explores what the added value is for the research community and practitioners, and suggests areas for future research.

3 Research approach

The first section of this chapter states the research problem and the model development approach. The second section describes the research methodology used. The last section describes the study process phases.

3.1 Research problem and model development approach

Research problem: To describe a system for SW Process Asset Management and Deployment in a multi-site organization that is a comprehensive description and so adds value to the current state-of-the-art.

The SW Process Asset Management and Deployment system in NMP has already been operational and successful since the end of 1996. Literature does not include any comprehensive description of such a system. However, this topic is relevant for all, especially large multi-site, SW development organizations. Management of SW Process Assets and SW Process Deployment are two of the cornerstones of successful SW Process Engineering. Therefore, a comprehensive description of SW Process Asset Management and Deployment system adds value both for practitioners and researchers. Practitioners can apply the description of the system to establishing, evaluating and revising the SW Process Asset Management and Deployment system in the context of their own organizations.

In his recent study Kinnula (1999) presents an architectural design of a SW Process Engineering system. It includes two architectural design models. The first model is a system level model identifying three essential elements for the SW Process Engineering system; the process, the infrastructure elements, and the organizational hierarchies and their respective scopes. SW Process Asset Management and SW Process Deployment are two processes identified in that model. The second model is an architectural design for the SW Process Engineering organization. Kinnula conducted his study in the same multi-site organization that is the object for this study: the Nokia Mobile Phones SW R&D. (Kinnula 1999.)

The system model for SW Process Asset Management and Deployment presented in this study report will refine and add detail to the relevant parts of the system model defined by Kinnula. These improvements are derived from the lessons learned from applying them in practice (in the area of SW Process Asset Management and Deployment), and from complementing input from the literature. There is considerable added value; the research significantly enriches the existing model and makes it more comprehensive, it brings the model closer to what actually happens in practice in areas that are critical for successful SW Process Asset Management and Deployment, and it furthermore adds the experiences of the case study to it. Thus, the resulting description of a SW Process Asset Management and Deployment system is more comprehensive than other related descriptions or models in the literature.

Kinnula's (1999) models were selected to be used as the basis for the research framework in April 1999 after a preliminary analysis of the case data collected so far. In May 1999, research

goals and questions were derived from the framework (see sections 4.2 and 4.3). Research questions were tested in a pilot interview in one of the SW R&D sites. The framework was found to be appropriate for describing the SW Process Asset Management and Deployment system.

3.2 Research methodology

This is a descriptive embedded single-case study (Yin 1988), the result of which is an artifact that gives a comprehensive description of a SW Process Asset Management and Deployment system.

The subject of this study matches the situation where Yin (1988) considers the case study approach to be the most practical approach. The study investigates a contemporary phenomenon within its real-life context; the boundaries between phenomenon and context are not clearly evident. Such an investigation requires the use of multiple sources of evidence, and the case study approach is able to deal with a wide variety of evidence. The use of multiple sources of evidence with the evidence coming from two or more sources but converging on the same set of facts or findings, is one of the main means of increasing the quality of a case study. (Yin 1988.)

This single-case study in one multi-site organization provided several embedded units used for analysis concerning local level issues. The level of implementation of the system varied in different sites. This made it possible to compare what seems to work and what does not.

Naturally, evidence from multiple cases would have been more compelling when compared to a single-case. This case was, however, a revelatory case where I had an opportunity to observe and analyze the SW Process Asset Management System from a central position during a period of more than five years. Moreover, I had access to a comprehensive amount of data. Even if it would have been possible to organize a similar position for observation and access to data in different case organizations, the required effort would have been beyond the means of one researcher. (Yin 1988.)

Furthermore, multiple-case studies do not follow sampling logic, like having multiple respondents in a survey. Instead, those follow replication logic. Therefore, one should consider multiple cases as one would consider multiple experiments. (Yin 1988.)

The study has also explanative elements in chapter 6, applying pattern matching. In addition, the resulting models can be seen as theories, so this research has also elements of theory building (Eisenhart 1989).

3.3 Research phases

The study was carried out in two phases. The first phase lasted from January 1995 to March 1999, and the second phase from April 1999 to September 2000.

During the period of June 1995 – December 1997 the initial models and methods for SW Process Asset Management and Deployment were developed and implemented in one multi-site organization, that is Nokia Mobile Phones. I acted as the chief contributor and manager of those activities as Global SW Process Asset Manager (see section 8.2.1). During the period of January 1998 – March 1999 the system was implemented in two other multi-site organizations in Nokia. Those were Nokia Multimedia Network Terminals and BTS SW Development of Radio Access Systems in Nokia Networks. In these cases, I acted as a lead consultant.

During the second phase, the system was evaluated and improved, and a comprehensive description of the SW Process Asset Management and Deployment system was created using a retrospective case study research approach. The focus for the second phase of the case study was defined and based on empirical experience, and the data was collected during the first phase. I still acted as the global manager of NMP SW Process Assets until April 2000, but changes to the study object during this phase were only minor.

4 Case study design

This chapter states the research constructs and presents the empirical study goals and questions derived from the research constructs. Secondly, it describes study objects, data collection techniques, and validity risks and their control.

The research constructs are derived from architectural design models by Kinnula (1999) that were selected as part of the research framework of this study (see section 3.1). The study goals are derived from the research constructs. The goals are defined by applying a template originally defined by Basili for the Goal-Question-Metric methodology (Basili & Weiss 1984, Basili 1992, Basili et al. 1994b). Section 4.3 contains the study questions that are derived from the study goals. The questions are answered by applying the multiple data collection techniques described in section 4.5.

4.1 Research constructs

The research constructs related to SW Process Asset Management and Deployment include:

- SW Process Asset Management and Deployment activities
- SW Process Asset Management and Deployment infrastructure, comprising:
  - organization
  - people
  - technology
  - knowledge
- SW Process Asset

4.2 Empirical study goals

This study includes six study goals derived from the research constructs. The first goal focuses on the results of the existing system for SW Process Asset Management and Deployment. The other five questions cover different aspects of the system itself.

Goal 1: To analyze the results of SW Process Asset Management and Deployment

Analyze	the results of SW Process Asset Management and Deployment activities,
in order to	verify that the implemented SW Process Asset Management and Deployment system is functional,

with respect to	process representation user activity, the use of SW Process Assets in SW projects, satisfaction for provided support services, the amount of feedback, and the number of process changes,
from the perspective of	the host organization,
in the context of	a multi-site SW development organization,
because	information about the level of success of activities in different sites, compared to the implemented infrastructure and performed activities, is necessary for analyzing whether the implemented system is functional.

Goal 2: To analyze and describe the current SW Process Asset Management and Deployment organization

Analyze	the existing SW Process Asset Management and Deployment organization,
in order to	describe the current SW Process Asset Management and Deployment organization, and to identify key factors in its implementation,
with respect to	structure, roles and responsibilities, and communication lines,
from the perspective of	SW Process Engineering management,
in the context of	a multi-site SW development organization,
because	this information is needed for improving the current organization model and for validating the importance of different roles in the organization.

Goal 3: To analyze and describe the people-related factors in performing SW Process Asset Management and Deployment activities

Analyze	the current staffing of SW Process Asset Management and Deployment organization,
in order to	describe and understand the people-related factors for success in SW Process Asset Management and Deployment organization,
with respect to	time allocation, standing, motivation and skills,
from the perspective of	SW Process Engineering management,
in the context of	a multi-site SW development organization,
because	this information is needed for improving the training of personnel, selecting candidates for different roles, and deriving estimates for proper resource allocation.

Goal 4: To analyze and describe the technology needed for SW Process Asset Management and Deployment

Analyze	the existing SW Process Asset Management and Deployment support technology,
in order to	describe current technology and identify possible shortcomings,
with respect to	types of support technology based on needs,
from the perspective of	SW Process Engineering and SW engineering personnel,
in the context of	a multi-site SW development organization,
because	this information is necessary for evaluating the success of instantiation of supportive technology and for identifying future improvement opportunities.

Goal 5: To analyze and describe the knowledge needs for SW Process Asset Management and Deployment

Analyze	SW Process Asset Management and Deployment activities,
in order to	identify used and needed knowledge,
with respect to	types of knowledge needs,
from the perspective of	SW Process Engineering personnel,
in the context of	a multi-site SW development organization,
because	this information is needed to understand what knowledge is required for successful SW Process Asset Management and Deployment.

Goal 6: To analyze and describe SW Process Asset Management and Deployment activities

Analyze	SW Process Asset Management and Deployment activities,
in order to	describe essential activities,
with respect to	comprehensiveness,
from the perspective of	SW Process Engineering personnel and SW development projects,
in the context of	a multi-site SW development organization,
because	this information is needed to ensure that all activities necessary for success in SW Process Asset Management and Deployment will be performed. In the case of scarce resources, this information can be used also for prioritization between different activities.

4.3 Empirical study questions

Empirical study questions were derived from, and organized based on, the empirical study goals presented in the previous section. During the data collection phase, these study questions were used as the basis for interview questions, and to guide the collection of data using the other data collection techniques described in section 4.5.

For instance, an user activity measurement, which instrumentation had been implemented in Lotus Notes databases, and monitoring the growth figures of SW personnel in each site gave the answer to the study question 1: "What percentage of the intended audience is using process representations?". Question 7, "What are the responsibilities of the roles relating to SW Process Asset Management and Deployment at the global level organization?" is answered by using data from ethnography, interviews, artifacts, and a personal log.

Goal 1: To analyze the results of SW Process Asset Management and Deployment

Questions about the results of performed activities:

Question 1: What percentage of the intended audience is using process representations?

Question 2: How satisfied (qualitative analysis) are the users about the process support services?

Question 3: How much feedback users of the SW Process Asset Library provide?

Question 4: How actively is the SW Process Asset Library maintained in respect to the number of changes and the ratio of solved change requests?

Goal 2: To analyze and describe the model of SW Process Asset Management and Deployment organization

Questions related to the organization study roles, responsibilities, structure / hierarchy, communication lines of the organization:

Question 5: What SW Process Asset Management and Deployment roles are in place at the global level organization?

Question 6: What SW Process Asset Management and Deployment roles are in place at the local level organization?

Question 7: What are the responsibilities of the roles relating to SW Process Asset Management and Deployment at the global level organization?

Question 8: What are the responsibilities of the roles related to SW Process Asset Management and Deployment at the local (site) level organization?

Question 9: What communication there is between local and global SW Process Asset Management and Deployment organizations?

Question 10: What communication there is between the local SW Process Asset Management and Deployment organization, SW projects and individuals?

Question 11: What internal communication is there in the local SW Process Asset Management and Deployment organization?

Goal 3: To analyze and describe the people-related factors in performing SW Process Asset Management and Deployment activities

Questions related to time allocation, standing, motivation and skills of the people performing SW Process Asset Management and Deployment activities.

Question 12: How much time has been allocated for performing different roles in the global and the local organizations?

Question 13: What is the role of process personnel standing (formal and informal) in the success of the activities?

Question 14: What issues affect the motivation of people in the SW Process Asset Management and Deployment organization?

Question 15: What skills are used in different roles of SW Process Asset Management and Deployment?

Question 16: Are there situations where the lack of some skills clearly creates problems?

Goal 4: To analyze and describe the technology needed for SW Process Asset Management and Deployment

Questions related to technology, representing the technical resources or assets used in the process:

Question 17: Which tools are used in the SW Process Asset Management and Deployment activities?

Question 18: What activities are supported by tools?

Question 19: Do existing tools suit the intended purpose?

Question 20: Are there some SW Process Asset Management and Deployment activities where the lack of tools clearly creates problems?

Goal 5: To analyze and describe knowledge needs for SW Process Asset Management and Deployment

Questions about knowledge, representing the undocumented and documented information assets that are used to guide the enactment of the process:

Question 21: What documented knowledge is used to guide the enactment of the SW engineering processes?

Question 22: What undocumented knowledge is used to guide the enactment of the SW engineering processes?

Question 23: What documented knowledge is used to guide the SW Process Asset Management and Deployment activities?

Question 24: What undocumented knowledge is used to guide the SW Process Asset Management and Deployment activities?

Goal 6: To analyze and describe SW Process Asset Management and Deployment activities

Questions about performed activities:

Question 25: What SW Process Asset Management and Deployment activities have been performed at global and local levels?

Question 26: How are the SW Process Asset Management and Deployment activities carried out?

4.4 Study objects

This embedded single-case study has as a study object one multi-site SW development organization; Nokia Mobile Phones. In March 2000, the total number of SW R&D sites was 13. At the site level, this study has used five representative sites for deeper analysis where interviews have been conducted. In the beginning of the study process the number of sites to be included was left open. The final number of included sites was decided during the study process when it became obvious that additional interviews would no longer provide more insight to the topic. However, in other data collection techniques, for instance artifacts and the personal log, information from other sites has also been used when applicable. In addition, observations have been made in two other multi-site SW development organizations; the Nokia Multimedia Network Terminals and BTS SW Development of Radio Access Systems in Nokia Telecommunications.

4.5 Data collection techniques

In this embedded single-case study, multiple data collection techniques were used in order to provide multiple measures of the same phenomenon, and thus to increase construct validity (Yin 1988). Those were ethnography, interviews, measurements, artifacts, personal log, and contextual inquiries. The techniques used in the study provided rich data for the basis of analysis and synthesis.

Ethnography

As the Global SW Process Asset Manager, I have acted as a chief contributor and manager of the implementation activities in the case organization, and I have also been consulting in two other multi-site organizations. My position in the case organization has given me an access to events and groups that would have otherwise been inaccessible to a scientific investigation. It has also given me the chance to perceive reality from the viewpoint of an insider to the case, rather than as someone external to it (Yin 1988). I also was the chief consultant in similar activities in two other multi-site organizations, which helped with the recording and analysis of the data.

Interviews

A series of interviews was conducted in different SW R&D sites within the multi-site case organization during the period of May 1999 – May 2000. The empirical study questions defined in section 4.3 were used as a basis for the interview questions. Interviews started with questions that aimed to explore how the local SW Process Asset Management and Deployment system had evolved over the study period. Open-ended questions were used during the interviews. All interviews were recorded using a tape recorder. This interview protocol was followed in all interviews.

The interviewees were selected based on their long experience in different SW Process Improvement roles in the case organization at both global and local levels. The local manager of SW Process Improvement activities was one of the interviewees in all sites except in Site A, where the manager only had less than one year's experience in SW Process Improvement roles in the case organization.

Measurements

The tools used for SW Process Asset Management provide instrumentation for several measurements. This data has been collected in the multi-site case organization since the first SW

Process Asset Library release in September 1996. The instrumentation has been implemented in Lotus Notes databases. The following measurements were used in the analysis:

- Number of sessions (per site, per asset library release, per month). One session means one visit to the SW Process Asset Library regardless of the number of documents read.
- Number of different users (per site, per asset library release, per month). One user is counted once per month regardless of the number of sessions.
- Number of change requests concerning the SW Process Asset Library
- Number of feedback instances concerning the SW Process Asset Library. Feedback consists of comments or suggestions that are not actual change requests.
- Number of improvements per SW Process Asset Library release

In addition, growth figures relating to SW personnel in each site have been used in the analysis.

Artifacts

The following artifacts have been used in this study:

- SW process documentation; several different releases in three different multi-site organizations.
- All change requests and feedback made concerning SW Engineering Process
- Meeting agendas and minutes, from all levels of the SW Process Engineering organization in NMP. This covers the period of 1995-1999. Some early documentation is missing but from 1996 onwards the documentation has been stored in a meeting management system in the SW Forum (an open electronic forum / project management system focused on SW technology issues).
- Action items for all the SW Process Engineering staff in NMP. This covers the period of 1995-1999. Some early documentation (recorded in meeting minutes) is missing, but from 1996 onwards all the documentation has been stored in an action management system in the SW Forum (see above)
- Annual local and global SW process improvement strategies and plans in SW Forum in NMP (see above)
- Local SW process improvement reports in the SW Forum (see above)
- Messages in an electronic discussion forum in the SW Forum (see above)
- Presentation materials, interim reports (usually filed monthly), project and action plans and deliverables
- Workshop memos
- Project working documents (SW Process Development Database and SW Forum)
- A collection of internal SW process assessment reports from 1996 – 1999, including full assessments and self-assessments.

Personal log

Personal log which covers the entire period of 1995-2000 and includes:

- Calendar notes: 1995 - 2000
- Personal e-mail: I have retained almost all mail exchange from the entire period of 1995-2000

Contextual inquiries

Feedback from the people who are expected to use process representations was collected using contextual inquiries. Contextual inquiry is one phase of the Contextual Design approach, which aims to design products or systems directly from an understanding of how the user works. In contextual inquiry, a team conducts one-to-one field interviews with users in their workplace to

discover what matters in their work. The interviewer observes users as they work and inquires into the users' actions in order to understand their motivations and strategy. (Beyer & Holtzblatt 1998).

4.6 Validity risks and their control

Several tactics have been applied to control different types of validity risks. The quality of any study design can be judged by four commonly used logical tests which are construct validity, internal validity, external validity and reliability (Yin 1988).

Construct validity requires that correct operational measures have been established for the study constructs (see section 4.1). Three approaches have been applied to control the construct validity. Firstly, multiple sources of evidence have been used as a basis for the findings of the study. Secondly, the chain of evidence from research problem through to research results has been presented. Lastly, all key informants have reviewed the draft study report. All the key people who were involved in the design, implementation and operation of the SW Process Asset Management and Deployment system between 1995 – 2000 were still available for interviews. Interviewees were used to review and approve those parts that deal with issues that they themselves had been focusing on, as well as the final results and conclusions presented in this thesis. (Yin 1988.)

Internal validity demands that a causal relationship is established, whereby certain conditions are shown to lead to other conditions. The nature of this study is mainly descriptive and exploratory. For such studies internal validity testing, according to Yin (1988), is unnecessary. However, chapter 6 includes also causal statements and therefore pattern matching and time-series analysis were applied to control internal validity. (Yin 1988.)

External validity deals with the problem of knowing whether the study findings are generalizable beyond the immediate case study. External validity has been only partially controlled by using findings from two other multi-site organizations, where I have been involved in similar activities, but no real replication of the case study has been carried out. This is a single-case study. However, multi-site organization provided several embedded units used for analysis concerning local level issues. The level of implementation of the system model varied in different sites. That made it possible to compare what seems to work and what does not. Another approach to increasing the external validity has been the extensive review of related work. (Yin 1988.)

Reliability requires that operations of the study can be repeated with the same results. To increase the reliability of the study, a case study protocol has been described (research goals, research questions used in data collection, and the data collection procedures) to such an extent that another investigator should be able to arrive at the same findings and conclusions in the same case. (Yin 1988.)

A special concern about reliability arises from the fact that I have acted as the chief contributor and manager of the implementation activities in the case organization. While this position has provided an insider view and insight into recording and analyzing data, it also creates a potential reliability risk in the form of researcher bias based on personal involvement. The bias is, however, greatly reduced because this study is heavily based on documentation produced as by-products, deliverables and measurements of past SW Process Asset Management and Deployment-related activities. Since, prior to November 1998 before there was any notion of a research project this material was created for project management and operational reasons, rather than for research purposes, it represent a fairly objective view on the issues. In addition, the peer review of results by the key informants helps in this respect.

5 Related work: SW Process Asset Management and Deployment

This chapter describes well-known models that contain process and/or infrastructure elements for SW Process Asset Management and Deployment. These models will be described and discussed here briefly. However, a more detailed discussion can be found in the context of each infrastructure element and process model in the analysis and synthesis part of the study (chapters 7 and 8). In the focus area of this study, the literature does not include any comprehensive system descriptions either in the form of industry experience reports or as synthesized models.

The focus of this chapter is to recognize the elements in the models which cover issues found to be important for a continuous SW Process Asset Management and Deployment in the case organization. The purpose is not to question the value of presented models from the literature. The SW Process Asset Management and Deployment system description in this study report does not 'compete' with the models discussed. Related work is rather used to provide support for the generalization of the findings in the case organization, and to provide more insight and sources of information for the reader. The more detailed discussion of related work in chapters 7 and 8 serve the same purpose.

First, section 5.1 briefly describes a model selected to be used as a research framework for the infrastructure model, as already stated in the working assumptions in section 3.1.

Sections 5.2– 5.6 discuss a selection of well-known models in the field of SW Process Engineering. These models were chosen because many organizations are using them as reference models in their SW Process Engineering activities. This can be validated for instance by browsing the Proceedings of SW Process Improvement conferences in recent years.

Section 5.7 presents knowledge domains, other than SW Process Engineering, that are relevant to the focus of this study. Finally, section 5.8 summarizes the related work.

5.1 SW Process Engineering in a Multi-site Organization: An architectural design of a SW Process Engineering System

The resent study by Kinnula (1999) approaches SW Process Engineering (SPE) as a system. The study presents two models: an architectural design model for a SW Process Engineering system, and an architectural design model for a SW Process Engineering organization. The first of the models actually consists of three different models; the Hierarchy Model for SPE architecture, the SPE Infrastructure Model, and the SPE Process Model. (Kinnula 1999.) Description of the architectural design model for a SW Process Engineering system is presented as a quotation from Kinnula (1999) in Appendix 6.

The models are architectural design models, therefore, the level of abstraction is quite high. For example, the SPE Process Model recognizes and gives a short definition of the following processes: Process Engineering Management, Process Evaluation, Process Asset Management,

Process Development and Process Deployment (Kinnula, 1999). It does not define or break down any of the activities further. However, these models provide a good basis for (and are selected for) describing more detailed process and infrastructure models for SW Process Asset Management and Deployment presented in this study. The relevant models from Kinnula's study are presented in more detail in Appendix 6, and in the Analysis and Synthesis part of the study, in chapters 7 and 8, and are therefore not discussed further here.

Kinnula's study contains a comprehensive review of the existing models related to SW Process Engineering. It presents an evaluation of the shortcomings of the previous models in the sense of their suitability for an architectural design model for SW Process Engineering. For that reason, the review of the other models in my study will not focus on evaluating their suitability as models for SW Process Engineering system. Instead I will here evaluate their strengths and weaknesses in providing support for implementing continuous SW Process Asset Management and Deployment activities.

5.2 SW-CMM 1.1

The purpose of the SW-CMM 1.1 model (Paulk et al. 1993) is to support SW process capability and maturity assessments. For that reason, it contains a process maturity model, which includes 18 key process areas (KPAs). These key process areas are layered across four different levels, where each higher level represents higher maturity of the organization. While the model recognizes five maturity levels, the first does not have any key process areas to fulfil, as it represents the lowest maturity state, called "Initial". Each key process area is organized into five sections called common features. Each common feature contains a set of key practices, which describe the activities and infrastructure that contribute the most to the effective implementation and institutionalization of the key process area. (Paulk et al. 1993a.)

In the model, SW process documentation is seen as a fundamental element for achieving higher maturity levels. All key process areas demand the existence of certain documented procedures. Furthermore at level three, called "Defined", an entire KPA - the Organization Process Definition - has been dedicated for this topic. (Paulk et al. 1993b.)

> *"The purpose of Organization Process Definition is to develop and maintain a usable set of SW process assets that improve process performance across the projects and provide a basis for cumulative, long-term benefits to the organization (Paulk et al. 1993b)."*

In addition, three other key process areas at level three (Organization Process Focus, Integrated SW Management, and Training Program) are partially relevant in the focus of this study. The key practices in these four KPAs identify vital elements of the infrastructure and the activities required to effectively carry out SW Asset Management and Deployment. The goals of Organization Process Focus require that SW process development and improvement activities are planned and coordinated across the organization, and that the strengths and weaknesses of the processes used are identified relative to a process standard. Goals of the Integrated SW Management state that the project's defined SW process shall be a tailored version of the organization's standard SW process, and that projects shall be planned and managed according to it. The purpose of the key process area Training Program is to develop skills and knowledge of individuals so that they can effectively and efficiently perform their roles.

SW-CMM 1.1 does not cover all infrastructure elements and activities that were found important in this case study. The descriptions are so brief that they neither serve as models for the infrastructure, nor for the process. This though, is not the purpose of the SW-CMM 1.1 as it is intended more as a good checklist than a model to be implemented. For an experienced SW

process professional this may be sufficient, but less experienced individuals need much more guidance for establishing a system for SW Process Asset Management and Deployment.

"A SW Process Framework for the SEI Capability Maturity Model" by Olson et al. provides more detail for each KPA of SW-CMM (Olson et al. 1994). It does not cover all required elements for a SW Process Asset and Deployment System either. However, it is a valuable source of information for many issues relevant to the focus of this study

The system elements identified by SW-CMM 1.1 are discussed further in the connection of each relevant section in the chapters 7 and 8 .

5.3 IDEAL^{SM} 1.0

The IDEAL^{SM} 1.0 (McFeeley 1996) describes a model for the SW Process Improvement program life cycle. It is meant to be used to guide the development of a long-range, integrated plan for initiating and managing a SW Process Improvement program. It describes in sequence the recommended steps for a SW Process Improvement initiative. The steps are organized in five phases; initiating, diagnosing, establishing, acting and leveraging, connected to a continuous loop. IDEAL^{SM} 1.0 is based on the experiences the SW Engineering Institute (SEI) has gained while working with its respective government and industry clients. (McFeeley 1996.)

Infrastructure for SW Process Improvement is seen in the IDEAL^{SM} 1.0 to play significant role in the success or failure of an initiative. The infrastructure in the IDEAL^{SM} 1.0 is seen to include only the organization element. Infrastructure for a SW Process Improvement program shall be defined in the terms of specific people, organizational entities, roles and responsibilities, and interfaces.

This model includes the description of three principal components of the infrastructure; the Management Steering Group (MSG), the SW Process Engineering Group (SEPG) and the Technical Working Group (TWG).

The management Steering Group's purpose is to guide SW Process Improvement implementation activities in the organization. It will establish the objectives and set direction and priorities for the SW Process Improvement program. The SW Process Engineering Group's mission is to sustain the SW Process Improvement program in an environment of change, through gaining and reinforcing sponsorship, planning and coordinating the individual improvement actions, leading the improvement effort, exchanging information and facilitating the improvement activity in general. The Technical Working Group is the operative element of the SW Process Improvement program, created to address a specific process area in order to improve it. Technical Working Groups are typically temporary, being created for a single objective and disbanded once the objective is reached. In addition IDEAL^{SM} 1.0 depicts two additional components which are meant for very large and geographically dispersed organizations, the SW Process Improvement Advisory Committee (SPIAC) and the Executive Council (EC).

The roles in the case organization, defined in section 8.2, fulfill similar responsibilities to the SW Process Engineering Group and the Technical Working Group. These roles are, however, broken down further, each having a logical set of responsibilities. Furthermore, these roles are permanent not temporary. In addition to the roles described in section 8.2, finite Technical Working Groups do exist. In the case organization, those are typically called Process Action Teams.

The IDEAL^{SM} 1.0 does not include specific role definitions for individuals performing different SW Process Engineering Activities. (McFeeley 1996.) The education or skills needed for performing different tasks in the model are listed in connection with each phase (McFeeley 1996).

5.4 Experience Factory and Quality Improvement Paradigm (QIP)

Experience Factory is an organizational model for SW Process Engineering. Its basic methodological device is the Quality Improvement Paradigm (QIP).

The QIP was developed by Basili et al. (Basili 1985). It includes the following six steps: Characterize, Set Goals, Choose Process, Execute, Analyze, and Package. The QIP is based on the notion that improvement requires the continual accumulation of evaluated experiences in a form that can be effectively understood and modified into a repository of integrated experience models. The QIP makes the logical separation of product development from the systematic learning and packaging of reusable experiences - the former performed by the Project Organization and latter by the Experience Factory.

The Experience Factory is a logical and/or physical organization that supports development projects by analyzing and synthesizing all kinds of experience, acting as a repository for such experience, and supplying that experience to various projects on demand. (Basili et al. 1994a, Basili & McGarry 1998.)

The Experience Factory and QIP together cover some of the activities and elements of the required infrastructure relevant to the focus of this study. Those are valuable sources of information for establishing or improving a system for SW Process Asset Management and Deployment. The problem with the models is that no comprehensive description of the models is available.

5.5 ISO 15504 and ISO 12207

The SPICE project (SW Process Improvement and Capability dEtermination), launched in 1993, is a major international initiative to support the development of an International Standard for SW Process Assessment. The project is carried out under the International Committee on SW Engineering Standards ISO/IEC JTC 1/SC 7. In June 1995 the SPICE project released Version 1 of a draft standard for SW process assessment to WG10 of the ISO/IEC JTC 1/SC 7 for international ballot among the standards community. Following this ballot, documents have been carried through the international standardization process and have been published as technical report ISO/IEC TR 15504:1998 - SW Process Assessment, which comprises nine parts.

In the case organization, working draft versions 1 and 2 were used as input for the restructuring and definition of the Organizational Standard SW Engineering Process (see section 6.2.2). The discussion of the ISO15504 in the context of SW Process Asset Management and Deployment system elements in chapters 7 and 8 is based on the technical report ISO/IEC TR 15504:1998.

The ISO 15504 is aligned with ISO standard for SW engineering processes, that is ISO 12207. As a process model ISO 15504 is more detailed than ISO 12207, however. Therefore, ISO 12207 is not discussed further in this study. (ISO/IEC 1995, ISO/IEC 1998a, ISO/IEC 1998b, ISO/IEC 1998c.)

Three parts of the ISO 15504 document set are relevant for this study. These are Part 2: A reference for processes and process capability, Part 5: An assessment model and indicator guidance, and Part 7: Guide for use in process improvement. (ISO/IEC 1998a, ISO/IEC 1998b, ISO/IEC 1998c.)

Part five contains a normative example of an assessment model that mainly covers the activities in the scope this study in the Organization process category. In addition, it includes, in appendices, lists of input and output work products for each process and work product characteristic. However, all the descriptions are short and they serve rather as checklists or characteristics than as process representations. Part two contains the actual formative reference

process model, but this is less detailed than the example model in part five. (ISO/IEC 1998a, ISO/IEC 1998b.)

Part seven provides a methodology for process improvement, formulated as an eight step model for improving SW processes within a continuous improvement cycle. The guide also includes a specific section about the management viewpoint of process improvement. The methodology contains some issues relevant for the study scope and which are not covered in parts two or five; for instance it recognizes the need for regular reviews of process improvement activities. (ISO/IEC 1998c.)

5.6 Zahran

Zahran (1998) provides in his book a framework for establishing an environment for continuous SW process improvement. The framework includes a SW process infrastructure, a SW process improvement roadmap, a SW process assessment method, and a SW process improvement plan. The book also has guidelines for creating a process support infrastructure. (Zahran 1998.)

Zahran defines the SW process improvement infrastructure as follows (Zahran 1998):

> *"SW process infrastructure is the underlying framework of organizational and technical foundations that support the ongoing SW process improvement activities including process definition, process modeling, process training, process monitoring, process enforcement, and ongoing feedback on the process performance."*

According to Zahran, the infrastructure is essential for process institutionalization and necessary to enable and facilitate SW development and to support process-related roles and responsibilities.

A SW process infrastructure covers two aspects:

- Organizational and management infrastructure: this includes roles and responsibilities that have to be in place to sponsor, manage, perform and monitor SW process improvement activities.
- Technology and tools infrastructure: this incorporates the necessary facilities and tools for automating process activities and supporting the various process improvement roles and responsibilities.

The guidelines for organizational and management infrastructure recognize most of the responsibilities found relevant also in the case organization. However, the described organizational model includes only the following entities based on architecture by Fowler and Rifkin (Fowler & Rifkin 1990): executive sponsor, SW Engineering Process Group, Process Improvement Teams, process owner and projects. The responsibilities recognized by this study are not allocated further in more specific roles, instead those are mainly covered either in the responsibilities of the SW Engineering Process Group or Process Improvement Teams. The way Zahran deals with process owner and project entities is inconsistent. Sometimes those are included in the model and sometimes not. (Zahran 1998.)

Technical infrastructure includes two parts: The Organization's SW Process Assets and the Process Support tools (Zahran 1998).

The implementation model of the Organization's SW Process Assets includes: the organization's standard SW process, approved SW lifecycles and tailoring guidelines as well as the organization's SW process database and the library of SW process-related documents (Zahran 1998). These have been copied directly from the SW-CMM 1.1 (Paulk et al. 1993b).

The way Zahran discusses process support tools and the technical infrastructure overall is not entirely clear. It is ultimately unclear whether the technical infrastructure covers the entire tool-set for SW Engineering and SW Process Engineering, or if it only covers the latter. Despite the

slight inconsistency, the section about process technical infrastructure provides valuable information for a thorough reader.

5.7 Other knowledge domains relevant in the study scope

The literature includes plenty of papers about methods and notations to define processes (e.g. Curtis at al. 1992, Armitage & Kellner 1994, Armitage et al. 1994, Gates et al. 1997, Kellner et al. 1998), and process-centered SW engineering environments (e.g. Christie 1993, Garg & Jazayeri 1994). This is relevant knowledge for organizations developing a process documentation standard, or support technology for SW Process Asset Management and Deployment. However, less is written about industrial experiences about what it takes to sustain continuous SW Process Asset Management and Deployment.

In addition to SW Process Engineering literature, there are other domains that are valuable sources of knowledge, especially concerning Process Deployment. Those include knowledge management, marketing, and change management. In addition, elements from other domains, for instance communication, human behavior and organization science, are relevant knowledge for SW Process Asset Management and Deployment.

SW Process Asset Management is about capturing organizational knowledge; Deployment is about using that knowledge. Therefore, the knowledge management domain (see e.g. Nonaka & Takeuchi 1995) is a very relevant source of information.

The importance of marketing and change management has been noticed by many in the context of SW Process Engineering. In recent years SW Process Improvement conferences have had presentations dedicated to these topics and papers are published in journals (see e.g. Asseldonk & Manduke 1998, van der Wal & Brinkman 1999, Potter & Sakry 1998, Richardson & Memarest 1999, Fichman & Kemerer 1997, Bomarius et al. 1998).

In marketing (see e.g. Kotler 1994), one of the main objectives is to influence potential customers' behavior in trying to get a desired response to the marketing message. Communication has a central role in marketing. Marketing literature includes plenty of theories about communication channels, message formulation, innovation diffusion, human behavior etc. While the domain is different, many of the techniques are applicable also in SW Process Engineering domain.

Compared to marketing, organizational change management is an even closer domain to SW Process Engineering. This domain also includes many of the applicable techniques from marketing, but in general it is more focused on organizational science.

While this study report does not explore these domains deeply, marketing-, change management- and knowledge management-related knowledge was recognized to be important for successful SW Process Asset Management and Deployment. Therefore, readers and practitioners of SW Process Engineering are encouraged to also study these domains.

5.8 Summary of related work

None of the models take a viewpoint of SW Process Asset Management and Deployment. However, documented process is one of the cornerstones of successful SW Process Engineering and therefore it is covered to some extent in all of the models.

None of the models cover well all the infrastructure elements, the organization, people, technology and knowledge. Nor do any of them provide enough detail to be considered comprehensive descriptions of SW Process Asset Management and Deployment. They are not suitable for the implementation of an infrastructure and the processes involved in the focus of this study. However, they do provide useful support for the findings of the case study.

The first of the models provides architectural design for the infrastructure of the SW Process Asset Management and Deployment. It does not provide any detailed descriptions of the content specific for the focus area, but it provides a useful framework for describing SW Process Asset Management and Deployment system elements.

In addition to SW Process Engineering, it is relevant to understand other domains - especially in the context of SW Process Deployment. These include marketing, change management, and knowledge management. In addition, those include elements from other domains for instance communication, human behavior and organizational science.

6 Study case

This chapter describes the embedded single-case at the focus of the study. The case of NMP forms the main source of lessons learned. In the NMP case, attention is given also to sub-units of the case; the NMP SW R&D sites. Therefore, this study follows embedded case study design. (Yin 1988.)

During the study period, I also consulted two other Nokia multi-site business units in similar activities. While these cases are not part of this study report, they have provided more insight to the topic and given the possibility of comparing case findings in the context of other organizations, much like good literary sources.

Firstly, the case organization is described in section 6.1. Next, a chronological description of the global level infrastructure development is presented in section 6.2. Site level embedded cases are presented in section 6.3, including pattern matching and time series analysis. The last section, 6.4, contains an evaluation of the SW Process Asset Management and Deployment results in the case organization.

The responsibility of process deployment relays heavily on the local SW Process Engineering organization in NMP. Therefore, the emphasis in section 6.1 is on SW Process Asset Management infrastructure and in section 6.2 on SW Process Deployment.

6.1 Case organization: Nokia Mobile Phones, Ltd.

Nokia comprised two business groups: Nokia Mobile Phones and Nokia Networks. In addition, Nokia includes a separate Nokia Ventures Organization and the corporate research unit, Nokia Research Center. Headquartered in Finland, Nokia is listed on the New York, Helsinki, Stockholm, London, Frankfurt and Paris stock exchanges and employs more than 60 000 people. In June 2000, Nokia was one of the ten largest companies in the world measured in stock value. (Nokia 1999.)

Nokia Mobile Phones was, in 1999, the wold's largest mobile phone manufacturer. Nokia's total mobile phone sales volume was 78.5 million units and net sales EUR 13 182 million. In 1999, the operating profit in Nokia Mobile Phones was EUR 3 099 million and operating margin 23.5%. During 1999, Nokia launched a total of 18 new mobile phone models. The product portfolio covered all consumer segments and for all major analog and digital (GSM, AMPS, CDMA, TDMA) standards. (Nokia 1999.)

The average personnel in Nokia Mobile Phones in 1999 was about 21 000 (Nokia 1999). The personnel growth, especially in SW R&D, has been rapid during the study period 1995 - 2000; about fivefold. In March 2000, Nokia Mobile Phones had SW R&D in eight countries and in 13 sites, whereas, in January 1995 the number of SW R&D sites had been only six.

Embedded SW for each mobile terminal model is done jointly across several sites and there are several mobile terminal development programs running in parallel. SW R&D sites normally

have a matrix organization, including both line and project organization dimensions. From the site level case sub-units, only Site D did not have a proper SW line organization prior to 1998.

6.2 Global level case

The global level case is presented as a chronological description of the development of the global level infrastructure. The purpose of this section, and of section 6.3 Site level embedded sub-units, is to depict how the overall system for SW Process Asset Management and Deployment has evolved over time, and to give rationale for each of the system elements described later in chapters 7 and 8.

6.2.1 Current state analysis

The only global organizational unit of the SW R&D in 1994 had been SW TAG (short for SW Technology Advisory Group). NMP SW-TAG had established a sub-group called the "Process Group" for SW process improvement. The group had its first "pre-inaugural" meeting on December 1994. (Artifacts.)

Prior to the existence of the Process Group, the SW-TAG had already started two process improvement projects, which landed under the steering of the Process Group:

- NMP SW Process Update (started in June 1994)
- NMP SW Process Training Roadmap (started in June 1994).

In 1994, a new SW configuration management tool was selected for NMP SW development. The SW process documentation had also been moved to the new repository. The SW process description consisted of about 150 ASCII or MS Word documents. This was used also as an opportunity to start a project that would look after the SW process documentation. In late 1994, the NMP SW Process Update project re-categorized the documentation to improve navigation in the repository and made some minor improvements to the existing documentation; for example, changing the cover pages to match the new version management standards. The project continued in 1995 with the responsibility of maintaining the documentation, especially focusing on managing changes to the documentation. (Kinnula 1999, Personal log.)

In early 1995, the newly-created process group of the SW TAG became a steering group for a project called SPIS (short for SW Process Improvement Support). The SW-TAG chairman launched SPIS to study what was needed to support process improvement activities and to come up with solutions for identified problems in SW Process Engineering. (Känsälä 1995.)

The SPIS project was a three person effort; one person from NMP with 60% time allocation to the project, and two from Nokia Research Center: the Project Manager with 50% time allocation and me as a full time consultant. (Känsälä 1995.)

When the SPIS project was launched, the objectives were defined only on general level. In the first phase, the SPIS project team conducted 'mini assessments' in all current NMP SW R&D sites in order to define more concrete goals for the project. The assessment was done by interviewing the SW practitioners to find out what the local and global improvement needs were. I also reviewed at that time current organizational standard SW process. The assessment results were documented and given to the project steering group as a recommendation for future SPI actions. (Känsälä et al. 1996, Personal log.)

Based on the assessment and the documentation review, the following problems with the old organizational standard SW process were identified (Artifacts):

- Didn't cover all SW engineering activities
- Overlapping and partially contradictory instructions
- Partially out of date

- Inflexible, ‘one size fits all’ structure
- No common glossary
- Difficult to use

The coverage of the process documentation was highly affected by the previous major updating effort during 1991 - 1992 aiming to fulfil ISO 9000 requirements. Some of the SW engineering activities were not even identified by the documentation that was current at that time, even though some of these activities were recognized to be critical to the success of the SW development projects. For example only project plan template existed for project management and risk management. Also all activities typically performed by line organization were totally missing; for example training, human resource management and providing a SW engineering environment. (Artifacts.)

The documentation review revealed that some of the instructions did overlap and were sometimes even contradictory. That was mainly due to unclear activity breakdown structure and different authors updating instructions in the interrelated process areas over the years. (Artifacts.)

Many of the instructions were found to be outdated. The SW engineering domain had evolved since the previous effort to capture 'as-is' processes. During the period 1993 – 1994 the SW Process Asset Management organization had been almost non-existent. Therefore, SW Process Assets were not properly maintained (Interview Jylänki). During the mini-assessment, we also found that many projects had their own templates and instructions that would have been applicable also for other projects, but which were not made available as reusable SW Process Assets. (Artifacts, Personal log.)

The process documentation was mainly created at a time when there were only four SW R&D sites and the projects were quite similar. Over the years, the number of sites, used methods and tools, and project types had increased. The structure of process documentation, the process architecture and design, could not cope with the new requirements of changing SW engineering domain. The structure could be characterized as an inflexible, ‘one size fits all’, solution. In addition, the notion of process tailoring did not explicitly exist.

The process documentation review revealed also that there was no common glossary as a basis for the SW process documentation. For example, six different role names referring to the role of SW Project Manager were found in the documents. (Artifacts.)

The process documentation was found to be difficult to use. Users had on-line access to the SW Process Assets, which were stored under the SW configuration management tool PCMS. The different documents were saved as, for instance, ASCII and MS Word files. No active links were established between related SW Process Assets. However some documents contained references to other documents. (Artifacts.)

Based on current state analysis, the SPIS project defined focus areas and objectives for year 1995. Firstly, it had the responsibility of developing a framework for NMP SW processes that could be tailored at all levels, including a hierarchical structure that would consist of two logical layers. The higher level "macro-processes" were to be common globally and they could not be modified without a formal approval from the global process owner. The lower level "micro-processes" were those that could be modified or customized locally or at project level. However, it was also stated that some of the 'micro-processes' would be obligatory globally with the purpose of enabling cross-site cooperation. This target was later implemented using an activity breakdown structure that allowed tailoring at the lower levels concerning how to perform certain activities and which activities were relevant to a project. This is discussed further in the section 6.2.2. (Känsälä 1995.)

Secondly, the SPIS project was to study what would be needed for global SPI coordination and local SW process customization. This objective included support for “preparing the NMP SW process improvement long-term program, including both the general SPI process, and the global/local SPI support solution, and the SPI plan for 1996” (Känsälä 1995). This covered, for instance, proposing an organization for managing and coordinating process work, defining

processes for process improvement, and defining basic approach how the projects would tailor their own processes from the standard SW Process Assets (Känsälä 1995).

After the objectives for the SPIS project were set, it was obvious that the NMP SW Process Update Project work would be either partially or entirely replaced with the results of the SPIS project. Therefore, the NMP SW Process Update project was planned to continue only until the end of 1995. The project focused on updating the process documentation in order to simplify the documents, improve readability and layout consistency, and to eliminate redundancy in the content and references. (Kinnula 1999, Personal log.)

6.2.2 Process architecture definition and process asset library prototyping

In 1995, the SPIS project had delivered a description of the forthcoming SW Process Documentation Framework and demonstrated its implementation in a Lotus Notes environment. The Framework contained both an abstract architecture and a structure for the contents of the process library. Armitage et al. (1994) identified the information content elements and their interrelationships - the 'conceptual schema' - that should be included in a process representation in order to be 'enactable' by humans. 'Enactable' in this case means that the process can be carried out as described in the process representation given that the organization provides the proper human and material resources. The architecture was based on the 'Activities – Agents – Artifacts' structure, as proposed by the conceptual schema. All three elements were cross-mapped so that the person accessing the SW Process Asset Library could start from an item of one element and find out which items in the two remaining elements were linked to it. A user might, for example, want to make a SW Project Plan. An experienced project manager could go directly to fetch a project plan template from Work Products. However, if she needs information about how to do the planning, she can follow the link from work product to activity, then to the process Manage SW Project. An inexperienced project manager could start from SW Project Manager role definition, and then go to the relevant processes and work products. (Armitage et al. 1994, Känsälä 1996, Artifacts, Personal log.)

The work by Armitage et al. (1994) also contains a set of checklists of specific content and related issues that the schema elements should cover in a process representation. The conceptual schema and checklists provided very comprehensive guidelines for SW process definition, but it still took lot of tailoring and definition before the process architecture and design was suitable for our needs. The tailoring principle was to simplify things as much as possible without losing the capability to capture any relevant (for human enactment) process information. (Armitage et al. 1994, Artifacts, Personal log.)

The activity hierarchy was based on the approach used in the ISO 15504 reference model; Process Category – Process – Base Practice (ISO/IEC 1996a, ISO/IEC 1996b). The solution between the global and local parts of the process was integrated in the process hierarchy by adding a fourth level below the ‘Base Practice’. This level, called ‘Procedures’, was the ‘how-to’ –part of the process representations, while the Base Practice level detailed what the process was about and what the expected results were like, using the widely known 'Entry Criteria – Tasks – Verification & Validation – Exit Criteria' framework (Radice et al. 1985). A Base Practice for developing a SW unit defines the purpose of the activity, the necessary inputs, generic tasks, the mechanism for verifications & validation of the results, resulting outputs, and the relationship to relevant roles and reference materials. However, the description is so generic that, for example, it does not matter what programming language is used. For example, there could be two procedures, one providing a detailed description of how the unit is implemented using C language, and the second using C++. Or alternatively one could describe how to implement a unit from scratch and another how to develop a SW unit using inherited code. This approach would give the local level freedom to decide how they wanted to carry out the activity, while still

retaining the compatibility of the results across sites and thus enabling NMP to work as a global company. (Känsälä & Kinnula 1997, Kaltio & Kinnula 1998, Personal log.)

Another important aspect of the new process documentation framework was that it was not built around a project progress or lifecycle model. Instead, it was a collection of all SW engineering activities, grouped into logical categories. The reason for this was that it was obvious that the project types would be changing in the future - possibly more quickly than the SW Process Engineering organization could keep up with. Should the documentation be structured around current project types and lifecycles as it had previously been, it would soon become obsolete or require major revisions although the activities themselves were not necessarily changing. The new process framework is best considered as a library of activity descriptions and the project view is built in separately by defining different project types and lifecycles, and linking those to the process descriptions. This way, the essential part of the process documentation, the activity descriptions, are protected from unnecessary changes even though the project types and lifecycles are likely to change. Since the new SW Process Asset Library was taken into use in September 1996, a project-specific process was defined by selecting relevant SW Process Assets from the library, defining deviations and rational for the deviations, and including additional project-specific information. The results were documented into SW Quality Plan. The definition process was supported by tailoring guidelines, project types and lifecycle models. (Känsälä & Kinnula 1997, Personal log.)

It was likewise decided to build the content of the framework around the ISO 15504 reference model architecture (ISO/IEC 1996b). In the end, the logical grouping of processes is a matter of choice, rather than an absolute truth, and the project considered that the ISO 15504 work represented the state-of-the-art in this field, both because of its depth and its wide coverage of SW Engineering Processes (Kaltio & Kinnula 1998). That was later supported by a graduate thesis (Nyström 1997). The ISO 15504 reference process model provided quite a comprehensive breakdown of SW process activities, characteristics of generic work products, and work product-to-activity mapping. The structure was also tested against the NMP's actual processes through a series of reviews with practitioners and managers and the results indicated that the contents of the ISO 15504 reference model matched with the NMP SW processes. To ensure that the resulting documentation would indeed reflect the NMP practices, only the structure was copied from the ISO 15504 work and the actual content of each process was decided to be derived from NMP (Känsälä & Kinnula 1997, Personal log.)

While the new structure provided a solution for the problem with local customization and helped to detect and remove the overlaps and conflicts, it did not ensure that the documentation itself would be user-friendly. To this end, the SPIS project decided to use the Information Mapping® –method (Horn 1992) developed for designing easy-to-read technical documentation (Kaltio & Kinnula 1998). The selection of the method was quite easy, because the SW Process Definition Guide (Armitage et al. 1994) gives a reference to the Information Mapping® method. I participated on a public Information Mapping® seminar in June 1995 and organized a Nokia internal seminar in October 1995. Later several people from different Nokia sites have participated on public and Nokia internal seminars. (Personal log).

The Information Mapping® method (Horn 1992) is an approach to capturing, categorizing and communicating information. It is based on research into how the human mind actually reads, processes, remembers, and retrieves information. It enables authors to break complex information into its most basic elements and then present those elements optimally to readers.

Information Mapping® has had a major impact on the standardized way of presenting process information in the case organization. The principles, layout and outlook adopted from the method are an integral part of the SW Process Documentation Standards. The resulting SW process architecture elements are described in Appendix 1: SW process architecture elements.

The goal to restructure the SW Process Documentation was communicated to SW Line organization and SW Project Managers in NMP SW Days September 1995 (Personal log).

However, the NMP SW Process Update project that started in 1994 had not been active in updating the documentation because of lack of resources. When the SPIS project objectives were set, it became more critical to do the planned updates before the SPIS project could start converting the old process description to the new process architecture. (Personal log.)

Since the NMP SW Process Update project's actual resources were only one person, it was obvious that he could not do all the updates to the documentation content. Instead, he acted as a co-ordination point for the change work, by collecting change requests. Based on preliminary analysis of the change requests, he identified individuals capable of doing necessary updates to the relevant process documents. (Personal log, Kinnula 1999.)

Once new or revised process documents were ready for release, the NMP SW Process Update project coordinator reviewed those to ensure consistent layout across process documentation, and to remove possible overlaps and conflicts with existing documents. In addition to acting as a co-ordination and review point, the NMP SW Process Update project had the responsibility of developing a guideline that detailed the procedure for updating the SW process documentation. That guideline was never actively used in the context of the old process library. However, the guideline was later used, as the basis for implementing, for example, the documentation management process in the SWEP (short for SW Engineering Process manual) Development Database. (Personal log, Witton 1995)

The NMP SW Process Update project was closed late in 1995. At this time the results of the SPIS project were shaping up and an implementation project to put them into practice was being planned for 1996. (Personal log, Jylänki 1995, Kinnula 1999.)

6.2.3 Establishing the foundation for infrastructure and processes

The work done by the SPIS project team was continued by me, as the other two members of the original team focused on other duties, which were out of the scope of this study report.

The SWEP Implementation was an action that implemented the new SW process documentation framework developed in the SPIS. This action was under the SPIS2 project, which included another action focusing on the SW metrics program. In practice, these two were independent projects. (Personal log, Kinnula 1999.)

The SWEP Implementation action was responsible for designing and implementing the next generation SW Process Asset Library, for restructuring the existing process documentation to match the new framework and inserting the documentation into the library, and for establishing what-level descriptions for the identified base practices. Some process areas that were not considered critical at this point were excluded from this last task. Those were processes from the Customer Supplier and Organization process categories from ISO 15504 working draft version 2.0 (ISO/IEC 1996b). (Jylänki 1995.)

As a first step, the NMP former organizational standard SW process SW_DOC was made available as a Lotus Notes database in January 1996. The solution simply contained 155 documents each of which had a file from the PCMS as file attachment and contents of the file pasted in the Lotus Notes document. The navigation was based on Table of Contents view that was based on the directory structure in PCMS SW_DOC. This was a temporary solution to be used until the new SW Process Asset Library was available. There was a three-fold rationale for the temporary solution. Firstly, to make access to documentation easier for the users. Secondly, this way a user would be more familiar with using Lotus Notes as a user interface to the SW Process Asset Library. Thirdly, the SW_DOC Lotus Notes version contained a link from the home page to a prototype of the future SW Process Asset Library. (Personal log.)

It was decided to carry out the implementation of the new process 'framework' as a series of workshops. Altogether, we had four workshops. The duration of workshops was either two or three days. In addition, we had some smaller meetings, involving only two or three people,

between the workshops. The first workshop was organized at the end of February 1996. Before the workshop, I developed the process architecture and design further by defining the content and layout of those process architecture elements that were used in the first workshop. Those were processes and base practices. As result, highly standardized templates were available in the workshop to guide the process information capturing. The templates were later finalized based on the comments gathered during the workshops. (Artifacts, Personal log.)

The workshops served also as training sessions for those who were to become local and global SWEP support people, introducing them both to the new Process Documentation Framework, as well as to the actual contents of the SW Process Asset Library. (Artifacts, Personal log.)

Before the first workshop, it was recognized that the detailed level coordination of process definition over the whole SW Engineering Process was too massive a task to be performed by one individual. Therefore, the responsibility was divided between six persons, who were coordinating the specific changes to that part of the library. The process areas were the same as ISO 15504 process categories with the exception of the SW Development Processes category, which contained most of the input from the previous SW process documentation, the SW_DOC. This category was further divided into two process areas. The first covered requirement definition, design and implementation, and the second covered unit testing, integration testing and system testing. That was the first time that the SW Process Area Responsible role (see section 8.2.1) was introduced. This role was established for the SWEP implementation effort, but it soon became obvious that the role should continue to exist after the first SWEP release. In addition, the role for a local SWEP support person, the Local SW Process Asset Responsible (see section 8.2.2), was established to train and support the local SW practitioners in using the asset library. These people, in the two above mentioned roles, were originally the members of the SWEP Implementation project, but their role changed in the latter part of the project and they became more of a coordination forum, the SWEP Forum, managing the releases of the SWEP database. (Personal log.)

During the first process definition workshop, the tool for managing the SW Process Assets, the SWEP Development Database (see section 8.5.2), was still in its testing phase. By the end of March 1996 it had been made available to all the people involved. At that time, it did not yet contain full functionality; for instance, change requests and feedback were not yet available. On the other hand, those were not relevant features before the first release. The SWEP Development Database was used during the SWEP implementation effort for storing the SW Process Assets and sharing the work in the distributed organization. Tool development continued during the whole period of SWEP implementation. The full functionality of the SWEP Development Database was ready in October 1996, however, several improvements have been made since. The SWEP Development database contained all the configuration management functionality relevant for managing the SW Process Assets, including, for instance, version control, different roles with access rights, life cycles for documentation, change request management, and so forth. The SW Process Development Database is a centralized tool for SW Process Asset Management in a distributed organization. (Personal log.)

One problem with the previous SW Process Asset Library, the SW_DOC, was that it was impossible to separate the approved releases and documents under development. People just used the latest document no matter whether is was approved or not. Also. most of the functionality needed for managing the SW Process Assets was unnecessary for the users of the SW Process Asset Library. For these reasons, in the SWEP Implementation project we wanted to have a clear separation between solutions meant for approved releases and solutions for managing the improvement and maintenance of the SW Process Assets. (Personal log, Interview Site C.)

Another database, the SW Process Release Database (see section 8.5.1), was developed for the process releases, based on the prototype developed during the SPIS project in 1995. The SWEP release database development continued during the whole period of SWEP implementation. Several participants of the SWEP implementation effort tested the database. The

database is replicated to all R&D sites and everyone in NMP has access to it. This database is the official SW Process Asset Library. The emphasis of the release database is on user friendliness. It also provides an easy way to send in feedback or change requests concerning content or the database itself. (Personal log, Kaltio & Kinnula 1998.)

Some other SW process-related activities were conducted in parallel to the SWEP implementation effort. I provided support services for such activities concerning process definition and other aspects of SW Process Asset Management. (Personal log.)

The second SWEP Implementation workshop was organized in April, the third in June and the fourth in August. The last workshop concentrated on reviewing the results. Prior to the workshop, representatives of current sites organized reviews in their sites. The SWEP Implementation project produced the first release of the new SW Process Asset Library, the SWEP, in September 1996. (Personal log, SWEP.)

After the first release the I and another person from the SWEP project visited all current SW R&D sites and organized SWEP-related training. There were two types of training conducted. Firstly, two hours of SWEP Introduction training where the intended audience was the whole SW personnel. Secondly, additional one day training for SW project and line managers. The intended audience of the second training was identified to be the potential key users and change agents in the organization, in addition to the SW Process Engineering personnel. Therefore, they got more detailed training about the content of SWEP. (Personal log, Artifacts.)

During the training sessions, I presented for the first time the idea of having a technical solution for capturing the results of process tailoring. This would be a project-specific process including active links to the relevant SW Process Assets -the Database for Project-Specific Process (see section 8.5.3).

In November 1996, an intermediate release, version 1.1, was published. The changes to this intermediate release were mainly minor bug fixes. Some new training materials had been added and also some existing materials had been updated. (SWEP.)

In January 1997, another intermediate release, version 1.2, was made, but since then only the main releases every third month have been made. A procedure describing how to make process releases available had already been documented and tested prior to the first release. (Personal log, Artifacts.)

During and after the workshops the process documentation standards were documented and put under configuration control in the SW Process Development Database (Personal log, Artifacts).

The original plans established by the SW TAG expected only a technical implementation. However, it soon became obvious to me that without the organization and mechanisms to manage and improve the assets and to control the integrity of the library, the situation would degrade to the same level it had been at before the implementation effort. In addition to the results defined in the project plan, the SWEP Implementation action also established an infrastructure capable of continuously maintaining and improving the SW process documentation. Some of the elements that were first intended to be temporary eventually became permanent. (Personal log, Kinnula 1999.)

The project was formally ended by the SW-TAG at the end of 1996 when the SWEP implementation goals were achieved, but in practice the activities continued without interruption, and the project was merged with the NMP-SPI project and continued as a permanent part of the new SW Process Engineering infrastructure. (Kinnula 1999, Personal log.)

The NMP-SPI project (short for Nokia Mobile Phones' Software Process Improvement) was responsible for defining, implementing and operating a complete infrastructure for SW Process Engineering within NMP. In early 1997, NMP-SPI established a global SW Process Improvement program in order to respond to the requirements set by the NOKIA corporate-level process improvement initiative. A Global SPE Coordination Team was established to manage and coordinate these activities at the global level. A Global SW Process Asset Manager (see section 8.2.1) was one of the roles defined for this team. (Kinnula 1999, Personal log.)

6.2.4 Institutionalization and maintenance of infrastructure and processes

The SW Process Asset Management infrastructure- and activity-related information was documented for the first time in February 1997 in the form of a slide set. The documentation defines the mission, objectives, roles and responsibilities, and communication channels for SW Process Asset Management. The document was reviewed in the new Global SPE Coordination Team to ensure that it would not conflict with the overall SW Process Engineering organization and strategy. Then the updated SWEP Improvement Strategy was refined in the SWEP Forum Meeting. (Artifacts, Personal log.)

The strategy reflected the principles of the new SW Process Engineering approach. SW Process Improvement is done mainly at a local level and the global organization is responsible for coordinating and supporting the local activities (SPI Plans and Reports).

During spring 1997, the Global SPE Coordination Team visited several SW R&D Sites. During those visits, the SWEP Improvement Strategy was introduced to local SW Process Engineering organizations and representatives of SW line management. Secondly, local SW Process Engineering roles were introduced and a requirement to fill the roles was communicated. The local organization provided feedback that was used to refine the approach. (Personal log, Artifacts.)

A three-month activity cycle for SW Asset Management, built around fixed release dates, was institutionalized during 1997. Each cycle has a SWEP Forum meeting about one month prior to release where there is a partially standard agenda including a review of the previous month's user activity figures, improvements for the following release, and a workshop with changing topics. Having this fixed release cycle has proven to be good decision. The reasons are two-fold. Firstly, users know that there will be new releases available every third month. Secondly, people documenting new SW Process Assets or updating existing ones have clear deadlines. (Personal log, SWEP, Artifacts.)

When the first SWEP release was published, a decision to collect user activity data was made. Lotus Notes provides as a standard feature the option of recording the following data concerning each database usage session: date and time of the session, user name, number of documents read, and number of documents written. Data is collected from all releases, and all SW R&D site-specific replicas are sent to a separate database for analysis purposes. I, as a Global SW Process Asset Manager, started to follow the user activity data right from the first release. A metric concerning the number of sessions per month was reported in the February 1997 SWEP Forum meeting. Since that meeting, SWEP user activity has been a permanent topic in each SWEP Forum meeting, that is, every third month. This metric report is made publicly available inside NMP via the generic SW-related discussion and coordination database, SW Forum.

Tracking SW Process Asset Management activities in 1996 was mainly done in SWEP implementation project meetings. In 1997, we started to follow activities in SWEP Forum meetings. The SW Process Development Database was a useful tool in following up activities. It summarized the results of each three-month cycle in the release notes of SWEP, and contained the possibility of following the status of change requests. In addition, starting from the beginning of 1997 quarterly reports were created and saved in the SW Forum database as a part of overall NMP SW Process Engineering status reporting.

Maintenance of the support technology has been carried out several times since putting the tools to use. Minor modifications have been made several times. In December 1997, we published SWEP version 5.0 that had a graphical user interface in order to support better navigation in the SW Process Asset Library. Similar changes were concurrently implemented to the SW Process Development Database. The development of the Database for Project-Specific Process started in 1999 (see section 8.5.3). (SWEP, Personal log.)

In February 1997, the SWEP Forum assessed the SW Process Asset Management and Deployment infrastructure and activities for the first time. Since then, this has been repeated

regularly in the first workshop of each year; 1998, 1999 and 2000. In 1997, the used SW process framework was evaluated to see how well it fulfilled the SW process definition objectives of NMP (Lalli 1997). The evaluation used a framework in order to determine how well the elements of a SW process framework fulfilled the SW process definition objectives of the case organization. The study showed that the process framework largely fulfilled the process definition objectives set to it. Some modifications were done to the framework based on the study findings. (Lalli 1997, Personal log, Artifacts.)

The usability of the SW Process Asset Library was assessed by conducting contextual inquires (Beyer & Holtzblatt 1998) in two NMP sites in May 1999. The contextual inquires were conducted by a usability consultant from the Nokia Research Center. The findings were used as basis for usability improvements in the areas of user interface and the content of the SW Process Asset Library. However, many of the findings revealed lack of training and problems in communication. Some of the study finding are presented in section 8.5.1. (Myllylä 2000, Personal log, Artifacts.)

During recent years, the local level infrastructure has been assessed by the local organization fairly frequently. From 1997 to 1999, the Global SPE Coordination Team actively followed the evolving local level infrastructure in each site. This study itself, however, is the most comprehensive assessment of the SW Process Asset Management and Deployment processes and infrastructure in the case organization so far. (Personal log.)

When new people joined the SW Process Asset Management organization, their training became inevitable. It was impossible to provide training to newcomers during SWEP Forum meetings and workshops without sacrificing the efficiency of the meetings. During the SWEP implementation phase, only two new people joined the process definition team. As a coordinator of the SWEP implementation, I conducted quite short personal training. This was also the main way of training during 1997-1998. This inadequate level of training started to cause problems in the form of misconception of principles, roles, and responsibilities. In addition, it become obvious that all the people participating in the maintenance of SW Process Asset Library did not know the documentation standards well enough. (Personal log.)

The SW Process Engineering organization started to grow faster at the end of 1998. I organized the NMP SPI Training for the first time in March 1999. The audience of the training was all the people working in the SW Process Engineering organization. The purpose of the training was to ensure basic knowledge about all the different areas of NMP SW Process Engineering regardless of the role that any individual had in the global or local SW Process Engineering organization. The purpose was to ensure that the future was built upon the work done so far, instead of repeatedly 're-inventing the wheel'. The training not only covered SW Process Asset Management and Deployment, but also other areas of SW Process Engineering. (Artifacts, Personal log.)

Also, more detailed training was organized in 1999 for SW Process Area Responsible personnel about packaging the SW Process Assets and using the SW Process Development Database. These training courses were Information Mapping training and SWEP Authoring workshops (Artifacts, Personal log).

Due to the growth of the SW Process Engineering organization it became even more important to document SW Process Asset Management and Deployment-related knowledge in detail in order to make knowledge transfer easier. Also, there was a need to transfer knowledge to other Nokia business units. (Personal log.)

The number of SW Process Engineering actions at local level organizations has been increasing as a result of the overall improvement of the infrastructure, especially because of growing SW Process Engineering organization. That has caused a need to provide more support for those local activities. The lack of resources has always been a problem at the global level roles especially in the SW Process Area Responsible role. Therefore, the global organization has not been able to solve all process change requests or to provide an adequate level of support

services for local SW Process Engineering activities. As a consequence, some of the process users have been disappointed by the slow pace of solving some change requests.

6.3 Site level embedded sub-units

This section contains a description of how a SW Process Asset Management and especially Process Deployment infrastructure was built in five NMP SW R&D sites; sites A – E. It also shows SW Process Asset Library user activity figures in those five sites. This section does not contain detailed descriptions of each infrastructure element in each site. Focus is on the people filling the roles in the local organization. Other local level case findings are presented in detail in chapters 7 and 8.

The purpose of this section is to depict how the local level of the overall system for SW Process Asset Management and Deployment has evolved over time in different sites, and to give the rationale for the importance of the system elements, described later in chapters 7 and 8, by comparing the infrastructure and SW Process Asset Library user activity figures in different sites (see 6.3.6).

6.3.1 Site A

Site A has had a rather stable process support infrastructure implemented since the beginning of the new global SW Process Asset Library. The support organization has been growing slowly during the study period. The Senior SW Line Manager and many other SW Managers have demonstrated visible commitment towards continuous SW Process Engineering.

At the beginning of 1995 there was only one person working with the SW Process Engineering issues. He performed project audits and provided process support for SW projects especially related to milestone schemas. (Interview Site A, Personal log.)

In summer 1995, another SW Quality Engineer joined in. Note that in the case organization, SW Quality Engineer is a title, not a role. A SW Quality Engineer may have one or more roles described in Table 5 (pg. 72). The second SW Quality Engineer performed the same activities as the first SW Quality Engineer. In addition, she had local SW metrics-related responsibilities. When the global SW metrics project started in November 1995, as a part of the SPIS project, she was the first the Site A representative, and later the head of the SPIS metrics activities at a global level. She continued to have local responsibilities with more than 50 percent resource allocation until she became the first Global SW Metrics Manager, which was one of roles in the Global SPE Coordination Team, in January 1997. However, she continued to also hold some local responsibilities. She held the Global SW Metrics Manager position until she went on maternity leave in June 1997. Another person took over the local SW metrics responsibilities when the second SW Quality Engineer was nominated the Global SW Metrics Manager. He had already been actively involved in the local SW metrics implementation effort as a SW Tool Developer (see section 8.2.2) for the local SW metrics database. (Interview Site A, Personal log.)

The first SW Quality Engineer participated actively in the SWEP implementation effort during 1996. He became Local SW Process Asset Responsible and Process Area Responsible after the first SWEP release. He held both roles until he moved to another Nokia business unit in September 1998. However, a lot of his time was allocated in SW Process Supporter and SW Quality Assurance roles (see section 8.2.2). (Interview Site A, Personal log.)

A third SW Quality Engineer joined in December 1997. She worked in the SW Process Supporter and SW Quality Assurance roles. Later she also took up the SWEP Responsible and Process Area Responsible roles, when the previous person in those roles moved to another business unit. (Interview Site A, Personal log.)

The local assessment team leader took the new Local SPI Manager role (see section 8.2.2), which was established by the Global SPI Coordination Team in January 1997. SW process assessment was conducted in Site A in April 1997 using SW-CMM. In September 1998, he moved to another site and became a Senior SW Line Manager. The former Global SW Metrics Manager had returned from maternity leave and had started to work in the local SPI organization. Now she took over the Local SPI Manager responsibilities. She held that role until she went to maternity leave again in October 1999. A new Local SPI Manager started soon after. (Interview Site A, Artifacts, Personal log.)

There has been a support person working in the SW configuration management process area during the whole study period. The support includes both tool and process support for all local SW projects. Another person has been supporting other SW development tools. (Interview Site A.)

In summer 1998, a SW Training Coordinator role (see section 8.2.2) was established in Site A as the first site to have such a role in NMP. Based on the experiences in Site A, the Global SPI Coordination Team recognized this new role to be valuable in all large SW R&D Sites. The Local SW Training Coordinator moved to a global position, and in summer 1999 became the first Global SW Training Coordinator. However, he continued also in local activities until the new Local SW Training Coordinator started in November 1999. (Interview Site A, SPI Plans and Reports, Personal log.)

A very experienced SW Developer joined the SW Process Support Team (see section 8.2.2) in October 1998. He started to work in the SW implementation process area, including, for instance, coding standards. He has been acting at a local level in several roles, those of SW Process Developer, SW Trainer and SW Quality Assurance (see section 8.2.2). He took also the Process Area Responsible role in the same process area. (Interview Site A, SPI Plans and Reports, Personal log.)

In spring 1999, one SW developer moved to the SW Process Support Team and started to work in the area of SW requirement management process. He acted also as a SW Quality Assurance person for three SW development projects. In summer 1999, there were two students working in the team. (Interview Site A, Personal log.)

Some of the SW Project Managers have actively participated, although with less than 10% of their time, in the development of project management practices. In Site A, many of the SW Line managers have been visibly committed to, and some also actively involved in, SW Process Engineering work. (Interview Site A, Personal log.)

In March 2000, Site A had about 15 SW development projects, all of which have a nominated SW Quality Assurance person. There were five persons in the SW Quality Assurance role. In autumn 1999, SW quality assurance training was organized with the purpose of harmonizing the services provided. All large projects also have an internal SW Process Supporter. SW Line is responsible for finding SW Process Supporters. They do not belong to the SW Process Support Team, but to different SW Line sections. The SW Process Support Team members consult the SW Process Supporters whenever necessary. SW Process Supporters attend also to the SW Process Support Team meetings but do not report effort to the SPI project. (Interview Site A.)

6.3.2 Site B

At the beginning of 1995, only one person in Site B was dedicated to SW process issues, as a SW Quality Engineer. SW Process Engineering issues were the responsibility of the local QMT team (Quality, Methods and Tools). The other members of the QMT team were focusing on SW engineering tools. There were four SW Tool Supporters (see section 8.2.2) working in the team. The level of tool support has remained roughly at the same level since then. (Interview Site B.)

The only full time SW Quality Engineer performed SW quality assurance activities in connection with project milestones. Also the SW Tool Supporters used some of their time for SW quality assurance activities. The role was called SW Quality Shadow. The responsibilities of the role were documented locally. Those instructions were later used as the basis for the definition of the SW Quality Assurance role and responsibilities. The SW Quality Engineer also worked close to 50% of the time for the SPIS project, in global SW process improvement activities. He moved to another position in the company at the end of 1995. (Interview Site B, Personal log.)

Another SW Quality Engineer joined the QMT team in the summer 1995; he came directly from university, and started in a SW Quality Shadow role. During 1996, he participated in the SWEP Implementation project as a representative of the site. After the implementation phase, he took the global role of SW Process Area Responsible, covering several process areas, and the role of Local SW Process Asset Responsible in the site. (Interview Site B, Personal log.)

The resource allocation for process-related support services was far too low for a long period. The SW Quality Shadows just had too many projects to support. Despite this they tried to cover all SW projects, which lead to a situation where they used less than four percent of their time on each individual project. In practice, SW projects did not gain much. (Interview Site B, Artifacts.)

At the beginning of 1997, when the corporate-wide Nokia SW Process Initiative was launched, Site B was also forced to form an organization to tackle the challenge. The Senior SW Line Manager took an active role in the startup. She nominated a Local SPI Manager, local organizational structure was planned, and names were allocated to the roles in the organization. However, those nominated people had hardly any time at all to perform SW Process Engineering activities. The Local SPI Manager worked also at the same time as a line manager for QMT team, and later had SW development project manager responsibilities. The new SPI organization did not achieve much during those days. (Interview Site B.)

The SW Quality Shadows originally participated only on milestone reviews, although there were plans to enhance the role to cover also other activities. Documented descriptions of the enhanced SW Quality Shadow activities existed, but those were never implemented as such. Instead, SW Quality Engineers' possible responsibilities were analyzed and two new roles as a natural package of responsibilities were defined. Those were SW Process Supporter and SW Quality Assurance. Definitions were created in cooperation with SW development projects in workshops. (Interview Site B.)

It was decided that process-related support should be done inside a project with big enough resource allocation. However, there were not enough SW Quality Engineers to support all the SW development projects. It was concluded that it was better to achieve results with fewer projects than to try to support all projects and fail with all of them. Based on prioritization only four high priority projects were selected to be supported by SW Process Supporters. The situation lead to local management approving the recruitment of more SW Quality Engineers. Besides, the NOKIA corporate –level process improvement initiative and the NMP SPI objectives caused pressure to increase the headcount. (Interview Site B, SPI Plans and Reports.)

In early 1998, new SW Quality Engineer joined the team. He took the Local SW Process Asset Responsible role soon after joining NMP. He also took the SW Process Area Responsible role in autumn 1998. In addition to the other responsibilities, he furthermore took the new SW Training Coordinator role. About the same time, one of the SW Tool Supporters moved to a SW Quality Engineer role. A new Local SPI Manager started in spring 1998. He had a previous background of working in SW projects. (Interview Site B.)

There were 14 people in SW Process Engineering roles in February 2000. Half of the SW Quality engineers had joined in 1999. There was still a need to continue the growth because not all projects yet had SW Quality Supporters. (Interview Site B.)

The local SW organization changed in December 1999. There used to be two groups in the SW Line, and in the new organization there were six groups. In addition, the organizational

model for local SW process support was changed. Each SW group became responsible for process issues and was supposed to have a given person responsible. (Interview Site B.)

In the new organization, most of the SW Quality Engineers were part of technology -based SW line sections, for example core cellular SW. The size of the SW Process Support Team was not supposed to grow. The SW Process Support Team provides support for the SW Quality Engineers in the different groups in the line. (Interview Site B.)

However, the main reason for the change was that the SW Process Support Team was not able to recruit new SW Quality Engineers. Therefore, a decision was made that each line is responsible for acquiring resources if projects in the group are supposed to be supported. However, this is seen as problematic in the sense that competence is distributed too much and no common competence center exists. The SW Quality Engineers have a meeting once a month where experiences are shared and solutions for different problems are discussed. (Interview Site B.)

The SW Process Asset Library-related training has been organized more or less frequently, depending of the organizational growth rate since the first release of the new SW Process Asset Library. The Local SW Process Asset Responsible normally organizes the training for new employees as a two to three hour introduction. When the new library was published for the first time in September 1996, introduction training was organized for the whole SW line. (Interview Site B.)

6.3.3 Site C

Site C was previously part of another company; Technophone. Nokia bought Technophone in 1991. (Interview Site C.)

In those early days, there was only one person working on SW quality issues. He worked as a SW Quality Engineer in the one and only large SW project of that time. In summer 1994, he became the leader of the NMP SW Process Update project, which was a global project updating current process documentation (see section 6.2.1). (Interview Site C, Witton 1995.)

In 1995, time allocation for local activities was about 75%. That was used for supporting local SW development projects by: giving induction training for new employees for instance about SW engineering process, organizing and giving other types of training, and deploying inspection practices to SW projects. He tried to give all projects at least some level of support, but that was clearly too much to do for one person. (Interview Site C.)

Two new people joined the unofficial SW process support team in Spring 1995. They worked mainly in the SW Tool Supporter role. However, they also attended to some SW quality audits and milestone reviews. The whole SW Line consisted of a SW Line manager, one SW Quality Engineers, and two SW Tool Supporters, one of which used some of his time in the SW Quality Engineer role. Additionally there was one person developing Lotus Notes solutions for local purposes. One of the solutions, relevant for the topic of the study, was a training database. (Interview Site C.)

The SW Line recognized the need for more process-related resources, and tried unsuccessfully to recruit new SW Quality Engineers. However, the situation became even worse as the number of SW projects increased. In addition, one of the SW Tool Supporters was transferred to lead one of the SW projects. When the NMP SPI was launched, this single SW Quality Engineer held all the different roles in the local organization, which the Global SPI Coordination Team insisted should be fulfilled in year 1997. Those roles were Local SPI Manager, SWEP Responsible, and SW Metrics Coordinator. (Interview Site C, SPI Plans and Reports.)

The situation improved slightly in January 1998, when a new SW Metrics Coordinator joined. However, throughout 1998 his effort was in practice focused on tool support for the SW

configuration management tool. In theory he was the SW Metrics coordinator, but due to lack of SW Quality Engineers and tool support for SW metrics it was not possible to do very much in this role. Less than 20% of his time was allocated to the SW Metrics coordinator role. (Interview Site C, SPI Plans and Reports.)

The SW Process Support organization consisted of only two persons until spring 1999. A SW Training Coordinator joined in April 1999, and three SW Quality Engineers joined in October - November 1999. Two of those started almost immediately to work as SW Process Supporters, and the third initially assisted the Local SPI Manager and then after a few months took the Local SW Process Asset Responsible role. In summer 1999, the part time SW Metrics Coordinator started to use less time for SW tool support and started to use the released time for SW metrics-related activities. As of February 2000, there was still a lack of resources in the SW Process Support Team. The Local SPI Manager set the practical recruitment target for year's end to be three, for the six places identified as a resource gap. (Interview Site C, Artifacts.)

SWEP training for newcomers was organized for individuals or for small (two to three persons) groups as short introduction training. During the period from spring 1999 to early 2000, training was not organized. Induction training for newcomers was partially implemented in February 2000 and the plan was to also include SW Engineering Process-related training. When SW Project Managers have asked for support, the Local SPI Manager has also provided coaching for them individually. (Interview Site C.)

6.3.4 Site D

Site D has a history of almost totally lacking SW line organization. Site D has however had over the whole study period some resource or resources working in the field of SW Process Engineering. Certain project or projects owned these resources. All SW process- and tools-related issues were the responsibility of each individual project. As default, the SW quality and processes were a responsibility of the SW Project Manager. This responsibility was in practice normally delegated to one of the SW Engineers in the project. However, they typically also had SW development responsibilities. (Interview Site D, SPI Plans and Reports, Personal log.)

However in fall 1995, one project recruited a person to work solely with the SW process issues in that project. He worked mainly as a SW Process Developer and SW Process Supporter for that project. One of the main tasks was to define a process for the project. He, however, consolidated the effort with the SWEP Implementation project and later took the SW Process Responsible role of the SW Project Management process category. (Personal log, SWEP.)

In another project a part time employee wrote quite a comprehensive 'work rules' document (about 100 pages); the project-specific SW process description for his project (Interview Site D).

When the NMP global SW Process Engineering activities were renewed at the beginning of 1997, one of the Global SPI Coordination Team members was located in Site D. He acted as site coach for several NMP sites, including Site D. He acted also as a part time Local SPI Manager for the site, and started to establish the local SW Engineering organization. (Personal log.)

A new SW Quality Engineer joined Site D in June 1997. He took the SWEP Responsible role when the previous person left the company early in 1998. He was nominated to the Local SPI Manager role in June 1998. However, he soon left for another business unit in October 1999. The follower in the Local SPI Manager role was not formally nominated until March 1999. Another SW Quality Engineer had joined in March 1998. He took the SWEP Responsible role in June 1998, and was later nominated to the Local SPI Manager role in March 1999. (Interview Site D, Artifacts.)

SW Process Engineering activities were under the Quality Manager of the site. SW Line was established 1998. It contained two large groups. The organizational chart did not yet recognize the SW Process Support team. Instead, it worked as a virtual team. A new SW Quality Engineer

joined the team in November 1998. She worked as a part- timer with process issues without any specific job profile. (Interview Site D.)

The SW Line organization was restructured in December 1998. There had been two SW lines, which were now combined to form a single line. In connection with restructuring the organization, the SW Process section was formed for the first time as a part SW Line. As early as summer 1998, the new Senior SW Line Manager from one of the lines had taken an active role in lobbying the need for a SW Process Support team as part of line organization. (Interview Site D.)

Now there was a commitment to building the SW Process Support Team. The resource situation stated to improve immediately. One SW Quality engineer joined in December 1998 and two more in January 1999. There was a better understanding of what those SW Quality Engineers were supposed to do. Job profiles started to be more concrete. One of the SW line managers was the acting manager for the SW Process Support Team. He had the central role of organizing the SW Process Support Team in the first quarter of 1999. (Interview Site D.)

In March 1999, the SW Quality Engineer with the longest experience took the role of Local SPI Manager, and another experienced person took the team leader position. The team includes also SW Tool Supporters (see appendix 5) and SW Build Managers, who support several SW projects. In late spring 1999, two more people joined the SW Process Support team to work as a SW Process Supporters. A SW Training Coordinator started in November 1999. In February 2000, the size of the team, excluding SW Tool Supporters and SW Build Managers, was 11 persons. (Interview Site D, Artifacts.)

Most of the new members were quite inexperienced and had no previous work experience. Two had previous experience from NMP. Some of them were still working as part-timers. The new members of the team started almost immediately to work on a project as SW Process Supporter. At the beginning, the team members were physically located next to each other. Later they moved to sit among the project personnel they were supporting. The SW Process Supporters have one or two projects to support and they may have some other roles, like Local SW Process Asset Responsible. The original plan was to have only one project to support for each SW Process Supporter, but due to a lack of resources and the number of SW projects, some of them have to support two projects. The workload of an individual project is highly dependent on the project phase. That knowledge is used to plan ahead for resource allocation and support for different projects. (Interview Site D.)

In February 2000, there were about 30 SW projects of which SW Process Supporters support 10. The prioritization of the projects is done by the SPI Steering Group, composed of SW Line Managers, Site Quality Manager, and representatives from SW projects. (Interview Site D.)

6.3.5 Site E

Site E has had a serious lack of SW Process Engineering resources. In 1995, there was only one person working part-time with the process issues. Another person joined in January 1996. In addition to them, there was a SW Tool Supporter related to the configuration management tool. In the beginning of 1997, when the NMP global SPI program started, the first process person took the role of Local SPI Manager. He however soon moved to another position in the site. The Local SPI Manger role was taken over by the other process person in summer 1997. He was the only process person until January 1999. In addition to the process responsibilities, he had other responsibilities for which he used most of his time. (Interview Site E, SPI Plans and Reports, Personal log.)

A new SW Quality Engineer joined in January 1999. He had great experience in the field of SW Process Engineering in Nokia, but not in NMP. About 50% of his time was allocated to working as a SW Process Supporter. He was the first person working in the SW Process Supporter role in Site E. With the first project, he did some process development work. In

September 1999, he started to work with another project where they have been able to reach good results. As a side effect, the concept of having a SW Process Supporter in a project has gain more acceptance. In March 2000, he also supported two other projects with quite minimal allocation. (Interview Site E.)

In summer 1999, another SW Quality Engineer joined the team. He was not dedicated to any specific project, but work with all of them as requested, and particularly worked on an organizational level. He has provided support for SW Management by collecting and analyzing data, and helping to use it. He is the Local SW Metrics Coordinator and works also in other process areas, for instance requirement management and estimation. (Interview Site E.)

In April 2000, Site E had about 10 SW projects. One of those has a SW Process Supporter with sufficient resource allocation. The SW Process Support Team, called SW Quality and Process, also includes configuration management support. The SW configuration management tool has greatly influenced the SW development process in Site E. The SW Process Support Team is part of the SW Support section, which also includes SW testing and SW testing tools development. If two persons from configuration management support are included, there was a resource allocation of about four and half persons to SW Process Engineering work. They provide support from time to time in specific issues for the rest of the projects without a dedicated SW Process Supporter, and participate in some of the project milestone reviews. In the beginning of year 2000, they started to implement common reporting and metrics collection for all local projects. (Interview Site E.)

6.3.6 User activity figures versus infrastructure

The purpose of this section is to compare SW Process Asset Library user activity figures to the evolution of the infrastructure in the case sub-units, i.e. Sites A-E. The technology used (the SW Process Asset Library), the content of the organization's SW process, and the characteristics of the SW development projects were the same in all sites. In addition, the implementation model of the local organization has been roughly the same. However, the allocation of people in the roles identified by the model has been different. In addition, there are remarkable differences in user activity figures between sites, which correlates with the system implementation level described in this study report in chapters 7, 8 and 9.

Fig. 2 presents the monthly number of different users divided by the number of personnel in each site. Note that the total percentage of SW Process Asset Library users is higher than the percentage of monthly users, because not all of them use it every month. Note that analysis in this section focuses on the 20-month period from August 1998 to March 2000, in order to simplify comparison between sites. User activity data was not collected in this format before August 1998. Data from September 1996 to March 2000, as monthly number of sessions divided by number of personnel, shows similar differences between sites. However, the data format used in this study report is more illustrative.

Table 1 shows the average percentage of monthly users in different sites during the whole 20-month period and also during the first and last 10 months, and during four five-months periods. Fig. 3 presents the growth of SW R&D personnel in each site.

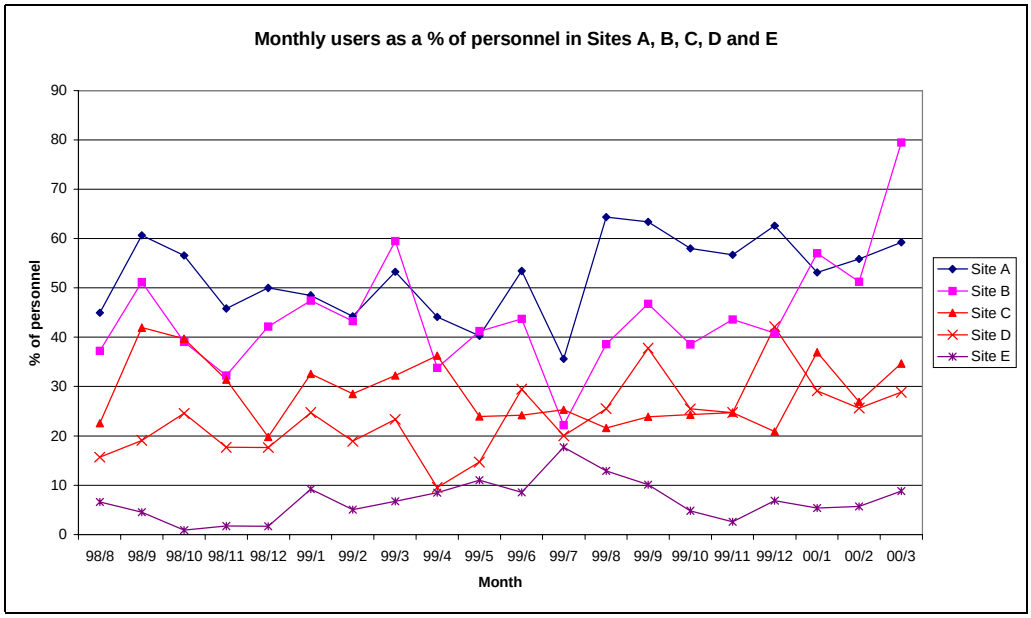

Fig. 2. Users / personnel in SW R&D sites A, B, C, D and E.

Fig. 2 and Table 1 show the outstanding difference between the example sites in the level of penetration. For instance, the percentage of users per month in Site A during the period of presented data is, on average, more than sevenfold of that in site E. The figures are respectively 52.5% and 7.0%.

In Site A the local level infrastructure was established quite early and has been maintained during the whole study period. In March 2000, all 15 SW projects had a SW Quality Assurance person, and all large projects had an internal SW Process Supporter. This can also be seen in the user activity figures. During the 20-month period, the average percentage of monthly users is highest from the study case sites, that is 52.5% of SW R&D personnel. (See section 6.3.1.)

Table 1. Average percentage of monthly users in different sites

Time period	Site A	Site B	Site C	Site D	Site E
All 20 months	52.5	44.5	28.6	23.7	7.0
First 10 months	48.8	42.7	30.9	18.6	5.6
Last 10 months	56.2	46.2	26.3	28.9	8.4
Months 1-5	51.6	40.4	31.1	19.0	3.1
Months 6-10	46.1	45.1	30.7	18.3	8.1
Months 11-15	55.0	38.0	23.8	27.7	10.8
Months 16-20	57.5	54.5	28.8	30.1	5.9

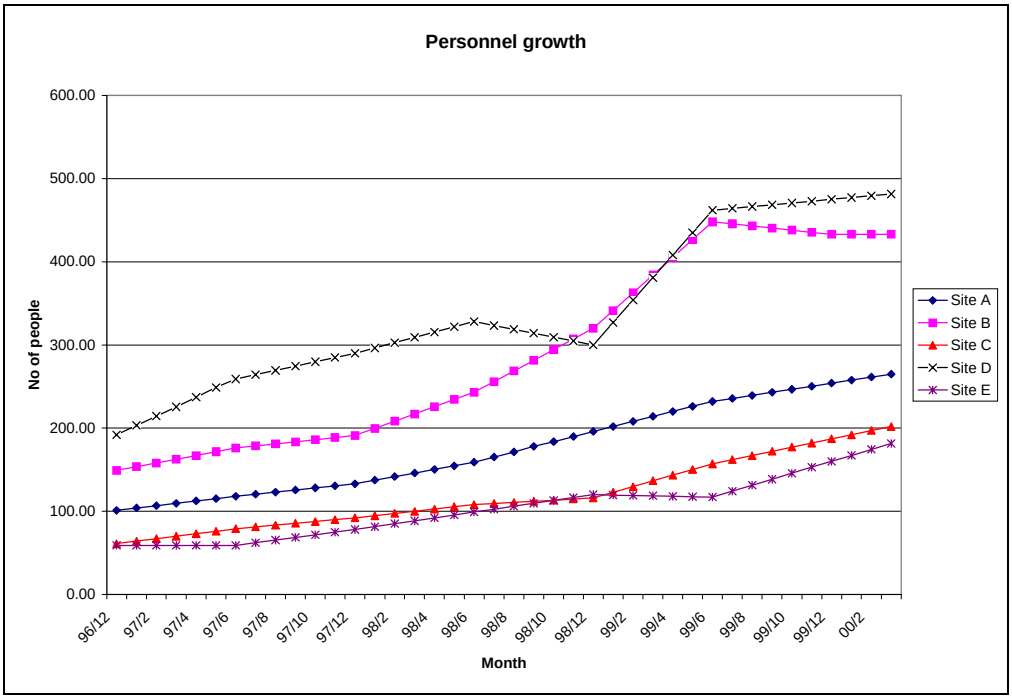

Fig. 3. Personnel growth

In Site B, there have been people working in the SW Process Asset Management and Deployment roles during the whole study period. However, Site B has never been able to provide process support for all local SW development projects. The user activity figures are on average 8 percent lower than for Site A, but are nevertheless second highest of the five case sites. (See section 6.3.2.)

In Site C, some level of process support for local SW projects has existed during the whole study period. However, Site C has been suffering from a lack of SW Process Engineering personnel, and the level of support for SW development projects, has been inadequate. This explains lower user activity figures than in Sites A and B. Even though the number of SW Process Support team members grew in late 1999, the average percentage of monthly users was lower during the last 10 months than during the first 10 months. This is possibly because SW Process Asset Library training was not organized during the period from spring 1999 to early 2000, and that the relative size of the SW R&D organization grew rapidly during the same period as Fig. 3 shows. In addition, there is a delay before the new SW Process Supporters' work becomes visible in user activity figures. (See section 6.3.3.)

Site D started to established the local infrastructure later than the other sites. The local Software Process Support Team was officially formed in January 1999 as part of the SW Line. The recruiting of new members for the team started early in 1999. Since late spring, the relative size of the team has grown rapidly. Also the four, five-month period average figures in Table 1 show clearly how user activity figures started to grow in summer 1999. When the Software Process Support Team resource situation improves, the effect is not immediate, however. The level raised more than 10 percent from about 20% to 30%. In February 2000, the team was able to support 10 out of a total 30 SW development projects. The relative size of team compared to the total size of SW R&D personnel, was still clearly smaller than in Sites A and B. This explains, at least partially, why the user activity figures were still at lower levels than in Site A and B. (See section 6.3.4.)

By March 2000, the local infrastructure, as it is described in this study report, had not been implemented in Site E. In April 2000, Site E had about 10 SW development projects. One of those had a SW Process Supporter with sufficient resource allocation. The user activity figures are the lowest among the case sites as Fig. 2 and Table 1 show. (See section6.3.5.)

The case data supports the notion that the contents and usability of the process representations are not the only factors affecting the success of process deployment. Instead, organizations should include all infrastructure elements covering not only technology and documented knowledge, but also organization and the appropriate people. Successful SW Process Asset Management and Deployment requires a system approach.

6.4 Evaluation of the SW Process Asset Management and Deployment Results

6.4.1 Summary of results from Establishing and Maintaining a SW Process Asset Management and Deployment Infrastructure

The infrastructure for SW Process Asset Management has been developed, maintained and institutionalized over the five-year period of the case study.

All the activities described in section 7.2 Establish and Maintain SW Process Asset Management and Deployment are performed in the case organization. Infrastructure and activity models are developed and maintained. This study report is actually a comprehensive description of the system for SW Process Asset Management and Deployment. Defined roles are filled and the organization has been growing stronger. However, more people were still needed in April 2000 both in global and local roles, especially for the Process Area Responsible and SW Process Supporter roles. Training and other means have been used to increase the competencies of the people in the related roles. Process architecture, documentation standards, and technical solutions supporting the activities have been developed and maintained. The infrastructure has been assessed using different methods and developed further based on the assessment results. (Interview Site A, B, C, D and E, SPI Plans and Reports, Personal log.)

There are big differences between sites concerning the implementation level of the defined infrastructure model. This is visible also in the SW Process Asset Library user activity figures. (Interview Site A, B, C, D and E, SPI Plans and Reports, Personal log.)

6.4.2 Summary of SW Process Asset Management results

Since the first SWEP release in September 1996, new releases have been made continuously. By March 2000, NMP had put out two intermediate and 14 official releases of the SW Process Asset Library. The official releases have occurred once every three months. (Personal log, SWEP.)

Each of the releases has included plenty of improvements in the form of new documents or updates to the existing ones. In SWEP version 1.0, the number of documents was 653 and the database size was 26 Mb. In March 2000, for SWEP version 14.0 the figures were 1095 documents and 114 Mb. (SWEP.)

Each SWEP release, starting from version 1.1, contains a release note describing the changes since the previous release. Also, all previous release notes are included in the release. The described changes vary from minor editorial changes to the introduction of long and detailed procedures. Respectively, the required effort to make a change may vary from few minutes to

several person months. The different release notes contain short descriptions of altogether 863 changes made between September 1996 and March 2000. Fig. 4 illustrates the distribution of changes across the releases. (SWEP.)

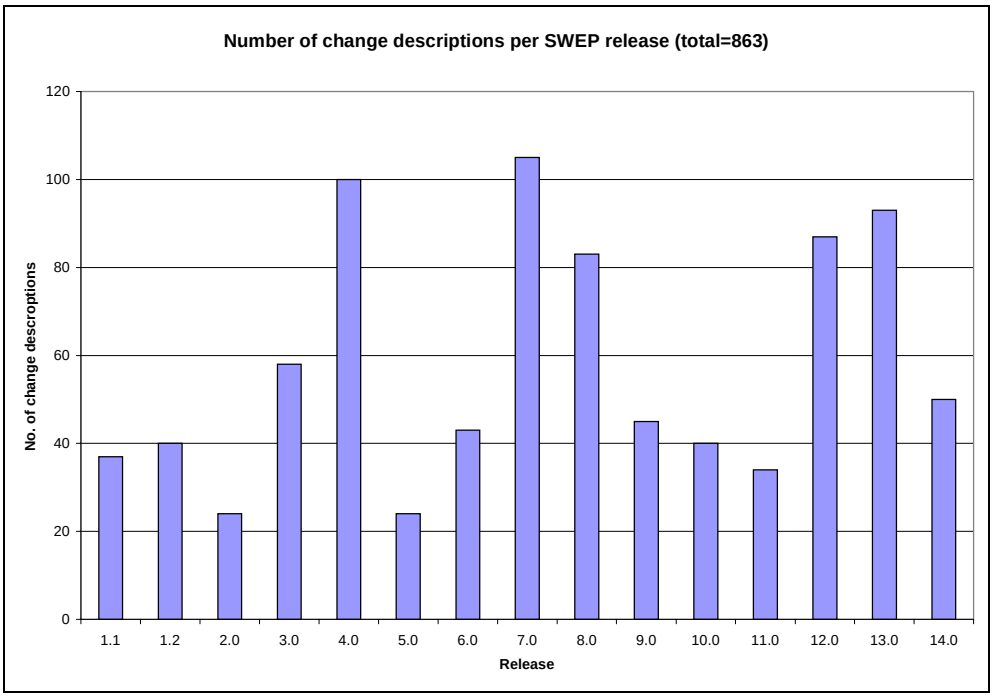

Fig. 4. Number of change descriptions in release note per SWEP release

The SWEP Development Database contains all change requests and other feedback made from different release and local replicas since the first release in September 1996. In March 2000, from the 519 change requests 374 had been solved, and from a total of 188 feedback incidences, 109 had been closed. (SWEP.)

The resource allocation for the roles of SW Process Developer and SW Process Area Responsible has been too small to enable us to deal with all change requests and feedback. With a limited pool of SW Process Engineering personnel, all additional resources in process development would have been away from the SW Process Supporter role, that is from SW Process Deployment. In a typical situation of limited resources an organization has to find a good balance between process definition and process deployment activities. (SPI Plans and Reports, Personal log.)

All the activities, described in section 7.3 SW Process Asset Management, are performed in the case organization. SW Process Assets are packaged, maintained and made available. Support services have been provided for SW projects and for other SW Process Engineering activities. The use of SW Process Assets has been followed and SW Process Asset Management activities have been tracked. However, with higher resource allocation especially in the SW Process Area Responsible role, both quantity and quality of the results would have been better. (Interview Site A, B, C, D and E, SPI Plans and Reports, Personal log.)

6.4.3 Summary of SW Process Deployment results

User activity data shows that the SW Process Asset Library user activity in some sites, especially in Site A and B, is high. At the same time, some sites with relatively weak local SW process support infrastructure have low user activity figures. This can be used as an indicator of the level of deployment. However, it does not tell how much process enactment in different SW development projects is based on the knowledge documented in the SW Process Assets Library. (SWEP.)

A strong culture exists in NMP for using milestone schemas as progress frameworks. SWEP contains criteria for different milestones, and processes for conducting milestone reviews. Many of the criteria are tied to the existence and status of different work products. It is also required that those work products are reviewed. The work product descriptions and related templates are also documented as SW Process Assets in SWEP. Conducted milestone reviews, process audits and assessments have proven that in most cases work products required by the criteria are developed using templates as they are, or by tailoring them from the ones in SWEP. Sometimes those work products are inherited from other projects, but they will still have been originally based on SWEP templates. (SPI Plans and Reports, Personal log.)

The SW Process Supporter role has been found to be key for successful deployment. Projects having a SW Process Supporter working for the project are able to get more benefit out of the existence of SWEP. Projects getting services from a SW Process Support team, especially in the form of a SW Process Supporter, have usually been satisfied. Due to successes in some projects, the others without a SW Process Supporter are now demanding also more support. None of the case sites was able to provide SW Process Supporter with proper allocation to all local SW projects in April 2000. All of them were actively seeking more people in that role. (Interview Site A, B, C, D and E, Personal log.)

6.5 Summary of the study case

This chapter described the embedded single-case under study. Firstly, it shortly introduced the multi-site case organization, Nokia Mobile Phones. Secondly, it gave a chronological description of SW Process Asset Management and Deployment system evolution at a global level. Attention was then given to sub-units of the case; the SW R&D sites. The development of the local SW Process Engineering organization in five sites was described. Lastly, the evaluation of the SW Process Asset Management and Deployment results was given.

The NMP organizational standard SW process as it was in early 1995 (section 6.2.1) had several problems. It was incapable of coping with the requirements of the then SW Engineering environment in the NMP. SW Process Asset Management activities and infrastructure hardly existed. Technology support for making SW Process Assets available and maintaining them existed but was not suitable for the purpose. Because of the situation described above, SW Process Assets were not actively used or maintained.

Two projects, NMP SW Process Update and SPIS (short for SW Process Improvement Support), focused on improving the situation with SW Process Asset Management in NMP. The NMP SW Process Update project had a short-term focus on updating the existing process documentation, and SPIS aimed at providing the basis for a longer-term solution.

The SW Process Asset Management-related results from the SPIS project during 1995 (section 6.2.2) were the SW Process Documentation Framework, the definition of the SW engineering generic roles and project types, and the prototype of the SW Engineering Process release database. The SW Process Documentation Framework included a definition of the SW process architecture elements and their relationships, drafts of content definitions of the

architecture elements, and an activity breakdown structure including purpose definitions of each activity tailored from ISO 15504 working documents v. 1.1.

In 1996 (section 6.2.3) the work continued by implementing a new SW Process Asset Library, publishing the first release in September, and organizing roll-out training in all SW R&D Sites. During this period most of the activities of the process SW Process Asset Management were introduced (see section 7.3). Some of the activities of the process Establish and Maintain SW Process Asset Management and Deployment System (see section 7.2) were also performed for the first time. Additionally, the SW Process Documentation Standards, support tools and the first model for the SW Process Asset Management System were developed. The **organization** element of the infrastructure evolved in the form of the establishment of an initial SW Process Asset Management organization, which included the Global SW Process Asset Manager, Process Area Responsible and Local SW Process Asset Responsible roles. The roles were not yet documented, however. The abilities of **people** in the organization were developed through training during the SWEP implementation workshops. The implementation of SW Process Asset Library content was concerned with documenting SW engineering **knowledge**. The defined Process Documentation Standards represent central knowledge in the context of SW Process Asset Management activities. The process architecture and design development of this case study had already been started in spring 1995 and it was finalized during the process definition phase by March 1996. The main ingredients of the defined process architecture and design can be accredited to Armitage et al. (1994), the Information Mapping® method (Horn 1992) and working draft documents of the ISO 15504 SW process assessment standard (ISO/IEC 1996a, ISO/IEC 1996b). The implemented tools, the SW Process Development Database and the SW Process Release Database, largely covered the necessary **technology** elements.

Starting from the beginning of 1997 (section 6.2.4), the nature of work changed from implementation to improvement and maintenance. This applies both to the SW Process Asset Library and to the SW Process Asset Management System. By March 2000, all the activities described in chapter 7 had been institutionalized and the **organization** as defined in this study was fully implemented (see section 8.2). The number of **people** in the organization was rapidly increasing. However, there was still a lack of resources. Employee abilities were systematically developed. SW Process Asset Management and Deployment –related **knowledge** had been partially documented in the form of SW Process Assets and training material by March 2000. In addition, a manuscript of this study report did exist. The development of a Project-Specific Process Database had started because it had been found to be a missing **technological** element of the system.

Section 6.3 described how SW Process Asset Management and especially Process Deployment infrastructure was built up in five NMP SW R&D sites; the sites A, B, C, D and E. The descriptions are focused on the 'people' element of the infrastructure. People element was the only element with significant differences between sites, and changes during the study period.

The site-level findings about other elements - the people, knowledge and technology - are discussed in chapter 8. Section 6.3, presented also a comparison between those five sites based on SW personnel growth, SW Process Engineering organization evolution and SW Process Asset Library user activity figures.

The section 6.3.6 compared the SW Process Asset Library user activity figures to the evolution of the infrastructure in the case sub-units, that is the Sites A-E. There were remarkable differences in user activity figures between sites, which correlated with the implementation level of the system described in this study report in chapters 7, 8 and 9. The sites were different concerning the relative size of the SW Process Engineering organization and the pace of implementing the organizational model. This also seems to correlate with the user activity level of the SW Process Asset Library in each site. In sites where SW development projects receive more support from SW Process Engineering personnel, the use of the SW Process Asset Library by project members is also higher. The case data supports the notion that the contents and

usability of the process representations are not the only factors affecting the success of process deployment. Instead, organizations should include all infrastructure elements covering not only technology and documented knowledge, but also organization and the people working in it. Successful SW Process Asset Management and Deployment requires a systems approach.

The roles and responsibilities were in a very similar way in each site. The broad definitions of the roles were given by the Global SPE Management Team early in 1997 based on roles recognized from different sites. The actual implementation of the roles was however done at a local level. All roles were found valuable in all case sites.

The summary of SW Process Asset Management and Deployment results (section 6.4) showed that the applied approach has been successful. System SW Process Asset Management and Deployment has been established, institutionalized and maintained during the period of 1995 – 2000. SW Process Assets are developed and maintained continuously and new SW Process Asset Library releases have been made every third month since the first release in September 1996.

User activity data shows that the SW Process Asset Library user activity in some sites, especially in Sites A and B, was high. At the same time, some sites, with relatively weak local SW process support infrastructure, had low user activity figures. This can be used as a one indicator of the level of deployment. Another indicator of the documented process role in SW development in NMP was the active use of standard templates as the basis for produced work products. Also, SW Quality Plans in projects describe the project-specific processes which are, in the case organization, for the most part based on SW Process Asset Library.

The main lesson learned was understanding that the SW Process Asset Management and Deployment should be seen as a system which has to be established, assessed regularly and maintained. The long empirical experience in the case organization also gave a good insight into what elements are needed to establish a successful system, what are the relevant activities, and how to define the important matters in organization, people, necessary knowledge and technology.

7 Processes for SW Process Asset Management and Deployment

This chapter describes first the role of SW Process Asset Management and Deployment in the context of SW Process Engineering. Then it describes the defined process models for SW Process Asset Management and Deployment. The process models are documented in the form of process representations in the appendices 2 - 5, including activity, output work product and role definitions.

7.1 SW Process Asset Management and Deployment in SW Process Engineering

The scope of this study is SW Process Asset Management and the Deployment of a defined process – the activities that support and participate in the deployment of SW Process Assets. These are seen to be part of a larger process domain known as SW Process Engineering.

7.1.1 Activities in the SW Process Engineering domain

The SW Process Engineering domain covers all activities that deal with the improvement and maintenance of the SW processes. At a high level, these are (Kinnula 1999):

1. **Process Engineering Work**: Elements that provide added value to the SW development community
   - SW Process Development – developing and piloting changes to the process
   - SW Process Deployment – putting changes (roll-out) and existing SW Process Assets (re-deployment or institutionalization) into practice
2. **Process Engineering Support**: Elements that form the foundation for process engineering work.
   - SW Process Asset Management – maintaining the SW process documentation, tools, methods, etc.
   - SW Process Evaluation – collecting data from process instances, e.g. with assessments, metrics, etc.
3. **Process Engineering Management**: An element that is required to control and coordinate process engineering in order to manage it and make it continuous
   - SW Process Engineering Management – managing all the SW Process Engineering activities

These activities are seen in Kinnula's (1999) study report as processes. A remarkable difference in this study report is that these are treated as activity types serving certain purposes rather than as a grouping of tasks having a common denominator. Real-life processes normally

serve several purposes, and it is impractical to group activities into clear-cut processes where each lower level activity belongs only to one process serving a single purpose.

For example, a SW Project Manager together with a SW Process Supporter may define a project-specific process using SW Process Assets from the organization's standard SW process. They may use this as a basis and put the results under configuration control to be maintained based on lessons learned. This is a natural part of SW project management and is a phase in project planning. On the other hand, this could be seen as SW Process Asset Management at project level, Process Development or the deployment of an organization's standard SW process. Another example is that many SW measurements can be used both for tracking progress in a SW project and for evaluating a SW process.

Activities normally serve certain purposes more than others, but those other purposes still exist. Real-life process models, like the ones described in this chapter, are not only defined based on their purpose but are also influenced by what seems to be good combination of responsibilities for different roles, for instance taking required abilities into account or the relationships between different work products. Therefore, the process models in this chapter do not use the activity types defined above as pure boundaries for the processes. For example, some base practices in the SW Process Asset Management process model (section 7.3) also serve the purpose of SW Process Deployment.

7.1.2 Activities in the scope of the study

The elements that fall within the scope of this study are SW Process Asset Management, SW Process Deployment, and, to some extent, SW Process Engineering Management.

The activity model for the SW Process Engineering domain is presented in Fig. 5. The areas this study focuses on have been encircled and shaded (Kaltio & Kinnula 1998).

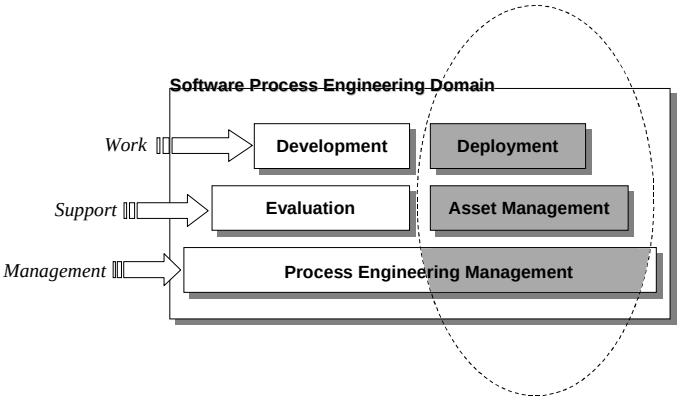

Fig. 5. Activities in the SW Process Engineering domain and the scope of this study

SW Process Engineering Management is the element that ensures that the various process engineering activities are coherent, coordinated and cohesive. It is a continuous activity that monitors the status of the SW process, plans and implements improvements to it, coordinates its maintenance and deployment, and maintains and develops the process engineering infrastructure.

It also provides process engineering with a vision and direction, guiding the organization towards the process state that best serves the organization's business needs. (Kaltio & Kinnula 1998, Kinnula 1999.)

In this study, the most important aspect of SW Process Engineering Management is to provide and manage the infrastructure for Deployment and Asset Management. As the focus is on SW Process Asset Management and Deployment, section 7.2 is devoted to the system for developing and maintaining those elements. Therefore, it does not cover all SW Process Engineering Management activities, for instance the management and control of process evaluation and development.

SW Process Asset Management is the activity that captures organizational learning into a form of reusable assets, maintains these assets, and makes them available to SW Process Deployment for reuse. It is a critical enabler for SW Process Deployment. The process model for SW Process Asset Management is described in section 7.3. (Kaltio & Kinnula 1998, Kinnula 1999.)

The activation of organizational learning is realized through **SW Process Deployment**. SW Process Deployment does not consist of a set of clearly bounded activities. Instead, deployment is an integrated part of a huge variety of activities, including all other SW Process Engineering activities. The process model for SW Process Deployment is described in section 7.4.

7.2 Establish and Maintain SW Process Asset Management and Deployment System

The need for infrastructure is common and analogous to all SW Process Engineering activities. Due to the focus area of this study, the process model presented below will focus on the SW Process Asset Management and Deployment system. However, the process model can quite easily be tailored to cover the whole SW Process Engineering system.

When the system for SW Process Asset Management was re-built (1995-1996), it was not evident at the beginning that the development of such a system (including the activities to perform and an infrastructure that would render activity execution possible) would take a major share of the time allocated. Only the technology element was obvious enough to be recognized in the project plans.

Neither did the available literature stress the importance of a systematic long-term effort for building the above-mentioned system. The system will never be perfect, and it will deteriorate without proper maintenance, therefore the effort spent in improvement and maintenance will always be critical (see section 6.2.4).

A SW Process Engineering system, with its infrastructure and activities, is almost impossible to establish in a short period of time based on, for example, an ideal model for SW Process Asset Management or measurement activities. Building the infrastructure takes time. There can be, for example, a lack of competent or overall resources for these activities, and support tools take time to develop or acquire. A major part of the effort put in by the people managing the system goes on activities such as establishing, monitoring and maintaining the different elements of the system. For the success of continuous SW Process Engineering activities, it is essential to recognize the activities aiming to strengthen the system itself. (Personal log.)

The purpose of the process **ORG.X Establish and Maintain SW Process Asset Management and Deployment System** is to establish and maintain activities and infrastructure - the organization, people, technology and knowledge - for SW Process Asset Management and Deployment.

The base practices belonging to the process ORG.X Establish and Maintain SW Process Asset Management and Deployment System, their purposes and the output work products are presented below in Table 2.

Table 2. Base practices, their purposes, and the output work products for the process Establish and Maintain SW Process Asset Management and Deployment System

Base Practice	Purpose	Output Work Products
ORG.x.BP1 Develop and Maintain SW Process Asset Management and Deployment Infrastructure and Activity Models	The purpose of this base practice is to develop models describing the activities and infrastructure, the organization, people, technology and knowledge, for SW Process Asset Management and Deployment.	Infrastructure Model (SW Process Asset Management and Deployment) Process Representation (SW Process Asset Management and Deployment)
ORG.x.BP2 Fill the SW Process Asset Management and Deployment Related Roles	The purpose of this base practice is to fill roles in the SW Process Asset Management and Deployment organization.	Staff Records
ORG.x.BP3 Develop SW Process Asset Management and Deployment Competencies	The purpose of this base practice is to ensure adequate competencies for people performing SW Process Asset Management and Deployment activities.	Competence Development Plan Staff Records
ORG.x.BP4 Develop and Maintain SW Process Architecture and Process Asset Documentation Standards	The purpose of this base practice is to develop and maintain SW process architecture and SW Process Asset documentation standards to be used as a framework and as documentation standards for SW Process Asset definition.	SW Process Asset Documentation Standards
ORG.x.BP5 Develop and Maintain Technology for SW Process Asset Management and Deployment	The purpose of this base practice is to develop and maintain the technology, e.g. tools, supporting the execution of SW Process Asset Management and Deployment activities.	Communication Mechanism Process Modeling and Simulation Tool Project-Specific Process Database SW Process Asset Library SW Process Development Database Tools Supporting SW Engineering Processes
ORG.x.BP6 Assess SW Process Asset Management and Deployment System	The purpose of this base practice is to assess periodically the operational SW Process Asset Management and Deployment system, in order to evaluate the implementation and to improve the related infrastructure and activity models.	Assessment Records

The full base practice descriptions can be found in Appendix 2: Generic Activities for Establishing and Maintaining SW Process Asset Management and Deployment System. The base practice descriptions include references to all related work products and roles. The role descriptions can be found in Appendix 5: Generic Roles for SW Process Asset Management and Deployment. The full work product descriptions, outputs only, are presented in Appendix 4: Generic Work Products for SW Process Asset Management and Deployment.

The illustration of the process Establish and Maintain Process Asset Management and Deployment System is presented in Fig. 6. The notation used is explained in Appendix 1.

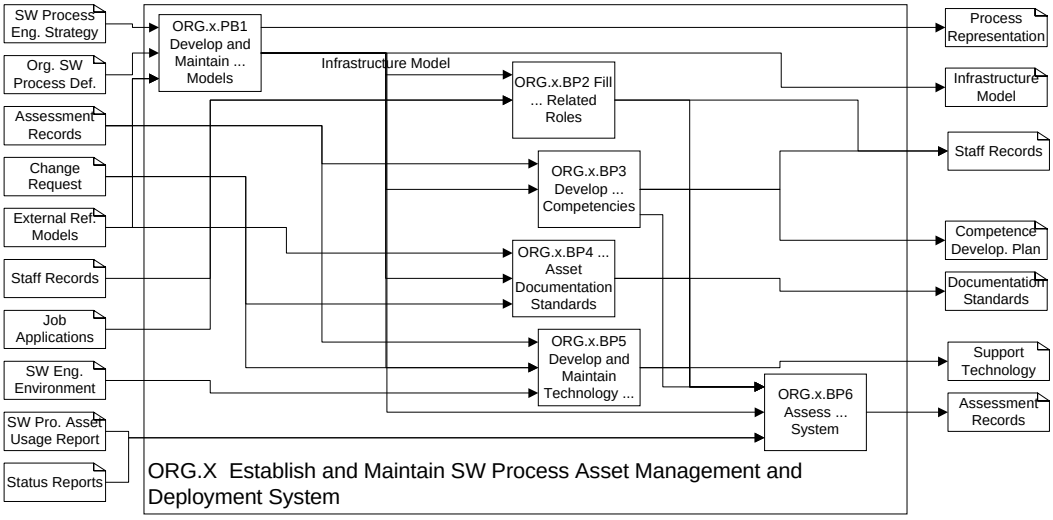

Fig. 6. Illustration of the process Establish and Maintain SW Process Asset Management and Deployment Infrastructure

The organization should systematically measure the results, activities and infrastructure for SW Process Asset Management and Deployment. The following are some examples of issues that measurements should cover (Raffo et al. 1999):

- Are process representations used and followed? (results)
- Do users provide feedback? (results)
- Are process representations maintained? (activities)
- Are users trained? (activities)
- Are roles in the organization filled? (infrastructure)
- Is enough time allocated to performing the activities? (infrastructure)
- Do people in the organization have the necessary skills? (infrastructure)
- Are the tools used suitable for the purpose? (infrastructure)

The measurements must reflect the activity and infrastructure models for SW Process Asset Management and Deployment of an organization. This kind of evaluation is as important for the improvement of the above-mentioned activities as it is for the improvement of the SW engineering process.

7.3 SW Process Asset Management

SW Process Asset management is the activity that enables the capturing of organizational learning into a form of reusable assets, maintains these assets, and makes them available to SW Process Deployment for reuse. The key activities for Asset Management from the output point of view are:

- Maintaining the integrity of the process architecture and documentation
- Providing support services for SW Process Deployment and SW Process Development activities

The purpose of maintaining the integrity of the SW process architecture and documentation is to keep the structure and contents of the SW Process Asset repository consistent. This is achieved for instance by:

- Establishing SW Process Asset Documentation Standards
- Reviewing process descriptions against SW Process Asset Documentation Standards before approval
- Glossary checking
- Process simulations e.g. 'Role plays'
- Feedback from users
- Providing process definition-related training for authors

In NMP, one of the objectives of SW Process Asset Management has been defined as providing support services for SW Process Deployment. The purpose is to help both the project and line to put SW Process Assets to use. This is achieved by providing consultancy and training for SW engineers and managers, making the assets easily accessible and improving their usability (e.g. format, media, etc). The process deployment work is also given technical and organizational support; for example, in the form of providing local copies of the SW Process Asset Library and ensuring that each local site has a person who can support the use of the library.

The purpose of providing support services for SW Process Development is to help with the documentation of the results of change actions using the SW process architecture and the related documentation standards. This is achieved by providing consultancy and training for local process engineers, reviewing the results and providing technical and organizational support for process development work, e.g. in form of managing the feedback loop, providing templates and a database for process development work, coordinating workshops, etc.

Continuous and systematic execution of the activities described above naturally requires planning and tracking of the activities, and assessing the use of SW Process Assets.

The purpose of the process **ORG.X SW Process Asset Management** is to capture the existing processes, and the improvements and changes to these processes into a set of assets (tools, methods, and process representations) that can be reused in future process instances, to store and maintain these assets, and to make them available for process engineering purposes.

The base practices belonging to the process ORG.X SW Process Asset Management, their purposes, and output work products are presented below in Table 3.

Table 3. List of base practices, their purposes, and output work products for SW Process Asset Management

Base Practice	Purpose	Output Work Products
ORG.x.BP1 Plan SW Process Asset Management Activities	The purpose of this base practice is to plan and establish the SW Process Asset Management activities and to take corrective action when targets are not achieved.	SW Process Asset Management Plan
ORG.x.BP2 Package SW Process Assets	The purpose of this base practice is to document SW process-related knowledge as reusable SW Process Assets.	SW Process Asset
ORG.x.BP3 Maintain SW Process Assets	The purpose of this base practice is to maintain the documented SW Process Assets, including minor content updates of existing SW Process Assets and changes aiming to ensure the integrity and consistency of the structure and contents of the SW Process Asset Library.	SW Process Asset
ORG.x.BP4 Make SW Process Assets Available	The purpose of this base practice is to make SW Process Assets available for process engineering purposes.	SW Process Asset Library
ORG.x.BP5 Provide Support Services for SW Process Engineering	The purpose of this base practice is to provide support services for other SW Process Engineering activities, including e.g. SW Process Development and SW Process Measurement. The form of support can be e.g.: training or consultancy concerning the contents of current SW Process Assets, support in SW Process Development, support in the use of SW Process Asset Management-related technology, and support in SW Process Engineering Planning	SW Process Asset Support Services
ORG.x.BP6 Provide Support Services for SW Projects	The purpose of this base practice is to provide support services for SW projects.	SW Process Asset Support Services
ORG.x.BP7 Assess Use of SW Process Assets	The purpose of this base practice is to assess the use of SW Process Assets.	SW Process Asset Usage Report
ORG.x.BP8 Track SW Process Asset Management Activities	The purpose of this base practice is to regularly report the status of the SW Asset Management activities and to compare them against plans. Note: Particular aspects to address include: Deliverables, Effort, Schedule, Resources, and Risks	SW Process Asset Management Status Report

The full base practice descriptions can be found in Appendix 3: Generic Activities for SW Process Asset Management. The base practice descriptions include references to all related work products and roles. The role descriptions can be found in Appendix 5: Generic Roles for SW Process Asset Management and Deployment. The full work product descriptions - outputs only - are presented in Appendix 4: Generic Work Products for SW Process Asset Management and Deployment.

The illustration of the process SW Process Asset Management is presented in Fig. 7. The notation used is explained in Appendix 1.

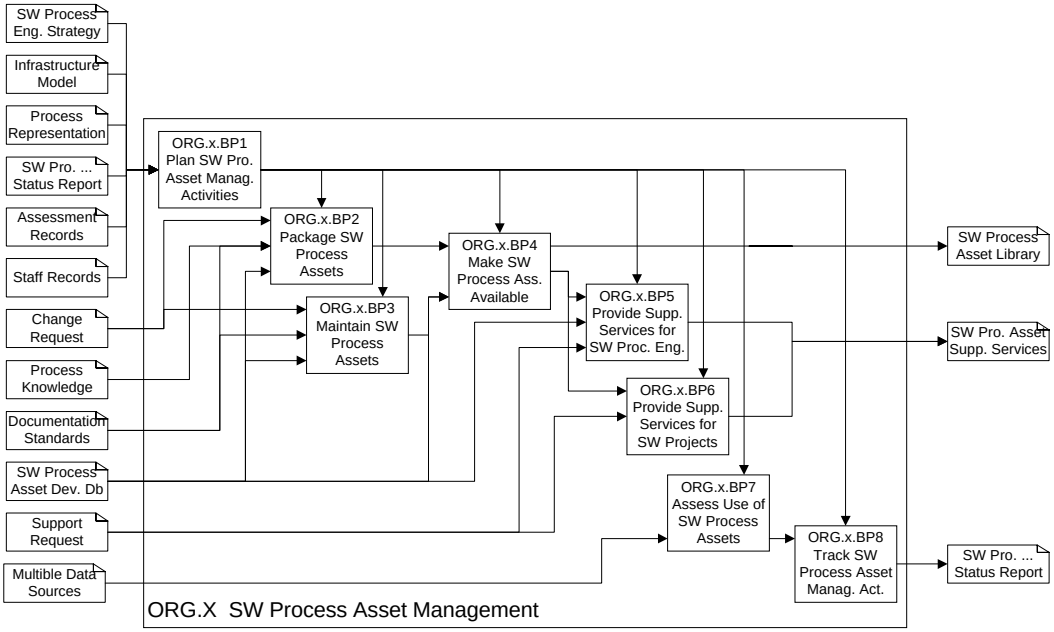

Fig. 7. Illustration of the process SW Process Asset Management

The defined SW Process Asset Management process does not cover Process Development activities. Instead, it focuses on packaging the SW Process Assets and maintaining them. Proper definition of all Process Development-related activities and work products in this study report would be considerably long and there are already good models describing the Process Development process or related issues (see e.g. SPC-93098-CMC 1994, McFeeley 1996, Kontio 1998, Armitage et al.1994, Kasunic 1998, Kellner 1999). In addition, SW process assessment models, like ISO 15504 and SW-CMM, contain process development-related information. However, those do not contain enough detail to really support enactment. In actual practice in the case organization, people in the SW Process Area Responsible and Local SW Process Asset Responsible roles package the results of process action teams, focusing on Process Development, as SW Process Assets for the SW Process Asset Library (SPI Plans and Reports, Personal log).

7.4 SW Process Deployment

The activation of organizational learning is realized through SW Process Deployment. Without deployment, the SW Process Assets are little more than shelfware. It involves a number of

activities such as: selecting appropriate SW Process Assets for deployment; tailoring the selected SW Process Assets to suit the needs and requirements of the business case; providing and taking required training; acquiring and installing necessary resources (including people); enacting the process and supporting this enactment; and monitoring the enactment to see that the process instance fulfills the goals and targets set to it. (Kaltio & Kinnula 1998, Kinnula 1999.)

An important aspect that needs to be built into the tasks of SW Process Deployment is promoting SW Process Assets and developing ways to promote and ensure the use of SW Process Assets. SW engineers are not always motivated to use the SW Process Assets - especially if this requires them, without any support, to personally study the organization's standard SW processes and to search for relevant SW Process Assets in the SW Process Asset Library. Therefore, promoting the existence of SW Process Assets, their usefulness, and so forth, is vitally important for successful SW Process Deployment. The obvious way to promote SW process is training, but there are several other means available. It is of the utmost importance that promotion work is built into other processes, for example project planning (tailoring support), quality assurance and auditing. As always in promotion, the way the message is formulated and how human factors are taken into account is vital. One can learn a lot from marketing theory. In essence, process deployment is about ‘selling solutions’. The background of SW Process Engineering personnel is quite often technical without any marketing experience.

Process deployment is an extremely complex issue that involves a large range of different activities, different infrastructure elements, and multiple dimensions spanning from technical to cultural. It is not only about the activities performed by 'process people', but covers all situations where process-related knowledge is transferred. For example, an extremely powerful form of deployment is a member of senior management asking the 'right questions' in a steering group meetings time after time. Thus 'management commitment' is essential part of SW Process Deployment. That is why a comprehensive process model for process deployment is hard to define. A simplified model can be based on, for instance, the Plan-Do-Check-Act cycle (where the DO represents huge variety of activities). The purpose of the process Deploy SW Process is to plan, perform and track the results of process deployment.

Instead of defining the 'process model' any further as a formalized process representation, some important lessons learned from the study case are discussed.

The scope of process deployment can vary from the re-deployment of existing processes to the introduction of a completely new process. Depending on the size and maturity of the company, the processes that are defined may take root in the culture quickly or slowly. The subject of the deployment is often an 'old' process without any recent changes. In a large multi-site organization with rapid growth, one cannot overemphasis the importance of re-deployment. Out of the total time spent on deployment, a large majority of effort should typically go to deploying old processes to new people in the organization, or to new SW projects. In the multi-site environment, a process developed, piloted and already institutionalized in one site can be totally new to other sites.

In the planning of deployment activities, one should find a balance between deployment and re-deployment and focus on high priority process areas. These can be described, for instance, on the basis of information about the use of SW Process Assets and process assessment. The scope of deployment planning and tracking the success of deployment should extend into all levels of the multi-site organization: the global, local, project and individual. In addition, those activities should be performed at least by the global and local level organization. In the case of a multi-site SW project, the planning and tracking should be done from the perspective of the project. (Personal log.)

As already stated earlier, deployment can and should be embedded in a large variety of activities. All SW Process Engineering activities include elements that can, when performed well, support successful process deployment. Thus SW Process Deployment establishes requirements to carrying out specific tasks that otherwise logically belong to different SW Process Engineering activity categories. This is a very natural thing, as successful Deployment is

one of the most essential targets of the entire SW Process Engineering system. In process development, the selection of people participating in an action team, size of change, timing of change, how practical the change is, how the process development effort is communicated through the organization, and so forth, do certainly influence the potential success of rollout activities - the process deployment. The main point in this example is that one should take a wide view of the different possibilities for deploying the SW process. This is doubly important when one considers the crucial status of SW Process Deployment. If it does not work, all the SW Process Engineering effort comes to naught.

Amongst the essential tasks in process deployment are training, process tailoring, and quality assurance. Those are discussed further in the following paragraphs.

Training is needed to transfer knowledge and build the necessary skills for enactment. It is powerful means of deploying the processes. In NMP, we have two basic types of SW Process Asset Library-related training:

- SW process introduction training (about two hours of training or a longer version containing exercises)
- SW process tailoring (training and a workshop)

Training related to different areas of the SW process should always use the standard organizational SW process as a reference framework.

One challenge in training, and in process deployment overall, is timing. The transfer of knowledge succeeds well only if the audience for the delivered message has an acute need for the information (Kotler 1994).

Tailoring is the core of process deployment. It is needed to ensure that the process instance matches the needs of the business case. Projects do not use everything from the SW Process Asset Library. All projects have to develop a project-specific process for that SW project by tailoring the organization's standard SW process. The organization should provide proper support for process tailoring. It is an effective way of influencing the project’s behavior and creating or strengthening the bi-directional communication channel between the project and the SW Process Engineering organization.

The purpose of the SW Quality Assurance process is to ensure that the SW activities and SW work products comply with all applicable standards, procedures, and requirements. The key requirement of SW Quality Assurance is that an objective, independent view of the quality of the SW process and the SW work products be determined and reported. SW Quality Assurance's main activity is regularly tracking the results of process deployment, that is checking the level of deployment in an individual SW project. Even though process assessment and audits can be used for the same purpose, based on our experience, these should not be applied as frequently because these are more disruptive for the projects.

7.5 Processes in related work

The discussion about processes in related work, relevant to the focus of this study, is categorized based on the three processes described in this chapter.

Establish and Maintain SW Process Asset Management and Deployment System in related work

SW-CMM 1.1 (Paulk et al. 1993b) does not recognize the activities covered by the process ORG.X Establish and Maintain SW Process Asset Management and Deployment System by any key process area. However, it does cover most of the outcomes of the successful execution of the process described above and in the related appendices. It does this using statements in several key practices, or sub-practices, in different common features. Those are mainly in the ability common feature, for instance in stating group needs such as "…exist, adequate resources and

funding is provided…, tools to support…are made available, …receive adequate training to perform these activities" (Paulk et al. 1993b). Thus, SW-CMM 1.1 does not contradict the process. On the contrary, it supports the notion that these activities are important.

Interpreting freely, most of the activities in the process ORG.X Establish and Maintain SW Process Asset Management and Deployment System can be found also in IDEAL^{SM} 1.0, even though the perspective in IDEAL^{SM} is different to that of the SW Process Improvement program. In the initiating phase, the initial improvement infrastructure is established. The infrastructure is limited to roles and responsibilities in IDEAL^{SM} 1.0. The infrastructure is established by defining the infrastructure elements, and by assigning initial resources. Those definitions are revised in the establishing phase. In the leveraging phase, the lessons learned from one process-improvement cycle are analyzed and, for instance, SW Process Improvement processes are enhanced. At a strategic level, in the Manage the SW Process Improvement Program there are activities related to organizing, staffing, assessing and monitoring the SW Process Improvement program. (McFeeley 1996.)

In the ISO 15504, the Improvement Process (ORG.2) from the organization process category is dedicated to SW Process Improvement issues. It does not cover any of the activities from the Establish Maintain SW Process Asset Management and Deployment System process described in this study. However, other processes in ISO 15504 identify many of the activities. (ISO/IEC 1998b)

The purpose of the Human resource management process (ORG.3) is to provide the organization and projects with individuals who possess the skills and knowledge to perform their roles effectively and to work together as a cohesive group. It is not focused towards SW Process Engineering personnel, but it is as such applicable also for that context. (ISO/IEC 1998b.)

The Infrastructure process (ORG.4) covers the development and maintenance of support tools. The purpose of it is to maintain a stable and reliable infrastructure that is needed to support the performance of all other processes. The infrastructure may include hardware, software, methods, tools, techniques, standards, and facilities for development, operation, or maintenance. (ISO/IEC 1998b.)

SW Process Asset Management in related work

The SW-CMM 1.1 (Paulk et al., 1993b) activities in the key process area Organizational Process Definition do not match the base practices of the process ORG.x SW Process Asset Management. However, the common features, measurement, and verification of the SW-CMM 1.1 cover these base practices. The descriptions in SW-CMM 1.1 are rather brief compared to the process described in section 7.3 and in the related appendices.

In the IDEAL^{SM} 1.0 acting phase, there is an activity "Packages the Improvements and Turn Over to the SW Engineering Process Group (SEPG)", which is performed by the Technical Working Group. The SEPG has the responsibility of long-tem maintenance and support concerning SW Process Assets. (McFeeley 1996.)

The QIP developed depicts the activities performed by Experience Factory organization. It includes the following six steps: Characterize, Set Goals, Choose Process, Execute, Analyze, and Package. Activities can be identified also from the Experience Factory descriptions. The purpose of the Experience Organization is to capture and package the experiences generated by the Project Organization, to deliver packaged experiences and recommendations to the project, and to act as a repository for those experiences. SW Process Asset Management is in a very central role in the Experience Factory – QIP concept. However, proper process description is not included in the available material. (Basili et al. 1994a, Basili & McGarry 1998.)

The improvement process (ORG.2) in ISO 15504 covers many of the activities in the SW Process Asset Management process described in this study. The improvement process consists of four base practices and three component processes, which are ORG.2.1 Process establishment

process, ORG.2.2 Process assessment process, and ORG.2.3 Process improvement process. (ISO/IEC 1998b.)

The purpose of the Improvement process is to establish, assess, measure, control and improve a SW life cycle process. A result of successful implementation of this process is, for instance, that a set of organizational SW Process Assets are developed and made available. The purpose of one of the Improvement process base practices is to define, document and maintain a set of organizational process descriptions. The purpose of the component ORG.2.1 Process establishment process is to establish a suite of organizational processes for all SW life cycle processes as they apply to its business activities. (ISO/IEC 1998b.)

SW Process Deployment in related work

SW-CMM 1.1 (Paulk et al. 1993b) does not have a separate key process area for process deployment, but it does cover many of the activities which have been found, in the case organization, to be good ways of deploying the processes. The obvious one is, of course, the key process area Training Program.

The IDEAL^{SM} 1.0 acting phase includes an activity Rollout Solution concerned with installing a new proven solution across the organization. It includes seven subtasks. Emphasis is on deploying first time, that is doing the rollout. For that purpose, IDEAL^{SM} 1.0 provides good guidelines. (McFeeley 1996.)

Experience Factory focuses on supporting projects, analyzes and synthesizes all kinds of experience, supplies the experience to various projects on demand, and acts as a repository for those experiences. QIP process steps Characterize and Set Goals, are performed by the product development organization, but are supported by the support organization. The experience organization also participates as a support function in the steps Choose Process and Execute Process, by providing packaged experiences to the project from the experience base and by giving project support, for example in the form of consultations about tailoring. (Basili et al. 1994a, Basili & McGarry 1998.)

Two of the base practices from the ISO 15504 Improvement process (ORG.2) focus on the issue of deployment. The purpose of the first is to deploy the standard processes by involving the whole organization and initiating quality improvement projects or activities. The purpose of the latter is to assess the deployed processes on a regular basis to determine the extent to which process implementation is effective in achieving the organization's goals. (ISO/IEC 1998b.)

The component process ORG.2.1 Process establishment process also includes deployment-related base practices; the ORG.2.1.BP6 Deploy the process, and ORG.2.1.BP7 Check the standard processes deployment. The purpose of the first base practice is to make the organization's standard process family available throughout the organization, and the latter, to control the deployment of the standard process family within the organization. (ISO/IEC 1998b.)

Summary

Both IDEAL^{SM} 1.0 and ISO 15504 identified most of the activities within the three processes described in this study report. The latter has the best coverage in identifying those activities found to be relevant in the case organization. However, ISO 15504 identifies rather than describes the activities. It contains only short purpose definitions of each of the identified activities. IDEAL^{SM} 1.0 contains quite detailed descriptions about installing a new proven solution across the organization. In addition, SW-CMM 1.1 identified the results of the successful implementation of these three processes.

The related work seems to support the general significance of the activities described by this study report as process models both in this chapter and in appendices 2 and 3.

7.6 Summary of processes

First, this chapter presents SW Process Asset Management and Deployment in the context of the SW Process Engineering domain. Based on recognized categorization, SW Process Engineering includes the following activity types: Process Engineering Management, Process Evaluation, Process Asset Management, Process Development and Process Deployment. These cover all the activities that deal with SW process improvement and maintenance. From these activity types, Process Asset Management, Process Deployment, and, to some extent, Process Engineering Management, fall within the scope of this study.

SW Process Engineering Management is a continuous activity that monitors the status of the SW process, plans and implements improvements to it, coordinates its maintenance and deployment, and develops and maintains the process engineering system.

In this study, the most important aspect of the SW Process Engineering Management is to establish and maintain a system for Asset Management and Deployment. A major part of the effort contributed by people managing the system goes on the activities of establishing, monitoring and maintaining the different elements of the system. For the success of continuous SW Process Engineering activities, it is essential to recognize the activities aiming to strengthen the system itself.

The process Establish and Maintain SW Process Asset Management and Deployment System (section 7.2) includes activities for developing the system model, implementing the model, assessing the system, and maintaining the system and related models based on assessment findings. The implementation of the model includes staffing the organization, developing competencies, and developing support technology.

The SW Process Asset Management (section 7.3) is the activity that captures organizational learning into a form of reusable assets, maintains the assets, and makes them available to the SW Process Deployment for reuse. It is a critical enabler for SW Process Deployment.

The activation of organizational learning is realized through SW Process Deployment (section 7.4). The SW Process Deployment does not consist of a set of clearly bounded activities. Instead, deployment is an integral part of a huge variety of activities, including all other SW Process Engineering activities.

8 Infrastructure Model for SW Process Asset Management and Deployment

This chapter describes the defined infrastructure model for SW Process Asset Management and Deployment.

8.1 Model overview

Process infrastructure consists of the structural elements that the organization uses to enable the enactment of the process instance. An effective infrastructure is essential to support the operation of any process and SW Process Asset Management and Deployment processes are no exception to this rule. (Kinnula 1999.)

Fig. 8. SW Process Asset Management and Deployment Infrastructure Model (modified from Kinnula 1999)

As illustrated in Fig. 8 above, the Infrastructure Model identifies five elements; the ‘Activity’, which represents the process instance that the infrastructure supports, and the four elements of the infrastructure itself. The structural elements are (Kinnula 1999):

> *"**People**, representing the human resources and their personal skills and capabilities that are used to execute the process instance.*
>
> ***Organization**, representing how the resources (people, technology) have been organized to carry out the process instance.*
>
> ***Technology**, representing the technical resources or assets used in the process.*
>
> ***Knowledge**, representing the undocumented and documented information assets which are used to guide the enactment of the process."*

The following sections describe the infrastructure elements, organization, people, knowledge and technology related to the SW Process Asset Management and Deployment system.

8.2 Organization

The set of responsibilities of the different roles described below does not follow the boundaries of the different SW Process Engineering activities defined in section 7.1.1. This is because the activities in the model are grouped into logical sets where categories are defined by the objective of the activity rather than by organizational boundaries (Kinnula 1999). An organizational entity typically has several objectives. Therefore, real-life instances are often combinations of more than one of the activities in the model - even to the extent that it may be difficult to separate the different activities. This is especially true of Process Deployment which, when performed well, is an integral part of all SW Process Engineering –related processes. Therefore, the roles described in this study report cover partially also cover other SW Process Engineering activities.

The SW Process Asset Management and Deployment-related organizational entities (in the context of the whole SW Process Engineering organization) are illustrated below in Fig. 9. The illustration is a slightly modified version of Kinnula's "An architectural design model for a SW Process Engineering organization" (Kinnula 1999). The entities, which are defined further in this study report, are highlighted with dark gray shading.

The descriptions of organizational entities are based on empirical experience from the case organization. The descriptions are in any case quite generic and can therefore be used as a reference model for process definition purposes. The exact definition of the roles suggested below will vary according to the specific situation within an organization. The role definitions contain quite detailed lists of responsibilities, which can be used as checklists when re-mapping them to different roles to match the organizational context. The introduction of these roles into the organization can occur in gradual stages. However, based on our experience, all the roles are valid.

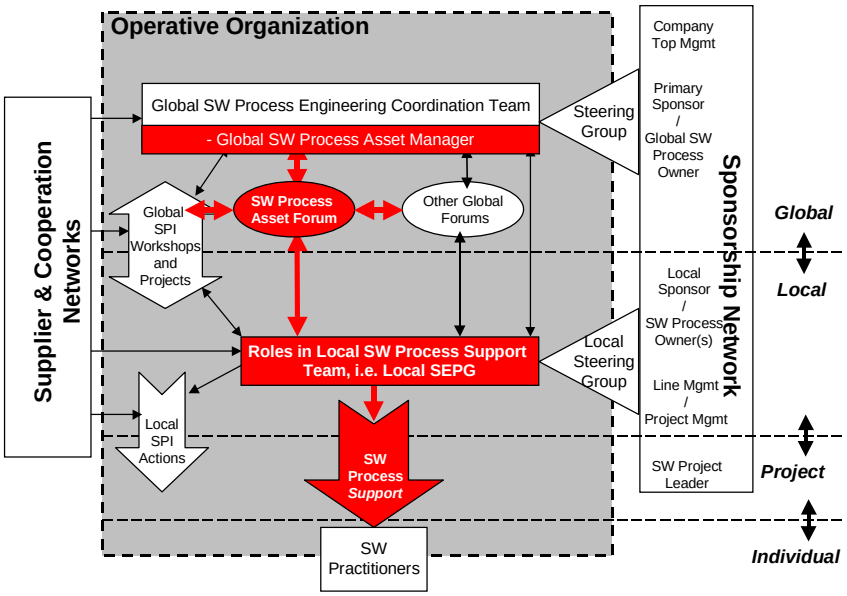

Fig. 9. Roles under the focus of the study in the context of the SW Process Engineering organization

A Role is a method of building a logical aggregate of responsibilities. A person may be in several roles concurrently. Moreover, there can be several people in the same role concurrently. For example, the SW Process Supporter role is from time to time blended with the role of SW Process Developer. When relevant process information in the SW Process Asset Library is missing or outdated, the person supporting a project will develop SW Process Assets for that individual project. If the asset is relevant to other projects, it will be documented following the process documentation standards, and will be included in future SW Process Asset Library releases. The same person might even also be the global-level SW Process Area Responsible for the process at issue. This means that all the roles described in the following sections do not have to be filled with different individuals, especially in a small single-site organization. Vice versa, in a large multi-site organization most of the roles require several people. This a factor of size that increases the workload of a role beyond the limits of what one person can cope with. Also, some roles providing support for SW development projects require in practice that the person is located at the same site as the project.

Sections 8.2.1 and 8.2.2 describe different roles at the global and local levels.

8.2.1 Global organization

The main role of the global organization is to support the local organization with SW Process Deployment and other SW Process Engineering activities, for instance by managing the SW Process Assets globally, providing mechanisms for experience sharing between sites and consulting members of the local SW Process Engineering organizations. Most of the individuals in the global organization also have local roles.

Roles or organizational units in the global SW Process Asset Management and Deployment organization are described in Table 4 (SWEP, Personal log, Interviews Site A, B, C, D and E).

Table 4. Global roles and organizational units

Role	Description	Responsibilities / activities
SW Process Asset Forum	Company-wide forum for managing the SW Process Assets and sharing information about the development and use of SW Process Assets in different SW R&D sites.	• Make decisions about the SW Process Asset Library release content • Plan and track SW Process Asset Management activities • Assess and improve the SW Process Asset Management system
Global SW Process Asset Manager	Role responsible for the coordination of all SW Process Asset Management-related activities globally. He or she is a member of the Global SW Process Engineering Coordination Team and chairperson of the SW Process Asset Forum.	• Global SPE Coordination Team member responsibilities. This team is the core team for managing the SW Process Engineering activities. • Coordination of planning, tracking and reporting of all SW Process Asset Management-related activities • Organizing SW Process Asset Forum meetings and SW Process Asset-related workshops • Provide support for SW Process Area Responsible • Provide support for Local SW Process Asset Responsible • Make new SW process releases available • Cooperation with representatives of other processes (e.g. marketing and HW) • Staffing of the SW Process Asset Management organization • Competence development in the SW Process Asset Management organization • Information gathering and distribution
SW Process Area Responsible	Role responsible for coordinating the improvement and maintenance of SW Process Assets in a defined sub-area of the whole SW process at the global level.	• Analyze and track change requests and feedback • Actively seek improvement needs and opportunities • Actively seek company experts (possible authors and reviewers) • Improve the descriptions of assets at process and base practice level (with the help of experts) • Support authors and reviewers (at

	procedure and template level) • Follow-up of local SW Process Improvement activities • Road-mapping of future improvement using input from local SW Process Improvement activities • Acting as a 'process area helpdesk'

Each of these roles has a set of responsibilities and required abilities relating to SW Process Asset Management and Deployment as well as to other areas. These are documented in the SW Process Asset Library as role definitions, which are linked to the related activities. Global roles are presented in the form of process representation in Appendix 5: Generic Roles for SW Process Asset Management and Deployment.

The **SW Process Asset Forum** discusses and decides things such as release contents for the SW Process Asset Library, actions needed to improve the asset management system, and so forth. SW Process Asset Forum members include at least one named person per site. Topic area experts are invited to meetings whenever necessary.

The SW Process Asset Forum chairperson is the Global SW Process Asset Manager. Meetings are arranged four times per year; the one for each release should be about one month before release. Special meetings can be arranged between official meetings if needed.

In conjunction with the Forum meetings, workshops are arranged on specific topics. While these are in fact mostly to do with SW Process Development work, the responsibility for their facilitation falls on the Global SW Process Asset Manager in NMP.

Global SW Process Asset Manager has Global SPE Coordination Team member responsibilities. This team is the core team for managing the SW Process Engineering activities across the multi-site organization.

As in SW Process Engineering overall, SW Process Asset Management-related activities also apply general project management principles. Planning includes all relevant levels from strategic long-term planning to operative plans for action items. The execution of plans shall be tracked end reported.

The Global SW Asset Manager prepares the agenda for the SW Process Asset Forum meeting and sends out invitations. Input for meeting and workshop topics is collected from SW Process Asset Forum Members between the meetings. The Global SW Asset Manager is the chairperson of these meetings and workshops.

The Global SW Process Asset Manager should have a better overall understanding of the SW Engineering process and its relationships than the SW Process Area Responsible persons. He or she should also have a larger contact network in the SW organization globally. The global SW Process Asset Manager is able to help when changes related to SW Process Assets cross the boundaries of process responsibility area. Sometimes SW Process Area Responsible Persons also need guidance in how to proceed with reviews and approval of changes.

The global SW Process Asset Manager also provides support for the Local SW Process Asset Responsible in his or her local activities. That can be seen mainly as a competence generation activity, but there are also plenty of situations where authority, knowledge, or the contact network of the Global SW Process Asset Manager is needed.

Making SW Process Assets available for SW Process Engineering purposes is a responsibility of the Global SW Process Asset Manager in NMP. This is done by creating new SW Process Asset Library releases every third month.

The global SW Process Asset Manager represents the SW Engineering Process in product creation process-related Process Asset Management and Development activities, and acts as a contact point for the process managers from the other disciplines.

All process areas of the whole SW engineering process shall have a nominated SW Process Area Responsible person. By default, the Global SW Process Asset Manager is responsible for all the process areas that do not have a nominated person. Since the role of Global SW Process Asset Manager is itself a full time job, the areas without a dedicated person responsible have in practice been neglected. Even though the local level has the main responsibility of nominating SW Process Asset Forum Members, the Global SW Process Asset Manager shall still act if a site doesn't fill the role.

The responsibility for ensuring competence development in the SW Process Asset Management organization lies naturally on the shoulders of the Global SW Process Asset Manager. He or she has the best view of the capabilities of the people in the organization.

The Global SW Process Asset Manager is a 'gate keeper' - a focal point - concerning a large variety of SW Engineering Process-related information. Therefore, an important responsibility is active information gathering and distribution.

The SW Process Area Responsible role is necessary, because the SW engineering process in its entirety is so complicated and huge and contains so much detailed knowledge. A single person probably cannot coordinate or especially provide adequate support for all the on-going improvement and maintenance activities of the SW Process Assets in a multi-site organization. That is why the SW Process Asset Forum found it useful to divide the SW process into sub-areas, and to nominate different individuals to coordinate activities and provide support in each of those areas. In a single-site organization, where the number of on-going process improvement activities is small, the Global SW Process Asset Manager might be able to also fulfil the responsibilities of SW Process Area Responsible persons.

The size of the process area can vary from one base practice, e.g. Develop SW units, to a whole process category, e.g. Management process category (ISO 15504-5).

SW Process Area Responsible persons analyze change requests and feed back concerning their area of responsibility. This is documented in the SW Process Asset Development Database (see section 8.5.2), and assigned to different people by the Global SW Process Asset Manager based on their responsibility area. During the analysis, the SW Process Area Responsible may use the help of other experts in the process area. Based on the analysis. the change request is either ignored, postponed, or accepted for implementation and an implementation proposal is created. If a change request causes changes to SW Process Assets, the SW Process Area Responsible seeks an author to implement the changes, or acts as author him- or herself. The SW Process Area Responsible tracks the change requests and feedback throughout the whole lifecycle.

Although the SW Process Asset Development Database provides technological support for the collection of improvement needs and opportunities in the form of change requests and feedback, many of these stay hidden at the site or project levels. To ensure both a better overall understanding of the problems and also good practices in different projects, one should not rely purely on the above-mentioned mechanism. For this reason the SW Process Area Responsible shall actively seek improvement needs and opportunities. There are several sources for this information; for instance, local process assessment reports, local SW Process Improvement plans, and local contact persons.

Building and maintaining a network of domain experts by actively seeking company experts (possible authors and reviewers), is important for the success of the SW Process Area Responsible. He or she should not rely solely on his or her own competence and effort. The reasons are at least threefold. Firstly, the experts in different sites provide a useful channel for collecting information about needs and possible available solutions. Secondly they may have a deeper insight into the matter than the SW Process Area Responsible. Thereby they can act as authors and reviewers. Thirdly, the involvement of local experts can be highly valuable when improvements are deployed.

Note that the SW Process Area Responsible is responsible for the actual editing of SW Process Assets only at the what-level, i.e. process, base practice and work product descriptions,

which are tool-, language-, and method-independent. The company experts may help with the actual work, but the responsibility lies with the SW Process Area Responsible person.

The SW Process Area Responsible may also act as an author for the how-level assets - for instance procedures and templates - but quite often the author is another person with expertise in that specific domain. In such a case, the SW Process Area Responsible provides support for the authors and reviewers. In the early stages, this is in the form of guidance for the documentation effort. Towards the end of the process, he or she reviews the results in order to ensure that the documented SW Process Assets do not conflict with the what-level information or with other process areas, and that the process architecture and design are not violated.

Local SW Process Improvement activities are the main source of changes in the SW Process Asset Library. Thus, it's important to track the local SW Process Improvement activities and to communicate the status and future plans in the SW Process Asset Forum Meetings. That information is also very valuable in the planning of the SW Process Asset Management activities.

The SW Process Area Responsible acts as a 'process area helpdesk' for the organization. The first contact point for SW projects is the local SW process support organization, but sometimes they do not possess the all the relevant knowledge. In such a case, the project or the local process organization can contact the SW Process Area Responsible. All relevant knowledge will never be documented as SW Process Assets. In such a case, the SW Process Area Responsible might be able to help, especially if there are no local domain experts available.

8.2.2 Local organization

The responsibility of process deployment relies heavily on the local SW Process Engineering organization in NMP. The main role of the global organization is to support the local organization in the SW Process Deployment and other SW Process Engineering activities. Of course, many of the people in the local organization also have global roles. The global roles related to the SW Process Asset Management were described in section 8.2.1.

SW line and project managers are essential players in successful process deployment. Shortly stated, they have far more influence on the behavior of the SW projects than process personnel (without their participation) can ever have. In Fig. 9 they are part of the SW Process Engineering Sponsorship Network. The role of process personnel is to provide support in process-related issues for all levels of the line and project organization.

The local SW Process Engineering organization consists of several roles, each of which contributes to the success or failure of SW Process Deployment. Those roles in NMP are described in Table 5 (SWEP, Personal log, Interviews Site A, B, C, D and E).

Table 5. Local roles

Role	Description
SW Process Support Team	Operative team that is responsible for SW Process Engineering activities at the local level organization. The team typically consists of the roles described below in this table.
Local SPI Manager	Role that has local responsibility for operative SW Process Engineering Management. Local SPI Managers responsibilities include e.g. management of SW Process Engineering activities, initiation and follow-up of improvement actions, taking part in the

	Global SPI Managers Forum, and reporting SW Process Engineering status locally and globally.
SW Process Supporter	Role focusing on SW Process Deployment, supporting the projects in SW process issues. He or she is responsible for supporting the SW project, tailoring the project's SW development process and ensuring conformance to the defined project-specific process. An individual in the SW Process Supporter role acts often also in the SW Trainer role. The SW Process Supporter provides an internal quality viewpoint into a SW project.
SW Quality Assurance	Role supporting SW Process Deployment by monitoring the adherence and state of enactment of the process. A SW Quality Assurance person would be responsible for ensuring conformance to the SW process and other agreed/defined quality requirements. The SW Quality Assurance provides an external quality viewpoint into SW projects and into SW line work.
SW Training Coordinator	Role focusing on SW Process Deployment and coordinating the training activities at the local level. A SW Training Coordinator is responsible for managing the resources and the work being done in training, and SW personnel development within SW Line. This work includes planning, development and acquisition, management and quality control activities.
SW Trainer	Role for SW Process Deployment, providing training on a specific SW Process Asset topic. A SW Trainer is a person whose responsibility is to provide training in a SW-related issue. This may include generic SW process/procedure training, SW design methodology training and SW development tool training.
Local SW Process Asset Responsible	Person locally responsible for SW Process Asset Management-related activities. Local SW Process Asset Responsible responsibilities include: SW Process Asset Library-related support for local SW projects, SW Process Asset Library-related support for local SW Process Engineering activities, actively seeking SW process improvement needs and opportunities, and company experts from the site, and participation in SW Process Asset Forum meetings. An individual in this role acts often also in the SW Trainer role.
Local SW Process Area Responsible	Role responsible for coordinating the improvement and maintenance of SW Process Assets in a defined sub-area of the whole SW process at a local level. The responsibilities include: maintaining and improving the process area competence, providing process area-related support, disseminating lessons learned, seeking and identifying improvement needs, and leading or taking part in improvement actions. An individual in this role acts often also in the SW Trainer role.
SW Process Developer	Role responsible for performing SW process definition and

	improvement activities. People in the role are often from SW projects, because it is critical for process deployment that the right individuals are involved in process change. If project personnel are not taking part in process development, it is very hard to convince them that the results will be suitable for them.
SW Tool Supporter	Person who is responsible for providing support for end users of specific SW engineering process-related tools. That includes also piloting and installing new tools or versions of existing tools. The tool can be an in-house or vendor-tool. One person can be tool supporter to one or several tools. An individual in the SW Tool Supporter role acts often also in the SW Trainer role.
SW Tool Developer	Person whose responsibility is to evaluate and develop SW engineering tools and environment. Developing includes tailoring the tools for the organization SW process and environment needs. This role exists both at a global and local level.

Each of these roles has set of responsibilities and required abilities relating to SW Process Asset Management and Deployment as well as to other areas. These are documented in the SW Process Asset Library as role definitions, which are linked to related activities. The role definitions for Local SW Process Asset Responsible, SW Process Developer, SW Process Supporter and SW Tool Developer are included in Appendix 5: Generic Roles for SW Process Asset Management and Deployment.

Each site shall have a nominated person for SW Process Asset Management-related activities, the **Local SW Process Asset Responsible**. He or she is responsible for ensuring that SW Process Asset Library-related training is organized at a local level for SW project and line personnel. He or she does not always have to be the one who acts as a SW Trainer. Instead, it is highly recommendable that almost everyone in the local SW process support organization can do the training.

SW Process Asset Library-related support for local SW Process Engineering activities should be provided by the Local SW Process Asset Responsible. He or she helps local SW process improvement teams to understand the current SW Process Assets, and to document the new or improved ones, helps local authors and reviewers in the use of SW Process Asset Development Database, provides support for process tailoring for the other local SW process support organization members, and so forth.

The person in this role shall actively seek SW process improvement needs and opportunities from the site, - for example best practices and problems - and communicate those to the global organization.

He or she shall actively seek from the site company experts such as possible authors and reviewers. Thus, he or she can help the SW Process Area Responsible to create the global contact network, and to transfer process-related knowledge inside the site in question. The local experts can be called upon in the deployment of specific processes.

The Local SW Process Asset Responsible is also the local representative in the SW Process Asset Forum meetings. Many of the SW Process Asset Forum members also have the role of SW Process Area Responsible in the global organization.

8.2.3 Communication channels

The SW Process Asset Forum, which meets every third month, is the main device for face-to-face communication related to SW Process Asset Management and Deployment at a global level. Between the forums, there is naturally more or less frequent communication going on between the Global SW Process Asset Manager and members of the forum, and between different members of the forum. In addition to e-mails and phone calls, the SW Process Development Database and SW Forum database are used to support communication (see section 8.5 Technology). (Artifacts, Personal log.)

SW Process Asset Management and Deployment issues are also discussed in other global SW Process Engineering forums, the Local SPI Managers Forum, SW Metrics Forum and Global SW Process Management Team meetings. The Global SW Process Asset Manager represents the SW process community in some other process domains, for instance in the Product Creation Process, which, in the case organization, includes all of the processes required to develop a mobile terminal. (Artifacts, Personal log.)

SW Process Support Team internal communication

The SW Process Support Teams in all sites organize team meetings, where plans and day to day activities are discussed. The frequency of these meetings varies between sites from one week to one month. Site D, which has several quite inexperienced SW Quality Engineers, organizes weekly meetings for SW Process Supporters and another for SW Tool Supporters. In site C, where the team consists of only five quite experienced persons, formal meetings were initially organized monthly. This was adequate for reporting purposes, but weekly, then fortnightly, meetings were found to be necessary for sharing information. (Interviews Site A, B, C, D and E.)

At the beginning, it is very useful for a newcomer to sit with experienced peers and the Local SW Process Manager. That way coaching for the role is easy to organize. In Site D, the Local SPI Manager has coaching sessions with each individual SW Process Supporter every week. In Site C, where the number of SW Quality Engineers is small, the Local SPI Managers have been able to provide support for the SW Quality Engineers on a daily basis without separate meetings. (Interviews Site C and D.)

SW Process Support Team and SW Projects

Frequent personal contact between local SW process and SW project personnel was seen as very important. That is why SW Process Supporters are typically located with the SW project they support. Thereby, they are able to communicate actively with project members on a daily basis. SW Process Supporters are actually considered to be 'one of us' by the project members if they are able to demonstrate the usefulness of the provided support services. In site C, the Local SPI Manager tried to have a SW Process Supporter starting on the project from 'day one', at the same time as the SW Project Manager. However, for newcomers it is better to sit with other SW Process Support Team members until they gain some competence, but after that they should move to sit together with the SW project personnel. The positive effect of being co-located was evident also from those cases where the SW Process Supporters did not sit among projects. In such instances, project personnel were clearly less actively involved and the intensity of communication was far more dependent on the individual SW Process Supporter's skills and the SW Project Manager's attitude towards process issues. (Interviews Site A, B, C and D.)

At the beginning of the project, most of the communication is between the SW Process Supporter and the SW Project Manager, who work together to write the SW Quality Plan. Other individuals having a central role in the project, for example the SW Requirement Manager, SW Configuration Manager and SW Release Manager, may also be involved. Sometimes writing of some sections of the SW Quality Plan is delegated to those people who are responsible for the

execution of the process. In later phases when the SW Quality Plan is put into practice, the amount of communication with other SW project members increases. (Interviews Site A, B, C, D and E.)

In Site D, the SW Process Supporter gives SW Quality Plan-related training to all project members as small groups. SW Processes Supporter activities related to the SW Quality Plan include authoring the plan, training the plan, tracking the plan, and updating the plan. Training in projects is normally organized in close connection to major milestones. (Interview Site D.)

Process audits and assessments intensify the communication between process support and project personnel during and also after the audit or assessment. That is caused by improvement opportunities found during the process evaluation. For example, changes in the review process have an impact on everybody in the project and will create the need for a great deal of communication. (Interviews Site A, B, C and E.)

The meeting practices vary from project to project. However, the SW Process Supporter normally attends at least the weekly project meetings and meetings related to major milestone. The SW Process Supporter reports the quality/process status to the project steering group either directly by himself, or by reporting to SW Project Manager who then presents the status in the steering group meeting. (Interviews Site B, C, D and E.)

The local SPI Manager communicates face-to-face with the SW Project Manager at the beginning of the project when the SW Process Supporter responsibilities are agreed. He gets feedback about results in milestone pre-checks and sometimes also on an ad hoc basis. (Interviews Site C and D.)

SW Process Support Team and SW Line

Local SW Process Asset Responsible persons normally organize SW Process Asset Library training for all members of SW Line as part of the induction training. Also, some project-specific and SW Line section-specific training has been organized. SW Process Support team members were invited to different meetings and forums to tell about various processes-related topics. (Interviews Site A, C, D and E.)

Most of the sites have some sort of steering group for the SW Process Engineering activities consisting of both SW Line and SW Project Managers. The local SPI Manager also attends SW Line Managers meetings. Some sites also had meetings for the whole SW Line where process issues were additionally covered. (Interviews Site A, B, C, D and E.)

When a new SW Process Asset Library release is available, the Local SW Process Asset Responsible or Local SPI Manager sends a release note via e-mail to the whole SW Line (Interviews Site A, B, C and D).

8.2.4 Organization in related work

SW-CMM 1.1 attempts to remain independent of specific organizational structures and models. However, it does recognize some groups related to SW Process Engineering; the SW engineering process group, SW quality assurance group, and the training group. It does not define further the different roles in the above mentioned groups. (Paulk et al. 1994.)

The IDEAL^{SM} 1.0 model includes a description of three principal components of the infrastructure; the Management Steering Group (MSG), SW Process Engineering Group (SEPG) and Technical Working Group (TWG) (McFeeley 1996).

The Management Steering Group's purpose is to guide SW Process Improvement implementation activities in the organization. It will establish the objectives and set direction and priorities for the SW Process Improvement program. The SW Process Engineering Group's mission is to sustain the SW Process Improvement program in an environment of change, through gaining and reinforcing sponsorship, planning and coordinating the individual

improvement actions, leading the improvement effort, exchanging information and facilitating the improvement activity in general. The Technical Working Group is the operative element of the SW Process Improvement program, created to address a specific process area in order to improve it. Technical Working Groups are typically temporary, being created for a single objective and disbanded once the objective is reached. In addition they depict two additional components which are meant for very large and geographically dispersed organizations; the SW Process Improvement Advisory Committee (SPIAC) and Executive Council (EC). (McFeeley 1996.)

IDEAL^{SM} 1.0 does not include specific role definitions for individuals performing different SW Process Engineering Activities. The roles in the case organization, defined in section 8.2, fulfill similar responsibilities to the SW Process Engineering Group and Technical Working Group. These roles are however broken down further, each having a logical set of responsibilities. Furthermore, these roles are permanent not temporary. In addition to the roles in section 8.2, finite Technical Working Groups do exist. In the case organization, those are normally called Process Action Teams. (McFeeley 1996.)

The Experience Factory is the infrastructure for supporting the development, packaging and deployment of reusable experiences. The QIP process requires certain supporting technologies and methodologies to be functional; the execution of the process needs an organization with defined roles to take care of the recognized activities or tasks within the QIP process. The Experience Factory approach separates product engineering (the SW development) from process engineering (the competence development). The Experience Factory infrastructure contains three organizational elements, which are: Product Development organization, Experience Packaging organization, and Support organization. (Basili & McGarry 1998.)

The roles are defined by the activities that they are responsible for. The purpose of the Experience Organization is to capture and package the experiences generated by the Project Organization and to deliver packaged experiences and recommendations to the project. The experience organization has the responsibility of the QIP process steps, Analyze and Package. In addition to these, the experience organization also participates in the QIP process steps Choose Process and Execute Process as a support function. It does this by providing packaged experiences to the project from the experience base and by giving project support, for instance in the form of consultations about tailoring. (Basili & McGarry 1998.)

The infrastructure model, presented in the ISO 15504-7 (ISO/IEC 1998c) material, is very much focused on the management responsibilities for the identified organizational elements. Consequently the model focuses on the management-related tasks of these elements, for example it describes what responsibilities the process improvement program management has, but leaves the element otherwise unexplored. (ISO/IEC 1998c.)

The only broader concept presented concerning the infrastructure is the statement that the improvement infrastructure should be able to involve the entire organization, if the improvement is to be performed effectively. The infrastructure proposed in the ISO 15504-7 model centers around organizational issues and management responsibilities. The main five elements, or roles, that the model recognizes are Senior Management, Process Improvement Program, Process Improvement Project, Process Owner, and Organizational Unit. Depending on the size and structure of the organization, some of these roles may be allocated to the same person or the responsibilities of one role may be spread across several people. However, the roles are not broken down any further. (ISO/IEC 1998c.)

Organizational and management infrastructure by Zahran (1998) includes roles and responsibilities that have to be in place in order to sponsor, manage, perform and monitor SW process improvement activities. 'Organizational and Management' should span the following organizational levels and identify / support the following agents (Zahran 1998):

- Corporate / Organizational level
  - Executive sponsor, Steering Committee, SEPG
- Project / Team level

  - Project managers, project controllers, team leaders and projects SW engineers
- Personal level
  - SW Engineers

The implementation model for the Organizational and Management infrastructure identifies the following roles: Executive Sponsor, Steering Committee, Corporate SW Engineering Process Group (SEPG), Process Improvement Teams, and Process Owners. Of these roles, Zahran considers The Executive Sponsor and the Corporate SEPG as the most critical roles for SW Process Improvement. In the focus of this study, the most relevant ones are SW Engineering Process Group and Process Improvement Teams. (Zahran 1998.)

The SW Engineering Process Group is the focus and the central driving force of all SPI effort. It is responsible for the coordination and support of all SPI activities across the organization, acts as a keeper of and manages the improvement of the organization's standard SW process, assumes responsibility for improving process-related assets within the corporation and maintains collaborative working relationships with SW engineers and SW project managers. Due to its critical role, the Corporate SEPG must be formed carefully in terms of its organizational structure, membership and responsibilities. (Zahran 1998.)

Process Improvement Teams are composed of part-time members who have experience in the area to be improved. The improvement teams are responsible for implementing the SPI actions assigned to them. This includes all process improvement –related actions; documentation, analysis, process redesign, technology selection, training, and so forth. (Zahran 1998.)

Summary

IDEAL^{SM} 1.0, Experience Factory and work by Zahran include descriptions of organizational elements. Three principal components of the infrastructure in IDEAL^{SM} 1.0 are Management Steering Group (MSG), SW Process Engineering Group (SEPG) and Technical Working Group (TWG) (McFeeley 1996). In addition IDEAL^{SM} 1.0 includes two additional components which are meant for very large and geographically dispersed organizations; the SW Process Improvement Advisory Committee (SPIAC) and Executive Council (EC). (McFeeley 1996.) The Experience Factory infrastructure contains three organizational elements, which are Product Development organization, Experience Packaging organization, and Support organization. (Basili & McGarry 1998.) The implementation model for Organizational and Management infrastructure by Zahran (1988) identifies Executive Sponsor, Steering Committee, Corporate SW Engineering Process Group (SEPG), Process Improvement Teams, and Process Owners.

The roles in the case organization, defined in section 8.2, fulfill similar responsibilities to the SW Process Engineering Group and Technical Working Group or Process Improvement Team in IDEAL^{SM} 1.0 and Zahran, and to the Experience Packaging organization and Support organization in Experience Factory. These roles are however broken further down, each having a logical set of responsibilities. Unlike the Technical Working Group, these roles are permanent, not temporary. In addition, the SW Process Asset Forum fulfills partially the purpose of SPIAC by providing a forum for sharing information regarding the SPI activities that are being undertaken by different parts of the organization (McFeeley 1996).

8.3 People

The 'People-element' is defined by Kinnula as covering the issues that influence a person's capability and willingness to carry out activities. These include (Kinnula 1999):

> *"**Abilities** – skills and knowledge that can be taught and acquired, and characteristics that people have. Examples include: use of a tool, process knowledge, understanding*

of how the organization works or how to deal with people, openness and natural networking skills, charisma or leadership abilities, etc.

***Standing** – both formal title and rank, as well as the more informal respect that the person has from the other members of the organization*

***Motivation** – influences the likelihood and the extent to which a person will actually use the time allocated to carry out the tasks and may affect the quality of the results as well.*

***Time** – the time allocated and available to carry out the activities."*

The abilities, motivation, time allocation, and standing of people are somewhat dependent on the organization in question (Kinnula 1999). However, some generic conclusions can be drawn from each of the people elements in the context of SW Process Asset Management and Deployment. Those should help the reader in filling the different roles in the organization, and in improving the efficiency of the existing organization.

8.3.1 Abilities

The necessary skills and knowledge to perform different roles must be considered and taught to people. A training- or competence development program for people engaged in process deployment is critical for the efficiency of the overall system of SW Process Asset Management and Deployment.

Special emphasis should be given to the training and coaching of new members of the SW Process Engineering Organization. Personnel turnover and growth without proper training can easily cause deterioration of the infrastructure. In other words, the need for process maintenance applies also to the SW Process Engineering process itself (Kaltio & Kinnula 1998, Kinnula 1999).

In the case study, two broad categories of abilities were identified; technical knowledge and skills, and soft skills. The soft skills, for example communication skills and ability as a public performer, are seen as very important in the context of Process Deployment. Technical skills were not seen as critical. (Interviews Sites A – E, SWEP, Personal log.)

The soft skills which should be possessed by the different roles for them to be up to standard, include the following partially overlapping skill sets:

- Change management skills
- Communication skills
- Consulting skills
- Selling skills
- Facilitation skills
- Interviewing skills
- Team work skills

Infrastructure element knowledge is discussed further in section 8.4. The required knowledge and skills in the different roles are presented as part of role definitions in Appendix 5: Generic Roles for SW Process Asset Management and Deployment.

The organization can influence the level of these abilities by an appropriate recruitment policy, systematic competence development, and by encouraging individuals in the SW Process Engineering organization to acquire missing skills by several different means including tutoring, conferences, external and internal training, self-study and 'learning by doing'.

Different sites in the multi-site case organization have applied different recruitment policies in respect of the skill and experience levels of newcomers. Sites A, B and D have also been recruiting inexperienced people directly from university to the SW Process Support organization, whereas Sites C and E have recruited only experienced people (Interviews Sites A, B and D). When there is a critical mass of experienced people in the team, you can more easily bring in inexperienced people (Personal log, Interview Site C).

In the case organization and in Nokia overall, competence development is taken very seriously. The supervisors conducted individual development discussions twice a year with each member of the organization, where the necessary skills and knowledge were discussed and plans to achieve these were drawn up. Role-specific skill definitions were used during those discussions. (Interviews Site A, B and D.)

Skills and knowledge can be acquired by several different means including tutoring, conferences, external and internal training, and self-study. In all case study sites, Local SPI Managers and experienced peers tutored the newcomers. Site A had nominated personal tutors, 'godfathers', for each newcomer. Their role was to speed up the learning process by tutoring newcomers on an almost daily basis (Interview Site A, Personal log). In addition, the SW Project Managers can have a huge influence on how fast new people in the SW Process Supporter role gain the necessary skills and knowledge by giving suitable assignments and the necessary support (Interview Site B). Frequent interaction with peers at a local and global level was also seen as a valuable vehicle for learning. (Interviews Site A, B, C, and D.)

Members of SW Process Support teams could, and did, participate in several different types of conferences and training aimed at increasing knowledge and skills. Most of them attended at least one international SW Process Improvement conference per year. Induction training included process and quality information in addition to covering technical and organizational issues. Since the beginning of 1999, an NMP-specific two-day SW Process Engineering course has been organized. In 1999, training was organized three times with total number of attendees numbering more than 70. Those were members of the NMP SW process community. Training about a large variety of SW Process Engineering topics (for example SW quality assurance, SW configuration management, SW metrics and process assessment) has been organized frequently at the Nokia corporation level, and at NMP global and local levels. Many of the well-known professionals in the international SW Process Improvement community have been giving presentations in these Nokia internal courses and seminars. Nokia also offers different types of training addressing soft skills. In addition to the Nokia internal training, public courses and seminars have also been actively used in skill development. (Personal log, Interviews Site A, B, C, D and E.)

One special skill requirement concerning the global multi-site environment is language skills. The official language in Nokia is English, which is used very frequently. Therefore, people who are not native speakers had to be sure to acquire an adequate level of English language skills to be able perform well in this multi-national working environment. In the case organization, even each site is a multi-lingual working environment (Interview Site A.)

8.3.2 Standing

Standing, both formal title and rank, as well as the more informal respect that a person commands from other members of the organization, has an impact on the ability to achieve results in SW Process Engineering. Standing does certainly influence the credibility of the message communicated by an individual.

Formal rank was not seen as very important in trying to achieve results in the projects. It was more important to be seen by the SW development project members as 'one of us', and as a good person. (Interviews Site B, C, D and E.)

However, the formal rank or title for the different roles in the SW Process Engineering organization should be high enough to attract the right kind of people to gravitate to these roles. These roles should not be a bad or uncertain career move. For example, for a SW Engineer, the SW Quality Engineer role can be a qualification towards the SW Project Manager role. In organizational project charts, the SW Process Supporter was often drawn high in the chart at the 'right hand' of the SW Project Manager. In addition, the Local SPI Manager was normally reporting to the Senior SW Line Manager. (Interviews Site B, C and D, Personal log.)

Informal respect has to be earned by achievements, but it is not a necessity to earn it in SW Process Engineering activities. A successful background as a SW Engineer or a SW Project Manager can bring respect in the eyes of former peers (Interview Site B). There is also a notion that the SW Quality Engineers should not be hired directly from university. Instead they should already have some practical experience (Interviews Site B and C).

There is a certain paradox in earning respect or informal standing by achievements, because in a communication-intensive and people-centered workplace you often need such standing to be able to achieve good results. Keeping this in mind, the first improvement actions should be selected carefully. A person can win the trust of the project personnel by first proving oneself useful to the project with a small, simple, practical and timely improvement. (Personal log.)

Personal characteristics, for example stamina, cheerfulness, voice, flexibility and boldness, may also have a remarkable influence on the standing of an individual. Some people can easily get others to co-operate and are therefore more suitable for process deployment-related activities. (Interview Site B, C, D and E, Personal log.)

A person who does not posses a high standing in the organization can increase the credibility of their message by referencing another respected individual, or their own experiences on a project that is known to have performed well (Interview Site B and E, Personal log). Local references had more influence on project personnel behavior than references from other sites or global or corporate level SW Process Engineering activities (Interviews Site B, C and E). Visible management commitment can increase the standing of the person performing SW Process Engineering activities (Interviews Site A, B and D, Personal log).

Personal networking was seen as valuable when trying to achieve something. In Site B, new SW Quality Engineers were advised to build a personal network inside the project to be able to influence efficiently. It was important to recognize people who were willing to co-operate or help. SW Quality Engineers did not have real authority. Everything normally had to be sold to someone, for example to a SW Line Manager or SW Project Manager, before trying to get things through at SW Engineer level. (Interview Site B, Personal log.)

8.3.3 Motivation

The motivation of the process personnel influences the actual effort put into, and the efficiency of, the SW Process Engineering activities. Face-to-face communication - the 'walk and talk' - is an essential part of successful SW Process Deployment. Motivation, or lack of it, can be easily recognized in face-to-face contact. Motivation does significantly affect the quality of communication and therefore how well the delivery of the intended message succeeds.

Issues influencing SW Process Engineering personnel motivation include:

- achievement of visible results
- existence and nature of feedback
- clarity of set targets
- management commitment
- intercommunication with peers
- turnover of people
- personal characteristics

A highly motivating, and on the other hand de-motivating, matter for the SW Process Engineering personnel was the achievement of visible results from the work done. Some of the SW Quality Engineers were de-motivated because they had not reached visible results in the projects. Motivation was highly dependent on how well project personnel were engaged in the project's SW process-related activities. If they did not get involved, SW Quality Engineers became frustrated. (Interviews Site B, C, D and E.)

Working in a low priority SW project demotivated one person in Site D, which has a young SW process support organization. No results were achieved in the project for a quite long time. That made the individual feel uncertain. Later the individual moved to another project that had higher priority. Soon visible results were achieved, which clearly increased motivation. (Interview, Site D.)

In Site C, lack of SW Process Supporters in the projects prevented the local SW Metrics Coordinator from achieving almost any results concerning SW metrics. The situation has changed since, which caused a shift from frustration to motivation. (Interview, Site C.)

In Site C a SW Quality Engineer got positive feedback from one of the project members that inspections were really worth doing, and this motivated the SW Quality Engineer in question. (Interview, Site C.)

These examples indicate that the organization should perhaps try to scope the activities in the projects so that the initial results of small, simple, practical, and timely actions can be achieved after only a very short period of time. If the SW project is not willing to work together with the SW Quality Engineer(s), the SW process support organization should avoid putting a SW Quality Engineer, especially an inexperienced one, in that project.

Clear targets both at the individual and team levels were seen as motivating. There was also money involved in the target-setting in the form of bonuses, but it was claimed that the main motivating factors were understanding what was expected from the individual, and how well he or she met the targets. (Interviews Site A and D.)

Bonuses, salary and job grade, were not seen overall as major motivating factors (Interviews Site A, B, C, D and E). However, it was pointed out that the SW development projects' personnel get on average higher bonuses than the SW Process Engineering personnel. That was seen as an indicator that management did not value their work as much, which was a bigger de-motivating factor than the actual money involved. (Interview Site B.)

In the past, lack of management commitment had been quite visible in Site C. There was no support for recruiting people to work with SW Process Engineering issues. They did not get any feedback or understanding of the plans and actions from management. Higher management did not push the process actions by showing visible commitment to the SW Project Managers. All this demotivated the Local SPI Manager. (Interview Site C, SPI Plans and Reports, Personal log.)

Participation in international conferences, seminars and other types of training, was seen to be good for motivation. An important issue was the chance to communicate with peers in the SW Process Engineering field. (Interviews Site A, B, C, D and E, Personal log).

Being together with the peers from the local SW Process Support team at team building events and team meetings was likewise seen to be important for motivation (Interviews Site A, B, and D).

Turnover of the people in the organization can cause de-motivation. New people do not always have the necessary competencies. At a minimum, they lack the knowledge about the organization's domain, historical events, and how the system for SW Process Engineering, and more specifically for SW Process Asset Management and Deployment, is supposed to work in the organization. It is important to package all relevant knowledge in such a way that it can be used efficiently in competence development. Otherwise new people have to 're-invent the wheel', and the system starts to deteriorate. (Personal log.)

A good way of finding the key motivation factors is to ask why people choose SW Process Engineering as a career in the first place. In the interviews, a chance to help people and "make a difference" seemed to arise as one possible theme. Some of the interviewees believed that people

have certain personal characteristics; enthusiasm and idealism were two of the characteristics used. One interviewee stated that: "It's motivating to try to prevent people from make the same mistakes they used to earlier in their career." Another described personal motivation by stating that: "Everybody has to work. If we can improve how people work, they will more probably take an interest in what they are doing. Great moments are when somebody can take on board the concepts that you have tried to put to them." (Interviews Site A, B, C and E.)

8.3.4 Time allocation

Sufficient resources are to be allocated. Based on experience, the organization can gain an understanding about suitable resource allocation for the different roles. That is however highly dependent on the size of the SW engineering organization, number of projects, size of projects, etc. Applying the ORG.x.BP.8 Track Process Asset Management Activities (see section 7.3) does, however, quickly provide more insight into the required resource allocation for different roles in the organization in question.

Some industry experience reports give simple rules of thumb concerning resource allocation to SW Process Engineering activities relative to the total allocation of resources to SW engineering activities. Those figures normally fall between 1 – 7% (McFeeley 1994, Krasner 1997). Other reports express similar information as costs of SPI per SW engineer, e.g. $490-$2004 per SW engineer (Herbsleb et al. 1994).

The following paragraphs provide some guidelines for role-based resource allocation. Roles and related responsibilities are described in section 8.2 and Appendix 5. These guidelines are based on the experiences in the case organization. Basic assumptions are that the organization has multiple sites, and each site has more than 50 people working in SW engineering. Individual abilities, motivation and standing have influenced the resource allocation necessary for achieving good results in these roles.

In the study focus, there are two global level roles, the Global SW Process Asset Manager and SW Process Area Responsible. The Global SW Process Asset Manager role is a full time role. In the case organization, none of the SW Process Area Responsible persons had used more than 20% of their time annually for this role. The effort was concentrated near to the release dates of the SW Process Asset Library four times per year. This allocation has been too little. Our understanding is that all critical process areas, for example requirement management, project management, and configuration management, should have one dedicated person with a minimum of 50% time allocation. On the other hand, the role could take full 100% allocation for shorter periods of time. We have found that to work in a local role, close to SW development projects, is a good combination with this role. Process areas that demand less active improvement or maintenance require smaller resource allocation. The responsible person can easily cover several processes, or alternatively be allocated more in other roles. Note that there are also other roles at the global level SW Process Engineering organization, for example the Global SW Metrics Manager. (SPI Plans and Reports, Interview Site A and B, Artifacts, Personal log.)

At the local level organization, we have found the SW Process Supporter role to be both critical for SW Process Deployment and also demanding largest amount of allocated resources. In the case organization, some SW Process Supporters used only 15%, or even less, of their time for each project. That was absolutely too little. Even 25% was found to be inadequate. It was impossible to provide proper support for the project. The proper amount has been found to be about 50%. The load can be sometimes 100%, especially in the beginning of the project and when approaching a major milestone. One person can properly support two SW projects, if those are conveniently in different life-cycle phases, and the person has no other roles. These guidelines naturally depend on the project characteristics, for instance the size, and competence of the people in the role. (SPI Plans and Reports, Interview Site A, B, C, D and E, Personal log.)

The SW Quality Assurance role, as defined in the case organization, demands much less resource allocation per project annually, that is, from 10 – 30%. However, the effort is not uniformly distributed. There are effort peaks slightly before the major milestones. In the case organization, some people had a SW Process Supporter role in one project, and a SW Quality Assurance role in another project or projects. This has proven to be a good combination. The roles support each other and increase the knowledge transfer between projects. (SPI Plans and Reports, Interview Site B, and D, Personal log.)

The local SPI Manager role was a full time role in Sites A, B and D. In Sites C and E they have also other responsibilities. Sites A, B and D had one full time SW Training Coordinator. The resource allocation for the SW Process Developer and SW Tool Developer roles was totally dependent upon the amount of ongoing activities. (SPI Plans and Reports, Interview Site A, B, C, D and E, Personal log.)

8.3.5 People in related work

The discussion about people in related work is categorized based on abilities, standing, motivation, and time allocation.

Abilities

SW-CMM 1.1 recognizes systematically the skills-element in the common feature abilities in all of the key process areas. One of the abilities, in each of the relevant key process areas, states "<Roles> receive required training <to perform their X activities>" or "<Roles> are trained <to perform their X activities>" (Paulk et al. 1994). However, the included examples do not cover all the skills indicated to be important for performing the activities. The 'soft skills' were identified in essence only in conjunction with the key process area Organization Process Focus in the ability 3, which gives "organization change management" as an example of training for the members of the group responsible for the organization's process activities (Paulk et al. 1993b).

Regarding, training or technical skills in the key process area Organization Process Definition, the following topics were listed as examples: SW engineering practices and methods, process analysis and documentation methods, and process modeling (Paulk et al. 1993b).

For the five organizational infrastructure components of the IDEAL^{SM} 1.0, model states skills and characteristics of the people who should be selected to be members of these organizational components. In addition, at the beginning of each IDEAL^{SM} 1.0 phase there is a table providing guidelines for skill development and training for the phase. This table maps necessary skills to organizational components, the MSG, SEPG, TWG, line managers and practitioners. (McFeeley 1996.)

The soft skills recognized by IDEAL^{SM} 1.0 are team development, team skills, managing technological change, change management, interviewing skills, and facilitation skills. Technical knowledge, or skills, are CMM for SW, SPI processes, SPI skills, planning skills, data reduction skills, business knowledge, baselining methods, strategic planning, vision development, sponsorship, business planning, new/modified processes, and problem solving techniques. (McFeeley 1996.)

The Experience Factory approach separates product engineering (the SW development) from process engineering (the competence development). The reason for this is that the roles and responsibilities of these two entities are very different, and so the skills required from the people allocated to each activity are different and profiles need to be planned accordingly. The process engineering skills of this are not, however, explicitly defined in the available material. (Basili & McGarry 1998.)

ISO 15504-7 model does not describe the characteristics, skills or attributes for the people within the infrastructure. (ISO/IEC 1998c.)

Standing

According to IDEAL[SM] 1.0, the SEPG leader should be a respected member of the organization, have gained the confidence of his or her peers, and have the support and confidence of the (local) senior management. Since SEPG members are critical to the success of SPI program, the members should be screened to ensure they have the relevant background, experience and enthusiasm. One of the stated personal characteristics of SEPG members is to be respected by peers. (McFeeley 1996.)

Motivation

IDEAL[SM] 1.0 states in A.2 The SW Engineering Process Group that "As the catalyst for the SPI program, one of the biggest challenges for the SEPG is to maintain the motivation and enthusiasm for process improvement across and between all levels of the organization."

Time

The SW-CMM 1.1 does not go into any details concerning time allocation. It merely states in the common practice ability, in all the relevant key process areas, that adequate resources and funding should be provided (Paulk et al. 1993b). IDEAL[SM] 1.0 recommends that 1-3% of an organization's personnel should be applied to managing and executing SW Process Improvement (McFeeley 1996).

Summary

The people abilities are mentioned is some form by all reference models discussed above. However, only IDEAL[SM] 1.0 defines explicitly the skills required by different organizational entities. Most of the skills are the same as the ones found important in the case organization. Standing and motivation-related issues are mentioned only in IDEAL[SM] 1.0. , and then only briefly. IDEAL[SM] 1.0 is also the only model that gives any concrete guidelines for resource allocation.

8.4 Knowledge

There are two main categories of knowledge relevant to the focus of this study report: SW Process Engineering Knowledge and SW Engineering Process Knowledge. The former is used by SW Process Engineering personnel in their activities. SW development project personnel in SW engineering activities use the latter. The knowledge needs in the relevant process domains include activities and different infrastructure elements.

8.4.1 Use of knowledge in SW Process Engineering

The SW Engineering Process is the main object of the SW Process Asset Management and Deployment activities, therefore SW Process Engineering personnel also have to possess a good understanding about it. The specific knowledge needed by an individual depends on their assigned responsibilities and the tasks in hand. However, everybody needs at least a basic understanding about the whole SW Engineering Process and a more specific understanding of some process areas. The highest priority processes are requirement management, project management, configuration management, and peer reviews, as suggested by the SW-CMM (Paulk et al. 1993a).

In the SW Process Engineering domain, a good understanding of all areas is valuable for people working in the organization. Knowledge needs include the global and local organization as well as the tools in use. More detailed knowledge is needed about issues that fall within the scope of the individual's responsibilities.

Only part of the knowledge will be packaged as process representations, some will be documented in other forms - for instance plans and reports - and some of the used knowledge will never be documented.

Since 'one size fits all' solutions seldom work, knowledge about organization and project domains including the SW under development is vital. Even though the offered solution would be overall suitable for the project needs, it is possible to find selling arguments, for example the rational, emotional and moral appeals (Kotler 1994), from the domain knowledge about the project's situation. In the case organization, newcomers gain understanding of how their work fits into the big picture through the induction training (Interview Sites A, C and E, Kaltio 1999).

Process deployment is in essence about selling solutions. Knowledge about the domains of marketing, human behavior and change management equips process personnel with valuable means to achieve the goals of SW Process Deployment. The main challenge in SW Process Engineering is to change the culture. This is discussed further in section 8.4.3 (Interviews Site A, B, C, D and E, Kaltio 1999.)

NMP has established the basic procedures and processes for SW Process Asset Management and Deployment. One of the most relevant procedures from the viewpoint of this study describes the structure of the SW Process Architecture and supports the development and deployment of new SW Process Assets. The development of a SW Process Architecture and SW Process Documentation Standards were discussed in section 6.2.2. The resultant SW process architecture elements are described in Appendix 1.

Documented knowledge, which is used to guide the SW Process Asset Management and Deployment activities, exists in different forms. In the case organization, role descriptions together with job descriptions that were relevant to the SW Process Asset Library were used to introduce roles to newcomers. Most of the activities performed by these roles were also documented in the SW Process Asset Library. The newcomers attended the SWEP Introduction Training and NMP SPI Training, the latter of which was organized by the global organization. The training delivered both documented training materials and undocumented knowledge - the parts of the presentations that were not covered by handouts, and discussions with peers. (Interviews Site A, B, C, D and E, SWEP, NMP SPI Training Material.)

For new roles, like local SW Process Assessment Coordinator, there are no proper documented instructions available as of yet in the case organization. Knowledge transfer is based on information that is documented external to the company, and on discussions between the newcomer to the role and an experienced member of the team. (Interview Site B.)

Knowledge transfer about an individuals' responsibilities in their SW Process Engineering role occurs also in bonus discussions and in discussions between the SW Project Manager, Local SPI Manager and the SW Quality Engineer, when the project responsibilities are agreed. SW Process Support Team meetings are also used for discussions about on-going and future activities. (Interviews Site A, B, C and D.)

When supporting SW project(s), it is very valuable for the SW process engineers to have some knowledge about the SW Process Asset Library contents, how other projects have applied SW Process Assets, and what were the experiences In addition, expertise in specific process domains provides credibility. (Kaltio 1999, Interviews Site A, B, C and D)

Knowledge about other projects', sites' or companies' experiences is also valuable as a means of persuading people to do something. The information can provide both good and bad examples of how one stage or decision led to a certain situation. That provides a context into which one can put one's own experiences or further plans. However, sometimes 'not invented here' syndrome may cause problems, and it is better not to use the experiences of others as selling arguments unless they contain undeniable facts. (Interviews Site A, C and E.)

In addition to process knowledge, organization domain knowledge and historical information has also been captured to increase the understanding of the SW Process Deployment in NMP. For instance. knowing how historical events have shaped the current system and environment can help in planning future actives and strategies. (Kaltio & Kinnula 1998, Kinnula 1999.)

An individual's personal cumulative knowledge based on their own experience provides an appreciation and understanding of how badly things can go awry if they are not done properly - and the opposite is, of course, also true (Interview Site C).

Different global SW Process Engineering-related forums were systematically used as a vehicle to transfer undocumented knowledge inside NMP. They were vital for keeping in touch with what was going on and to get the undocumented knowledge. (Personal log, Interview Site C.)

8.4.2 Use of knowledge in SW Engineering

Members of the SW development projects use both documented and undocumented knowledge to guide the enactment of SW engineering processes.

Before the projects started to have SW Process Supporters working for them, the SW Quality Plan was done by the Project Manager as a 'write only' document. Now, projects that have SW Process Supporters are starting to have realistic quality plans. Certain parts of the plans have become living part of the project life. This is mainly because the working practices documented in the quality plans now have SW Process Supporters to drive them. Projects are now able to give the SW Quality Plan to new members of the project to read; this has helped them to become a full member of the project. (Interviews Site A, B and D.)

The relevant knowledge from the SW Process Asset Library is used when the SW Quality Plan is written. The relevant SW Process Assets are either included in the contents of the SW Quality Plan or the SW Quality Plan refers to those assets. As the user activity figures showed in section 6.3.6, project members also actively use the SW Process Asset Library. (Interviews Site A, B, C, D and E.)

Rather than using the SW Quality Plan, people often ask experienced team members for advice and then follow the advice given. It is normal human behavior for the majority of people to ask peers or friends when they need instructions for something. (Interviews Site A, B and C, Personal log.)

The information in the SW Quality Plan and the SW Process Asset Library was sometimes too abstract to provide guidance for process enactment. References from the SW Quality Plan to the SW Process Asset Library are at times at too high a level to enable finding concrete support for the task in hand. (Interview Site B.)

In the past, before the new SW Process Asset Library, individuals from projects wrote process-related documents for themselves. Sometimes those were also used by other projects. Because of the continuous change in the SW engineering environment, there will be always a need to write project-specific instructions, for instance due to new tools or methods in use, which may also be applicable for other projects. These are then included later in the SW Process Asset Library. (Interviews Site A, B, C, D and E, Personal log.)

Some of the knowledge is stored only as personal experience. If the knowledge is relevant also to others, it is a task for SW Process Engineering personnel to capture that experience and to turn it into SW Process Assets (Interviews Site A, B and C). A search of undocumented knowledge can be an effort-taking task demanding several e-mails, phone calls, meetings and corridor discussions (Interview Site A, Personal log).

Documented knowledge becomes more important as the number of potential users of the knowledge increases. Documenting process knowledge requires a significant amount of effort. In addition, some of the knowledge will be out-dated rapidly. Therefore, it should always be

considered if the exercise is worth doing. There is always a lack of resources in a SW process engineering organization. Organizations should try to prioritize alternative documentation efforts and find a balance between the effort spent on deployment, or re-deployment, of existing SW Process Assets and on documenting new ones.

8.4.3 Change management, human behavior and marketing-related knowledge

The obvious way to deploy, or promote, the SW process is training, but there are several other means available. It is very important to build the deployment work into other processes, for example project planning (tailoring support) and quality assurance.

As always in promotion, the way the message is formulated and how human factors are taken into account is vital. One can learn a lot from marketing theory, human behavior, and change management. In essence, process deployment is about ‘selling solutions’. The background of SW process improvement personnel is quite often technical without any experience from other domains such as marketing.

Individuals and organizations trying to deploy processes should study and apply theories, models and ideas from, for instance, the domains of change management and marketing. Below are some examples of theories applied in the case organization.

Innovation diffusion process

People are different in their readiness to try new things, for instance new products or processes, and to respond to the change. Rogers (1962) defines an individual's 'innovativeness' as the degree to which the individual is relatively earlier in adopting new ideas than the other members of his social system. People can be classified into five adopter categories, the innovators, early adopters, early majority, late majority, and laggards (Rogers 1962).

When a new innovation is introduced, it is nearly impossible to convince all these 'categories' at once. One should recognize the type of audience and the phase of innovation diffusion (e.g. adoption level of new process), whenever planning the message, channel, and means of achieving the next level. Each of these categories will relate on different type of rationale.

Individuals belonging to different categories can be sometimes recognized in advance. On the other hand, an individual can be an innovator or early adopter in some issues, and belong to the late majority or laggards in some other innovations. (Moore 1991.)

Message

The person trying to convey an idea has to figure out what message one should send to the target audience to produce the desired response. One has to formulate some kind of benefit, motivation, identification, or reason why the audience should react to the message, for instance use the process. Three different types of appeals can be identified: the rational appeals, emotional appeals, and moral appeals (Kotler 1994).

Rational appeals appeal to the audience’s self-interest showing that the ‘product’ will produce the claimed benefits. **Emotional appeals** attempt to stir up negative (e.g. fear, quilt, and shame) or positive (e.g. humor, pride, and joy) emotions that will motivate the audience to produce the desired response. **Moral appeals** exploit the audience’s sense of what is right or proper. (Kotler 1994.)

SW professionals are typically highly educated people with a technical background. It is obvious that in SW Process Deployment, rational appeals are in a main role, but one should not neglect emotional and moral appeals. (Kotler 1994.)

The following are examples of how different types of appeals that can be built into the message:

- Rational: With a minor change in the way you report test results, all the people involved can get direct access to up-to-date data, and we can automatically calculate the following useful metrics.
- Emotional (pride): These best practices are captured from local SW projects. Other SW R&D sites have found these very useful. For example, project A in site B has started to use the effort estimation method developed and piloted here. We hope that you can document method C as soon as possible, so that other projects could also benefit from the good results achieved here.
- Moral: If some sub-project of this multi-site SW project doesn't have proper change management in place, the consequences for other related projects can be severe.

Besides the content, the structure also has a major influence on the effectiveness of a message. Here we discuss two related issues which are one- versus two-sided arguments, and their order of presentation.

One- or two-sided arguments is a question about whether the communicator should only present positive aspects or also mention some of the shortcomings. Here are some findings (Hovland 1948):

- *"One-sided messages work best with audiences that are initially predisposed to the communicator's position, and two-sided arguments work best with audiences who are opposed.*
- *Two-sided messages tend to be more effective with better-educated audiences.*
- *Two-sided messages tend to be more effective with audiences that are likely to be exposed to counterpropaganda."*

The order of presentation in the case of two-sided message raises the question of whether to present the positive arguments first or last (Kotler 1994). On average, people are not keen to study quality systems and process representations, and many people tend to concentrate on finding faults and problems in the processes rather than on trying to find what is good or useful. We have found it better to present the shortcomings almost at the beginning of the presentation. That will disarm the audience and allow one to get the 'real' message through.

The previous theories were a limited sample of issues that people performing SW Process Engineering, especially deployment-related, activities could and should consider. The purpose was to encourage the reader to study further marketing, change management, human behavior and organizational science literature (see section 5.7).

8.4.4 Knowledge in related work

The SW-CMM 1.1 puts an emphasis on the documentation, and does not talk about undocumented knowledge. This is common also for Experience Factory, IDEAL^{SM} 1.0 ISO15504 and Zahran. However, in reality the role of undocumented knowledge will always remain important and should not be neglected.

The knowledge required to perform SW Process Improvement program activities is covered in the IDEAL^{SM} 1.0 by a table providing guidelines for skill development and training at the beginning of each IDEAL^{SM} 1.0 phase.

The Experience Factory is based on the philosophy that actual improvement is essentially systematic organizational learning, in the form of reusable organizational assets (corporate knowledge and core competencies) created from past experiences and used in appropriate future cases. The essential point is, that the experience must be refined into organizational asset, and be easily accessible to all those who may benefit from it. Implicit improvements, where the

experience is accumulated to personnel only, and ad-hoc process changes, are not process improvements as such. (Basili & McGarry 1998.)

8.5 Technology

In the early phase of SW process architecture and design development, we recognized that purely paper-based process representation could not meet our requirements. Paper-based process representations cannot support navigation well enough in the modular structure of the documentation. Some hypertext solutions are necessary for usability when the SW Process Asset Library contains hundreds of interrelated documents. (Kaltio & Kinnula 1998.)

For the management of the SW Process Assets, some kind of database solution is another must. Otherwise, the continuous improvement of those assets becomes an impossible mission, especially in a decentralized SW Process Engineering organization.

Main tools for SW Process Asset Management and Deployment are:

- SW Process Release Databases – the SW Process Asset Library
- SW Process Development Database – a database for managing SW Process Assets
- Project-Specific Process Database – a database containing the project-specific SW process tailored from the organizational SW Process Assets, and supporting experience captured from the process enactment
- SW Forum – a database used for managing SW Process Asset Management and Deployment, and other SW Process Engineering activities

Tools that are part of the infrastructure element technology in the study context are depicted in Fig. 1.

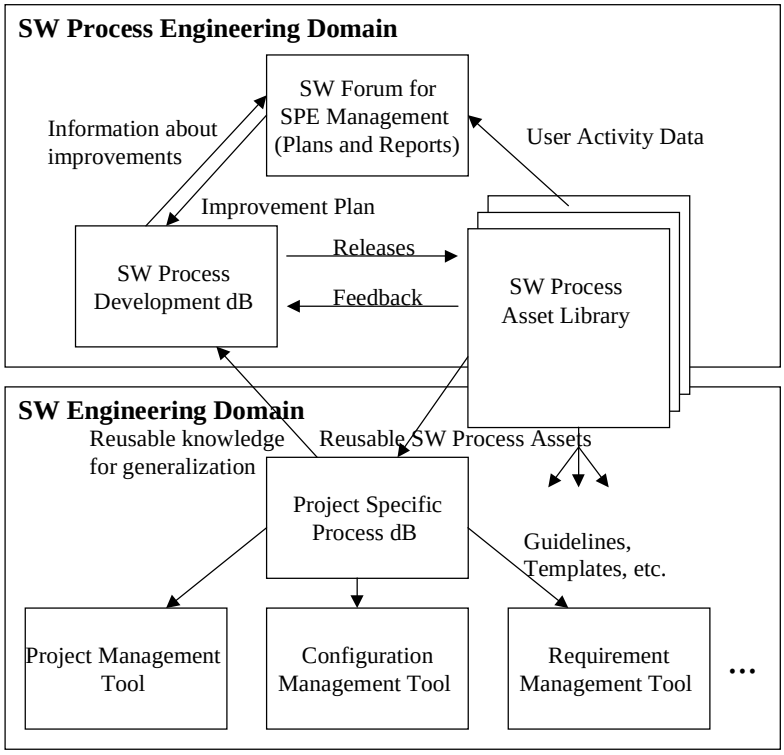

Fig. 10. Tools related to the SW Process Asset Management infrastructure

In the case organization, all of these tools have been implemented as hypertext solutions in Lotus Notes™, with access through Intranet Web. These tools, except for the Project-Specific Process Database, have been in active use for several years and have been found to be very useful. The Project-Specific Process database has only recently been taken into pilot use in the case organization, thus it was too early to evaluate how well it fulfills the identified needs.

In addition to the above-mentioned tools, there is heterogeneous combination of tools applied in different sites of the case organization. These tools support communication, management of SW Process Engineering, training, and metrics. These tools are of local concern, and none of them is used in all of the sites across the entire case organization. (Interview Site A, B, C, D and E, Artifacts.)

In order to support communication, intranet web pages were used in some sites for information sharing about SW Process Engineering issues. In some sites, web pages were not yet in use, but there were plans to start using them in the future. For SW Process Engineering tracking, Sites A and D use Excel-sheets. In site A, a database is used for SW Process Support Team meeting minutes and action points. Sites A, C and E have local solutions for training-related information. The tool in Site E includes, for instance, information about courses, attendees, and the training history of personnel. Sites A and D used a common tool as a SW metrics database. (Interview Site A, B, C, D and E, Artifacts.)

All the tools supporting different SW engineering processes, for instance SW configuration management, are a possible means to deploy better practices. In many cases, proper process can be implemented as an integrated part of the natural way to use the tools. Some good practices,

like the collection of measurement data, are very hard to implement without proper supporting technology.

Like all the other elements of the infrastructure, the supporting technology also needs to be assessed and improved to better meet the defined purpose. For example, we applied contextual inquiries for collecting feedback from the end-users concerning the usability of the SW Process Release Database (see section 8.5.1). A usability expert from Nokia Research Center conducted the inquiries. Many of the findings have resulted in improvements to the technology, but changing the technological solution alone cannot solve all the problems that were found. Changes are required to the other infrastructure elements as well, for example the contents of training and support services provided by local process support personnel. (Myllylä 2000, Lankinen 2000, Personal log.)

8.5.1 SW process asset library

The first prototype of the SW Process Asset Library, using the draft process architecture, was implemented to Intranet Web directly encoding HTML. That approach was immediately found to be unpractical in the sense of SW Process Asset Management. The maintenance of links between hundreds of documents would have been difficult. The actual implementation was made using Lotus Notes. However, users can access the database using either Lotus Notes or a Web browser. (Personal log.)

Because the usability was an essential requirement for the success, a Lotus Notes developer, a usability expert, and a graphic designer all played important roles in the implementation of the database. (Personal log.)

Users can navigate through the manual using different views, navigators (illustrations with hotspots), and links between documents (using the linking rules described in the process architecture and design). Lotus Notes also provides the possibility of searching documents. The user interface is as consistent as possible in all areas of the database, the basic layout of views and functionality is always the same. The user interface via both Intranet Web and Lotus Notes is the same as far as possible. (SWEP, Personal log.)

Suggestions or comments about the content of the SW Process Asset Library can be sent to the SW Process Development Database from the SW Process Asset Library releases. A definite suggestion about changing SW process can be sent as a formal change request by clicking the 'Change Request' button at the top of each SW process representation. General comments or suggestions can be sent as feedback by clicking the 'Feedback' button at the top of each SW process representation. The status of a change request or feedback can be followed by using the SW process development database.

The development of the SW Process Asset Library is release-based. Releases of the library are made four times per year on the 1st March, 1st June, 1st September and 1st December. Each release is replicated to all NMP’s SW R&D sites. (SWEP, Personal log.)

When new SW projects starts to define a project-specific process, it takes the latest version of the SW Process Asset Library as a main reference point. During the life cycle of the project, there will be new release(s) available. Each release contains a release note that describes the changes made since the previous release including links to changed SW Process Assets. Project can decide, based on the changes and the situation of the project, to continue with the older release, to change the main reference, or to have specific reference to some new or old SW Process Asset. (SWEP.)

Fig. 11. SW Process Asset Library homepage

The users of the SW Process Assets know when new releases of the library are available because there are fixed release dates. Experience has shown another benefit from the fixed release dates: the 'deadline effect'. The three-month release cycle is one very practical milestone schema for continuous process improvement. By March 2000, 16 SW Process Asset Library releases had been made. All of those contained plenty of improvements to the SW Process Assets (see section 6.4.2). (SWEP, Personal log.)

Usability study results

The usability of the SW Process Asset Library was evaluated by conducting contextual inquires (Beyer & Holtzblatt 1998) in two NMP sites in May 1999. The findings were used as the basis for usability improvements in the form of the user interface and content of the SW Process Asset Library. (Myllylä 2000, Lankinen 2000.)

Clearly the most serious usability problem commented by almost all interviewed users, was that of a problem in finding information. None of the users understood the underlying structure or terminology, and they felt that navigation was difficult due to an overwhelming amount of information. That led, for instance, to the implementation of a better search functionality and a restructure of the content of the SW Process Asset Library. (Myllylä 2000, Lankinen 2000.)

The study results also contained findings about common situations of use and factors motivating the use of the SW Process Asset Library, which are copied below from an unpublished internal Nokia study report by Myllylä (2000).

Common situations of SW Process Asset Library use are (Myllylä 2000):

- "**Fetching a document template known to exist.** Trigger: the user is about to start to write a document. She is looking for a template that she knows is in the database, either because she has fetched it before (getting the latest version) or someone (colleague or process support person) has told her so.
- **Searching for support for writing a new document.** Trigger: the user is starting to write a new kind of document. She wants to first find whether a document template is available and whether it is suitable. She may also want to find some more general information relating to the document or to the task at hand. She may not know the name of the document she is looking for.
- **Looking for information in order to prepare for a milestone.** Trigger: milestone is approaching. The user (typically a project manager) wants to find out what documents are required. He often consults a process support person for interpretation or applicability of requirements. In this situation, the application is used intensively for a period of time.
- **Getting acquainted with the SW development process in general.** Trigger: the user comes to NMP or to a new kind of project. He wants to get an overview of the software process.
- **Looking for information when starting a new project.** Trigger: the user is responsible for writing the quality plan. He is looking for processes that apply to his project and for information about how these can be customized. In this situation, the application is used intensively for a period of time.
- **Checking whether a certain document or template has been updated.** Trigger: the user is starting to write or to update a document, or is starting a new project phase. He wants to see if the template or document he is using is up-to-date.
- **Looking for new information in general.** Trigger: the user has some free time and wants to keep himself updated. The user wants to see if there is something new that might be of use to him.
- **Browsing process information.** Trigger: new kind of project phase or task, or preparation for future. The user wants to discover process information which will be useful to him either in the immediate future or in the long-term."

Factors motivating the use of the SW Process Asset Library include (Myllylä 2000):

- "**Practical things are good.** Users appreciate things that are of immediate use in their work, such as document templates, sample documents or case studies (from similar type of projects), practical 'how-to' information and instructions based on experience (e.g. C coding instructions cited as the most useful document).
- **Tailored, ready-to-use things are good.** Users appreciate information tailored to the needs of their particular project or role and which requires no reference to other documents (e.g. "Work Rules" document, quality plan with embedded document templates).
- **Local things are good.** Instructions or templates developed at the same site, or already in use there, are perceived as valuable. Users would like to get in contact with other similar projects (at the same site).
- **Up-to-date information is good.** Recently-updated documents are used more often. It is important to know whether a document has been recently updated or is about to be updated. It is also important to know the status of a document (work-in-progress or not).
- **Common standards are good for solving conflicts.** Several users mentioned that it is good to have standards so that, for example, review disputes can be solved by referring to an outside source.
- **Supporting newcomers is important.** Several users explicitly mentioned that this would be valuable. It would save their time in instructing newcomers and would also provide a good first contact to SWEP for newcomers."

8.5.2 SW process development database

Much of the tool support for SW Process Asset Management was implemented in the SW process development database. It contains far more functionality than the SW Process Asset Library releases. The database provides all the necessary configuration management features for SW Process Asset Management including:

- the possibility to save different versions of SW Process Assets
- different functionality for different roles (the process area responsible person, author, reviewer, reader)
- life cycle for SW Process Assets (draft, proposal and approved)
- different life cycles for change requests and feedback
- change request form supporting the lifecycle
- feedback form
- responses to feedback

It contains also several additional views compared to the SW Process Asset Library, for example Change Requests by Process Area Responsible and Working Views by Status (see Fig. 12). Those views are vital for effective SW Process Asset Management, and because of these different site views to the database, they are useful for local SW Process Engineering activities. The SW Process Development Database is open for everyone in NMP. (SWEP.)

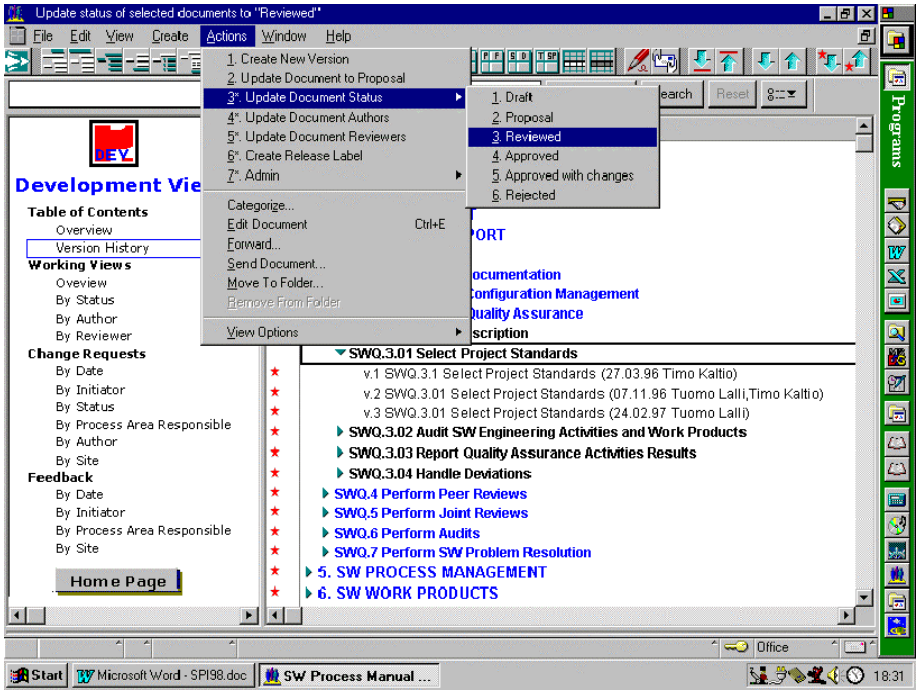

Fig. 12. SW process development database view

8.5.3 Database for project-specific process

In March 2000, the database for project-specific processes was under piloting in the case organization. It was not an institutionalized part of the technological infrastructure. However, the need for such a solution had already been recognized in 1996 and had been on the agenda ever since. Therefore, discussion in this section is relevant albeit partially representing plans rather than empirical experience.

In NMP, SW projects had already created a document called SW Quality Plan before the new SW Process Asset Library was released for the first time in September 1996. The SW Quality Plan presents the quality objectives for SW to be developed, and the means to achieve those objectives. The 'means' includes a definition of project-specific process that contains references to the SW Process Asset Library. The SW Quality Plan is a guide that explains what parts of the SW Process Asset Library should be used and how. Project members should use SW Process Assets only through this document. However, in practice many people did not actively use SW the Quality Plan. The references to the SW Process Asset Library were difficult to follow due to a lack of hyperlinks. Moreover, the SW Process Asset Library contains a huge amount of information, which made it hard for an infrequent user to quickly find the information they needed, no matter how much effort had been spent in improving the usability of the library.

Already in 1996, I presented an idea of having a technical solution for capturing the results of process tailoring as a project-specific process including active links to relevant SW Process Assets. The vision for the concept was later defined to be the following: A database for project-specific processes is the primary source of process information for SW project personnel, and an important tool for capturing and sharing experience gained in the project (Tuhkanen 1999).

The database for Project-Specific Process is an electronic document, document database or intranet site that defines a SW project's defined process. It can be thought of as a SW Quality Plan in electronic form. By March 2000, three pilot implementations of the Database for Project-Specific Process as a replacement of the SW Quality Plan were underway in the case organization. Two of them simply had the contents of the SW Quality Plan as a Lotus Notes document with active links. Another approach studied the usability issues more and had the same information although accessed via different type of use interface. Both pilot approaches have decided to present the information from the SW Quality Plan without any additional functionality. However in March 2000, future plans included broadening the concept to be a project dashboard and knowledge base. (Tuhkanen 1999.)

According to the defined use-cases, the SW Project Manager and SW Process Supporter create the database at the beginning of the project. The SW Process Supporter maintains the database during the project, informs project members about process improvement actions, and uses the database as a process action database. (Tuhkanen 1999.)

The SW Project Manager uses the database during the project for training and tutoring project personnel, demonstrating the project's process (instead e.g. of MS PowerPoint etc.), communicating the project's status, focus areas, risks etc., and gathering experience for the project final report. (Tuhkanen 1999.)

Project members use the database during the project for self-studying, for example the project's process, organization, or project interfaces. They use it for seeking working instructions, templates, checklists or other documentation, or hints, solutions, feedback, future process or other improvements etc. when they perform an activity, create a new work product, prepare for a review etc. Project members provide daily and up-to-date feedback on methods, tools and processes based on their experience. (Tuhkanen 1999.)

At the end of the project, the SW Process Asset Manager or Local SPI Manager together with a SW Process Supporter analyze the tailoring and any lessons learned from the project final report. The lessons learned may influence the contents of the SW Process Asset Library for future releases. (Tuhkanen 1999.)

8.5.4 SW Forum - SW process management planning and reporting

A separate database, SW Forum, is used for the planning and tracking of all the SW Process Engineering activities. Strictly speaking, it is a tool for SW Process Engineering Management, including managing the SW Process Asset Management activities. It is included here for the sake of completeness.

The database categorizes documentation according to identified projects and has a dedicated category for asset management coordination. The database includes management-related documentation, for example strategy, plans (roadmaps etc.), organization, reports, meeting agendas and minutes, and action items. In addition, the database has functionality for tracking the actions to closure, and it provides separate discussion areas for each project. (Kaltio & Kinnula 2000, Artifacts.)

8.5.5 Technology in related work

The SW-CMM 1.1 key process area Organization Process Definition in the ability 1 sub-practice 2 states only about the technology that: "Tools to support process development and maintenance are made available." As examples of tools, it mentions desktop publishing tools, database management systems, and process modeling tools. In the activities the model does, however, talk about the organization's SW process database, the library of SW process-related documentation, and the fact that the organization's standard SW process is placed under configuration management. (Paulk et al. 1993b.)

IDEAL^{SM} 1.0 identifies one technical infrastructure component, namely the organizational process database. This may be a set of file drawers or an electronic database, storing multiple forms of data. The SEPG is responsible for establishing and maintaining the database, gathering new artifacts into it and disseminating the information stored within. (McFeeley 1996.)

Experience Factory identifies the need for tools for specific activities, such as experience / data storage (Basili & McGarry 1998). There are no technical infrastructure elements identified in the ISO 15504-7 model (ISO/IEC 1998c).

The scope of the Technical infrastructure by Zahran (1998) is the technical tools and facilities needed to support the process. This includes technical platforms and computing facilities as well as tools that support the process improvement organization. The Technical infrastructure covers two areas, those are the organization’s SW Process Assets and process support tools. Characteristics of effective Technical infrastructure are listed as (Zahran 1998):

- Support for the storage and retrieval of the organization’s process definitions and data
- Support for process flexibility (changes to accommodate new methods etc.)
- Support for the communication and feedback mechanisms
- Coverage across the organization’s physical distribution
- Flexibility and the ability to adapt to any major changes in the organization’s business strategy or geographical distribution

As described earlier, the Technical infrastructure includes two parts: The Organization’s SW process Assets, and the Process Support tools. The implementation model of the Organization’s SW Process Assets has been copied directly from the CMM (Paulk et al. 1993b) and includes: the Organization’s standard SW process, Approved SW lifecycles, Tailoring guidelines, the Organization’s SW process database, and the Library of SW process-related documents. (Zahran 1998.)

The Organization’s Standard SW Process covers the definitions and descriptions of the SW process architecture and the elements within. Approved SW Lifecycles cover the descriptions of the project lifecycles that the organization has formally approved for use. Tailoring Guidelines include the guidelines and criteria for tailoring the project’s SW process from the organization’s

standard SW process. The organization's SW Process Database holds all the process-related data, the actual process definitions and the process performance measurements. The Library of SW Process-related Documents is a repository for all process-related documents created by the SW projects. The documentation represents the process experiences and lessons learned. (Zahran 1998.)

In the implementation model for Process Support Tools, Zahran provides four different lists that deal with the definition of process support tools. The most comprehensive one include following tools (Zahran 1998):

- Process definition & data storage and management tools, the
  - Process Modeling and Simulation Tools (enabling the storage and retrieval of graphical presentations)
  - Process Data Storage and Management Tools (database for SW process definitions and data)
- Process definition & data retrieval and distribution tools, the
  - Communications and Workgroup tools (access and dissemination of SW process database contents)
  - Management Reporting and Statistical tools (process data summary and trend analysis, supporting decision making)
- SW (Engineering) activity and process management activity support tools, the
  - Life Cycle Activities Tools (tools for design, coding, testing, etc.)
  - Life Cycle Management tools (tools for project planning, tracking, configuration management, etc.)

Summary

The book by Zahran (1998) provides the most comprehensive description of the infrastructure element technology from the related work discussed above. It matches very well with the findings in the case organization. In addition, all the other sources also recognize the SW Process Asset Library.

8.6 Summary of infrastructure

An effective infrastructure is essential to support the operation of any process and SW Process Asset Management and Deployment processes are no exception to this rule. The structural infrastructure elements are: Organization, People, Technology and Knowledge.

Organization (section 8.2) in a multi-site organization consisting of four levels, the global, local, project and individual level.

The main role of the global organization is to support the local organization in SW Process Deployment and other SW Process Engineering activities. Roles or organizational units in the global SW Process Asset Management and Deployment organization are: SW Process Asset Forum, Global SW Process Asset Manager and SW Process Area Responsible.

The responsibility of process deployment relies heavily on the local SW Process Engineering organization in NMP. Local SW Process Engineering organization consists of several roles, which each contribute to the success or failure of SW Process Deployment. Those roles in NMP are: Local SW Process Owner, Local SPI Manager, SW Process Supporter, SW Quality Assurance, SW Training Coordinator, SW Trainer, Local SW Process Asset Responsible, Local SW Process Area Responsible, SW Process Developer, SW Tool Supporter and SW Tool Developer.

Each of these roles has a set of responsibilities and required abilities relating to SW Process Asset Management and Deployment and to other areas. These are documented in the SW Process Asset Library as role definitions, which are linked to related activities. The roles are presented in

the form of a process representation in Appendix 5: Generic Roles for SW Process Asset Management and Deployment.

People-element (section 8.3) covers the issues that influence the person's capability and willingness to carry out the activities. Those are abilities, motivation, standing and time.

Abilities means the skills and knowledge that can be taught and acquired, and the characteristics that people have. In the case study, two broad categories of abilities were identified: technical knowledge and skills, and soft skills. Soft skills, for instance communication skills and ability as a public performer, are seen as very important in context of Process Deployment.

The organization can influence the level of abilities by its recruiting policy and systematic competence development. Individuals in the SW Process Engineering organization can acquire missing skills by several different means including tutoring, conferences, external and internal training, self-study and 'learning by doing'.

Standing, both formal title and rank, as well as the more informal respect that a person commands from the members of the organization, does influence to the ability to achieve results in SW Process Engineering. Formal rank was not seen as very important in trying to achieve results in the projects. However, the formal rank or title for the different roles in the SW Process Engineering organization should be high enough to attract the right kind of people to gravitate to these roles. Informal respect has to be earned by achievements, but it is not a necessity earn it in SW Process Engineering activities. Personal characteristics, for example stamina, cheerfulness, voice, flexibility and boldness, may also have a remarkable influence on the standing of an individual. A person who does not posses high standing in the organization can increase the credibility of the message by referencing to another respected individual, or to experiences in a project which is known to have performed well.

Motivation influences the likelihood and the extent to which a person will actually use the time allocated to carry out the tasks and may affect the quality of the results as well.

Issues influencing SW Process Engineering personnel motivation include: achievement of visible results, existence and nature of feedback, clarity of set targets, management commitment, intercommunication with peers, turnover of people, and personal characteristics, for example enthusiasm and idealism.

Time allocated and available to carry out the activities directly influences the capability of people to achieve results. Sufficient resources are to be allocated for SW Process Asset Management and Deployment activities. Based on experience, an organization can gain understanding about suitable resource allocation for the different roles. Section 8.3.4 provides some guidelines for role-based resource allocation.

There are two main categories in the **knowledge** (section 8.4) that are relevant to the focus of this study report: SW Process Engineering Knowledge and SW Engineering Process Knowledge. The former is used by SW Process Engineering personnel in their activities. SW development project personnel in SW engineering activities use the latter. The knowledge needs in relevant process domains include activities and the different infrastructure elements.

Only part of the knowledge will be packaged as process representations, some will be documented in other forms, for instance plans and reports. Some of the used knowledge will never be documented, instead it is stored as accumulated experience within individuals.

SW Process Deployment is in essence about selling solutions. Therefore, knowledge about marketing, human behavior and change management domains equip process personnel with a valuable means to achieving the goals of SW Process Deployment.

When supporting SW project(s), knowledge about the SW Process Asset Library contents, and how other projects have applied SW Process Assets and what the experiences were, is very valuable for the SW Process Engineering personnel. Knowledge about other projects, sites'- or companies' experiences are also a valuable means to persuading people to do something.

In addition to process knowledge, organization domain knowledge and historical information should also be captured to increase the understanding of the SW Process Engineering in the context organization.

Documented knowledge becomes more important as the number of potential users of the knowledge rises. Documenting process knowledge is not a trivial task. An organization should try to prioritize alternative documentation efforts and to find a balance between the effort spent on deployment, or re-deployment, of existing SW Process Assets and on documenting new ones.

Technology (section 8.5) represents the technical resources or assets used in the process. The main tools, the support technology, for the SW Process Asset Management and Deployment in the case organization are:

- SW Process Release Databases – the SW Process Asset Library
- SW Process Development Database – a database for managing SW Process Assets
- Project-Specific Process Database – a database containing the project-specific SW process tailored from the organizational SW Process Assets, and supporting experiences captured from process enactment
- SW Forum – a database used for managing SW Process Asset Management and Deployment, and other SW Process Engineering activities

In addition, all the tools supporting different SW engineering processes, for instance SW configuration management, are a possible means of deploying better practices.

To better meet the defined purpose, all the infrastructure elements should be assessed and improved as part of the SW Process Asset Management and Deployment system.

9 Model for the SW Process Asset Management and Deployment system

The SW Process Asset Management and Deployment system consists of relevant activities (see chapter 7) and infrastructure elements; the organization, people, knowledge, and technology (see chapter 8). The system does not work in a vacuum. It is an integral part of the SW Process Engineering system and the organization where it operates and which it serves. The roles, described in section 8.2, also have responsibilities that involve activities that are not categorized to be part of SW Process Asset Management and Deployment activities. All the other SW Process Engineering activities - Process Development, Process Evaluation, and Process Engineering Management (see section 7.1.1) - are interrelated with the activities in the focus of this study.

Another important process domain is SW Engineering. It is the subject of the SW process improvement and maintenance activities, and the whole reason for the existence of the SW Process Asset Management and Deployment system. Therefore, the system model illustrated in Fig. 13 depicts also these highly related process domains. Furthermore, both the SW Process Engineering and the SW Engineering domains include activities and infrastructure elements.

To make the SW Process Asset Management and Deployment Engineering system operational it must penetrate all organizational layers. In NMP, these are Global – Local – Project – Individual. The global level covers the entire NMP R&D division while the local level corresponds to the line organization of a single R&D site. In addition, the organizational dimensions are included in the model. (Kinnula 1999.)

The different infrastructure elements and activities in each process domain are interrelated. This is illustrated by double-headed arrows forming circles in Fig. 13. The infrastructure elements are also interrelated across domains. For instance the same tool can serve different domain areas. However, this is only illustrated with an arrow from the SW Engineering domain to knowledge, and with an Influence-arrow from SW the Process Engineering domain to the SW Engineering domain. The basic forms of relationships between activities, organization, people, knowledge and technology are depicted in Table 6. The relationships are expressed in generic terms. In each specific process domain where a model is applied, for instance SW Process Asset Management at global level, the details of relationships shall be defined. Relationships between activities and infrastructure elements exist also in other process domains outside the study focus, for instance SW measurement in a SW R&D site or project management in a SW development project.

Activities in the focus of this study are presented as process models in chapter 7 and in appendices 2 and 3. The processes are Establish and Maintain SW Process Asset Management and Deployment System, SW Process Asset Management, and SW Process Deployment.

Organization represents how the resources have been organized to carry out the processes. It includes structure, roles, responsibilities, and communication channels. Those are depicted in section 8.2 and in Appendix 5: Generic Roles for SW Process Asset Management and

Deployment. Roles or organizational units in the global SW Process Asset Management and Deployment organization are SW Process Asset Forum, Global SW Process Asset Manager and SW Process Area Responsible. Roles at local level are Local SW Process Owner, Local SPI Manager, SW Process Supporter, SW Quality Assurance, SW Training Coordinator, SW Trainer, Local SW Process Asset Responsible, Local SW Process Area Responsible, SW Process Developer, SW Tool Supporter and SW Tool Developer.

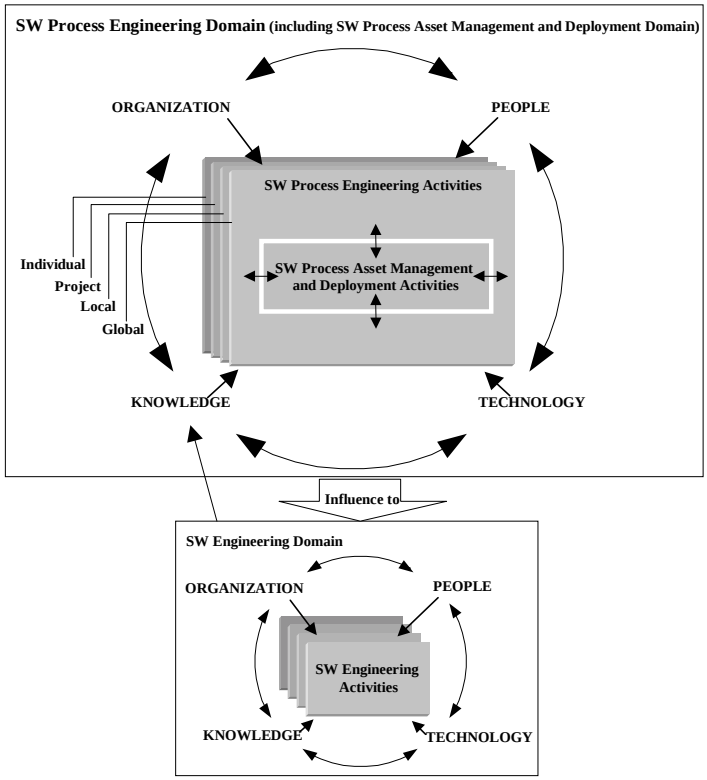

Fig. 13. The SW Process Asset Management and Deployment System and related process domains

People (section 8.3) represents the human resources. It covers the issues that influence a person's capability and willingness to carry out the activities. Those are abilities, motivation, standing and time allocation.

Abilities (section 8.3.1) means skills and knowledge that can be taught and acquired, and characteristics that people have. In the case study, two broad categories of abilities were identified; the technical knowledge and skills, and soft skills.

Standing (section 8.3.2), both formal title and rank, as well as the more informal respect that a person can command from the other members of an organization, does influence the ability to achieve results in SW Process Engineering. Formal rank was not seen as very important in trying to achieve results in the projects, but should be high enough to attract the right kind of people to gravitate to the SW Process Engineering roles. Informal respect has to be earned by achievements, but it is not a necessity earn it in SW Process Engineering activities.

Table 6. Basic relationships between activities, organization, people, knowledge, and technology

	Activities	**Organization**	**People**	**Knowledge**	**Technology**
Activities		shall map to the **organization**.	are performed by **people**, whose performance is dependent e.g. on their abilities, resource allocation, standing, and motivation.	produce, use and reuse **knowledge**.	are supported by **technology.** Available **technology** may influence the definition of activities.
Organization	shall include roles performing the necessary **activities**.		is filled with **people.**	captures and reuses **knowledge**.	is taken into account in the development of the supporting **technology**.
People	perform **activities** based on their roles and related responsibilities in the organization.	fill roles in the **organization**.		need **knowledge** about issues relevant to their responsibilities.	use **technology** when they perform activities.
Knowledge	is needed about **activities** in all relevant domains.	is needed about **organization** in all relevant domains.	is needed about **people**, e.g. about human behavior in general, and the attitudes etc. of real individuals in the organization.		is needed about **technology** used in all relevant domains.
Technology	is used to support **activities**, it has to be suitable for performing the **activities**.	shall map to the roles and responsibilities in the **organization**.	is used by **people.** Human factors have to be taken into account in development of the technology.	can be used for storing and making **knowledge** available.	

Motivation influences the likelihood and the extent to which a person will actually use the time allocated to carry out the tasks and may affect the quality of the results as well. Issues influencing the SW Process Engineering personnel motivation are described in section 8.3.3.

Time allocated and available to carry out the activities directly influences the capability of people to achieve results. Sufficient resources are to be allocated for SW Process Asset Management and Deployment activities. Section 8.3.4 provides guidelines for role-based resource allocation.

There are two main categories of **knowledge** relevant in the focus of this study report: SW Process Engineering Knowledge and SW Engineering Process knowledge. The former is used by SW Process Engineering personnel in their activities. SW development project personnel in SW engineering activities use the latter. SW Engineering Process knowledge is also needed by SW Process Engineering personnel, because they support SW development projects. The knowledge needs in the relevant process domains include activities and different infrastructure elements. The knowledge element is discussed in section 8.4.

Technology represents the technical resources or assets used in the process. The main tools for SW Process Asset Management and Deployment in the case organization are: SW Process Release Databases, the SW Process Asset Library, the SW Process Development Database for managing SW Process Assets, the Project-Specific Process Database, and the SW Forum database that is used for managing the SW Process Asset Management and Deployment activities. In addition, all the tools supporting different SW engineering processes, e.g. for SW configuration management, are possible means to deploy better practices. The technology element is described in section 8.5.

10 Conclusions

The first part of this thesis described the background (chapters 1 and 2) and defined the research plan (chapters 3 and 4), including the research problem that was answered in this study. The second part (chapter 5) summarized the previous research done on this subject. The third part (chapter 6) depicted the embedded single-case of this study. The fourth part analyzed case and literature input (chapters 7 and 8) and synthesized the findings (chapter 9) in order to answer to the research problem. Appendices 1 – 5 provide more detail for the issues covered in the fourth part.

First in this final chapter, the research results are summarized as an answer to the research problem, and the added value of the study results is discussed. Then, limits and biases in this study are discussed. Finally, some possible topics for future research are presented.

10.1 Research results and contribution

The research problem concerned describing a system for SW Process Asset Management and Deployment. As an answer to the research problem, the study presented three process models, depicted each element of the infrastructure, and finally established a system model as a synthesis of the previous.

The first of the processes was about establishing and maintaining the system for SW Process Asset Management and Deployment. That was found to be critical for the success of the actual SW Process Asset Management and Deployment activities. The second process was for SW Process Asset Management. These two processes were documented using formalized templates for activity-, role- and work product- descriptions. The third process, SW Process Deployment, was discussed but similar formalized process representation was not presented. That was because process deployment was found to be an integrated part of large variety of different activities.

The infrastructure elements of the system - the organization, people, knowledge and technology - for SW Process Asset Management and Deployment were described in detail. Part of the infrastructure-related information was presented in formalized process models as generic role descriptions. This relates to the organization element, which included roles and responsibilities, and to the people element, covering the abilities needed in those roles.

The system model included activities and infrastructure elements and the interrelations between them. It also presented a relationship to two other process domains relevant for SW Process Asset Management and Deployment: the overall SW Process Engineering process domain and SW Engineering process domain.

The models presented in this study are the result of more than five-years of evolution of the SW Process Asset Management and Deployment system in the case organization. Current system elements were first evaluated in 1995 and were found to be inadequate. A decision was made to establish some of the first elements of the revised system. Input from available literature was

used for the definition of those elements. Lessons learned from implementing those elements, and applying them in practice, helped us to recognize missing elements and the need for improvements. By 1997, all of the elements existed in some form. Since that the system has been institutionalized as part of the overall SW Process Engineering system, and has been under continuous maintenance. Lessons learned from the case organization and other Nokia multi-site business units, and from input from literature have been used to improve the system and its related models.

Consequently, the SW Process Asset Management and Deployment system model integrates current state-of-the-art knowledge in concise form. Compared to other models in the literature, the model presented in this study is clearly the most comprehensive one.

The system model and even the detailed descriptions of the system elements are generic. Therefore, other practitioners can apply those for establishing, evaluating and revising the SW Process Asset Management and Deployment system in the context of their own organization.

In this study, Kinnula's (1999) architectural design models for the SW Process Engineering system were used as a basis for the research framework. Therefore, this case study served as a test case for Kinnula's models; these were found mostly practical for the purpose. However, one remarkable difference with this study report is that the SW Process Engineering processes from Kinnula's (1999) study report are not treated as processes, but as activity types serving certain purposes. The rationale for this is discussed in section 7.1.1.

10.2 Limits and biases

Until March 2000 I had a central position as a Global SW Process Asset Manager in the establishment and maintenance of the system described in this study. Therefore, there was a risk of biased results based on personal involvement.

To minimize personal bias, data triangulation has been applied. Firstly, multiple sources of evidence, including interviews with several key people, have been used as a basis for the findings of the study. Secondly, all key informants have reviewed the draft study report. Interviewees, and several other individuals, were used to review and approve those parts that deal with issues they have been focusing on, as well as the final results and conclusions presented in this thesis. Finally, this study was heavily based on documentation produced as by-products, deliverables and measurements of past SW Process Asset Management and Deployment, and related activities.

The second concern relates to the generic applicability of the results, because this is a single-case study. However, the multi-site organization provided several embedded units used for analysis concerning local level issues. The level of implementation of the system model varied in different sites. That made it possible to compare what seems to work and what does not. Furthermore, literature was used for finding supportive evidence for the observations.

Naturally, evidence from multiple cases would have been more compelling compared to single-case. This case was however a revelatory case, where I had an opportunity to observe and analyze the SW Process Asset Management System from a central position during a period of more than five years. Moreover, I had access to a comprehensive amount of data. Even if it would have been possible to organize a similar position for observation and access to data in different case organizations, the required effort would have been beyond the means of one researcher. (Yin 1988.)

Finally, multiple-case studies do not follow sampling logic, like having multiple respondents in a survey. Instead, they follow replication logic; one should consider multiple cases as one would consider multiple experiments. I hope that this study stimulates other researchers to do the replication and to perform analysis following cross-experiment design and logic. (Yin 1988.)

10.3 Recommendations for future research

This study described a SW Process Asset Management and Deployment system in one multi-site SW R&D organization. The system has been successful over long period of time. However, this does not mean that the described approach would be the only possible way to succeed. On the contrary, successful approaches probably exist in different multi-site SW R&D organizations that are more or less different ways of implementing a system for SW Process Asset Management and Deployment. Since this study was a single-case study, it is a challenge for future research to justify or rebut the generic applicability of the study findings. This could be done by replicating the study, describing a system in a different multi-site SW R&D organization applying the same research framework, and by performing analysis following cross-experiment design and logic (Yin 1988).

This study focus included SW Process Deployment. The discussion of the topic was not at all exhaustive. This study suggested that the purpose and objectives of SW Process Deployment can be supported by a large variety of activities, that re-deployment of existing processes is at least as important as deploying new processes first time, and that other domains like change management and marketing include relevant knowledge for this issue. A second research topic is to study these issues further, for instance by taking the viewpoint of process deployment to all SW Process Engineering activities.

This study applied Kinnula's architectural design models as a research framework. The framework was found to be practical. The framework could probably be applied not only to other process domains in SW Process Engineering, but to any other process domain. The third topic is to apply the same research framework to some other process domain.

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Appendices 1-6

Appendix 1: SW process architecture elements

This appendix describes the applied SW process architecture elements and some important issues from the design. This study report does not contain any detailed rationale for tailoring and definition decisions taken, but these were driven by the defined requirements for the SW process representation. In the requirement definition for the new SW process representation, both SW Process Asset Management and Deployment perspectives were considered. The defined requirements were to:

- allow each person to easily find out what to do and how to do it in his/her roles – focus on usability
- describe the entire SW process (also line activities)
- allow different types of projects, and rapid changes in those
- allow different methodologies and tools
- allow local site & project variation
- allow mixing & tailoring of these

First process architecture elements are briefly described. Then the information content of each element is described in more detail.

Basic process architecture elements

The cornerstones of all process representations are activities, artifacts and agents.

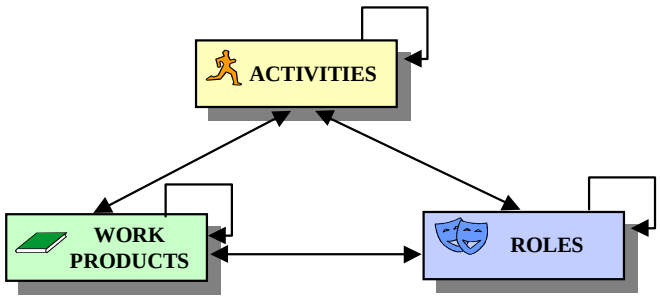


Fig. A1 - 1. Conceptual framework for SW processes (tailored from Armitage at al. 1994)

In NMP SW process architecture, the terms artifact and agent are replaced with work products and roles, respectively. In our early presentations of the draft process architecture, the audience felt the previous terms were unfamiliar. The elements are defined in Table A1 - 1.

Table A1 - 1. Basic process architecture elements

Element	Description
Activities	A description of what happens, what is done, and how it is done, within a SW engineering process.
Work products	A document, or a piece of information or materials, which is produced by an activity and/or used or updated in an activity.
Roles	A person, group or organization that performs an activity.

All these elements can be identified from any organization's process representation, but they are typically more or less mixed in physical documents. Based on our defined requirements, modularity is a necessity for process representation. None of the elements contain descriptions of other elements. If a relationship to another element exists, only the type of relationship, the title of the other element, and the link are presented.

Other process architecture elements

However, basic architecture elements more or less describe the process, but more information is needed for human enactment. That information is presented following the process architecture elements: process tailoring guidelines, glossary, metrics, training and references. These are depicted in Table A1 - 2.

Table A1 - 2. Other Process Architecture Elements

Element	Description
Process tailoring guidelines	Process policies and guidelines for tailoring the SW process for a project based on different project types.
Glossary	Definitions of process-related terms
Metrics	Definitions of process-related metrics
Training	Role-based tutorials and course materials
References	References, which are external to the SW process, but relevant to a SW audience, e.g. references to other processes of an organization, tool user manuals, or books.

None of the elements contain descriptions of other elements. If a relationship to another element exists, only the type of relationship, the title of the other element, and the link are presented.

SW process architecture elements are depicted in the SW Process Asset Library homepage in Fig. A1 - 2.

Fig. A1 - 2. Process architecture elements in an online navigator

Activities

An important requirement for activity descriptions is to have a homogeneous structure in all different areas of the whole process. Therefore, a number of different activity break-down levels shall be the same in all activity areas, and all same-level activities shall be described in a consistent way. The main beneficiary of this is the user of the manual. When a user learns the logic of the used notation in one process area, for instance in SW integration testing, it is much easier to access information in any other process areas, for example project management or peer review.

Based on the ISO 15504 (ISO/IEC 1998b) reference process model, activities are broken down into three levels in all the SW process areas; those are process categories, processes, and base practices. Process categories include processes, processes include base practices, and base practices refer to procedures. Procedures is an additional fourth level that does not exist in ISO 15504. Procedures describe in detail how activities defined by base practices can be performed. All these four activity elements are described using standardized notation.

SW activities are grouped into five **process categories** tailored from the ISO 15504. The **process category** is the uppermost level in the SW Engineering Process and deals with SW activities. Each process category consists of a set of **processes**. Each process consists of a set of base practices.

A **base practice** describes in greater detail what should be done, but it does not tell how it should be done. Base practices are referenced by, and are linked to, their related SW work products, SW roles, and references.

Table A1 - 3 contains standard description elements and examples of process categories, processes and base practices.

Table A1 - 3. Standard description elements and examples of process categories, processes and base practices

Architecture element	Standard description elements	Examples
Process category	• title of the process category • purpose definition • list of processes belonging to the process category (links to processes) • illustration of the process category	• SW Project Interfaces • SW Project Management • SW Development • SW Quality Support • SW Process Management.
Process	• title of the process • purpose definition • list of base practices belonging to the process (links to base practices) • illustration of the process	• SWD.3 Develop SW Design • SWQ.4 Perform Peer Reviews • ORG.x SW Process Asset Management
Base practice	• title of the base practice • purpose definition • entry criteria (E) (links to work products) • stages (including links to available procedures (S)) • verification & validation (V) (may contain links to checklists, metrics) • exit criteria (X) (links to work products) • roles (links to roles) • references (links to references)	• SWD.3.02 Design Interfaces Between SW Subsystems • SWQ.4.02 Conduct Peer Review Meeting • ORG.x.BP4 Make SW Process Assets Available

Appendices 2 and 3 contain descriptions of SW Process Asset Management and Deployment-related processes and base practices.

The **procedure** describes HOW the stages, or some of the stages, of a base practice should or could be performed. There may be several alternative procedures for a base practice - for instance based on different methods, tools or project types.

The structure of a procedure is not as highly standardized as for other process elements, but it is based on a set of presentation standards. These are examples of the procedures:

- SWD.4.01.c.cpp How to Develop C/C++ SW Units
- SWQ.4.02.02 How to Conduct Inspection Meeting
- ORG.x.BP4 How to Make SW Process Asset Library Release

Work products

Work products are a single document, or a piece of information or materials produced by an activity and/or used or updated in an activity. Standard elements of each SW work product description are:

- title
- purpose
- contents
- rules (optional)

- templates (links to work product templates and/or examples)
- states
- relationships to:
  - activities (links)
  - work products (links)
  - roles (links)

There may be more than one alternative template and/or examples relating to a SW work product. Work product **templates** and **examples** contain the following elements: Introduction (including a link to a related work product), File Attachments, and a reference copy of the template or example. The file attachment may be detached to form the basis for a project document or checklist.

The following are examples of SW work products: SW Test Plan, SW Module Code, Checklist for Review of SW Specification, and SW Project Plan. Appendix 4 contains descriptions of SW Process Asset Management and Deployment-related work products.

Roles

Role is a method of building a set of responsibilities. One person may be in several roles concurrently (e.g. in a SW project). Role is not tied to any particular job title. Job titles, and the allocation of roles to people, can vary widely between R&D sites.

Role description contain the following elements: Definition, Activities (links to processes and/or base practices), Typical Scope, and Skills (links to training).

SW Designer, SW Process Supporter and SW Project Manager are examples of SW roles. Appendix 5 contains descriptions of SW Process Asset Management and Deployment-related roles.

Each SW role requires a certain set of skills. The skill set provides the minimum requirements for acquitting well in the role. Skills are categorized into three levels, which are described in Table A1 - 4.

Table A1 - 4. Skill levels

Skill level	Definition
Basic	General knowledge about the subject in question
Good	Knowledge can be used to perform the activities
Master	Knowledge is backed up with experience and used to perform activities effectively

Tailoring guidelines, glossary, metrics and references

The purpose of process tailoring guidelines is to support tailoring of the project-specific SW process from the organization's standard SW process as a part of the project planning activity. Process tailoring guidelines do not have a fully fixed structure, but are based on a set of presentation standards.

Tailoring guidelines include process policies, for instance global and site-specific, and project type-based tailoring guidelines. The latter contains information about, for example:

- Project type definition
- Organization and roles

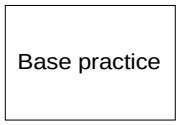
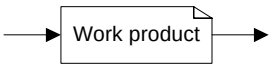
- Project interfaces
- Progress Framework, the SW Lifecycle and milestone schema
- Pre-selection of relevant SW Process Assets e.g.
  - activities (processes, base practices and procedures)
  - work products and templates
  - metrics, and
- waivers and additional information for all above.

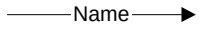
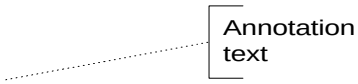
Glossary terms contain title, definition, example (optional), non-example (optional), and reference (optional). In addition, metrics and references are described using standardized content elements.

Process illustrations

Process illustrations are used in the SW process representation. A standard notation is used to support navigation through activity hierarchy and as a part of process category- and process descriptions. In the procedures and tailoring guidelines, more than one notation can be used whenever necessary. Illustrations are an important part of process presentation, but one should not use too much effort in the search for perfect notation. The legend for illustrations is defined in Table A1 - 5.

Table A1 - 5. Legend for process illustrations

Symbol	Description
	SW process, or SW process category, as the main object of the illustration. Note: Below in this table only SW process is considered as the main object.
	SW base practice in a SW process illustration
	Data Storage for work products as an archive or a database used or updated by different SW projects
	SW work product as input to or output from the whole process
	One or more (partial or complete) SW work products when it is not important to name the individual work product. Note: Controlling work product enters a base practice from the top.

	One or more (partial or complete) SW work products when it is important to name the individual work product. Note: Controlling work product enters a base practice from the top.
	Annotation to other symbols

Appendix 2: Generic Activities for Establishing and Maintaining SW Process Asset Management and Deployment System

Introduction	This attachment describes activities in the generic process ORG.X Establish and Maintain SW Process Asset Management and Deployment System.
Roles and Work Products	Base practice descriptions in this appendix include references to all related work products and roles. The role description can be found from Appendix 5: Generic Roles for SW Process Asset Management and Deployment. The full work product descriptions, outputs only, are presented in Appendix 4: Generic Work Products for SW Process Asset Management and Deployment.
Tailoring	The process and base practice descriptions in this appendix can be used as checklists for evaluating and revising, or as a reference model for establishing, process representation in the context of own organization. The breakdown and naming of activities, work products and roles, and used terminology can be tailored to suit organizational context. However, the issues covered by these descriptions are all found essential in the case organization and should not be left uncovered without careful consideration.

ORG.x Establish and Maintain SW Process Asset Management System

Purpose

The purpose of this process is to establish and maintain activities and infrastructure - the organization, people, technology and knowledge - for SW Process Asset Management and Deployment.

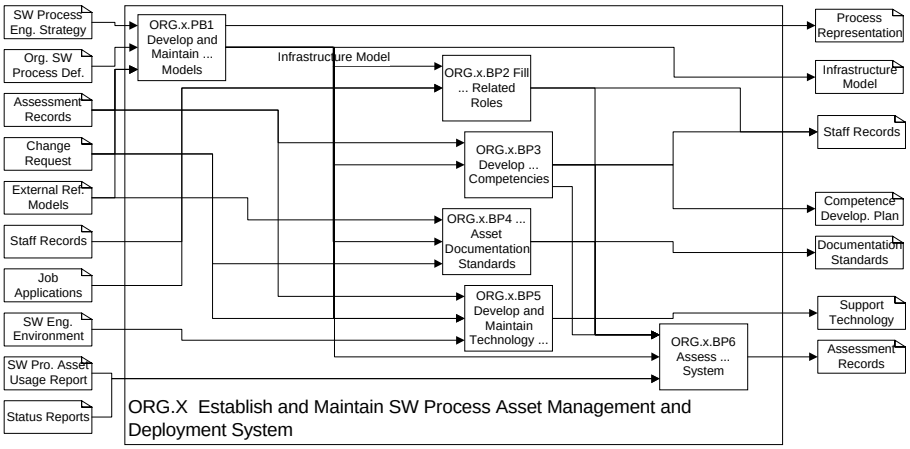
Base practices

The base practices belonging to the process ORG.X Establish and Maintain SW Process Asset Management and Deployment System are:

Base practices	See
ORG.x.BP1 Develop and Maintain SW Process Asset Management and Deployment Infrastructure and Activity Models	
ORG.x.BP2 Fill the SW Process Asset Management and Deployment Related Roles	
ORG.x.BP3 Develop SW Process Asset Management and Deployment Competencies	
ORG.x.BP4 Develop and Maintain SW Process Architecture and Process Asset Documentation Standards	
ORG.x.BP5 Develop and Maintain Technology for SW Process Asset Management and Deployment	
ORG.x.BP6 Assess SW Process Asset Management and Deployment System	

Illustration

Illustration of the process ORG.X Establish and Maintain SW Process Asset Management and Deployment System:



ORG.x.BP1 Develop and Maintain SW Process Asset Management and Deployment Infrastructure and Activity Models

Purpose

The purpose of this base practice is to develop models describing the activities and infrastructure, the organization, people, technology and knowledge, for SW Process Asset Management and Deployment.

Entry Criteria

The entry criteria are:

Item	Criterion	See
SW Process Engineering Strategy	Approved	
Organizational SW Process Definition	Approved	
Assessment Records	Available	
Change Request	Available	
External Reference Models	Available	

Stages

The stages of the base practice are:

Stage	Description
1	Define/re-define process for SW Process Asset Management, and SW Process Deployment.
2	Define/re-define organizational model, including roles, responsibilities and communication lines.
3	Define/re-define resource allocation guidelines for different roles.
4	Define/re-define skills and knowledge needs in different roles.
5	Define/re-define requirements for support technology.
6	Document the results and place under configuration control.

Verification & Validation

Audits, inspections and reviews

The results of this base practice shall be reviewed by SW Process Area Responsible and Local SW Process Asset Responsible persons, and Global SPE Management Team. The Global SPE Management Team approves or disapproves the results.

The references are:

Procedure	See
SWQ.4 Perform SW Peer Reviews	

Exit Criteria

The exit criteria are:

Item	Criterion	See
Infrastructure Model (for SW Process Asset Management and Deployment)	Approved	
Process Representation (for SW Process Asset Management and Deployment)	Approved	

Roles

Related roles are:

Relationship	Role name	See
Responsible / performing	Global SW Process Asset Manager	
Participating	Local SW Process Asset Responsible	
Participating	SW Process Area Responsible	

ORG.x.BP2 Fill the SW Process Asset Management and Deployment Related Roles

Purpose

The purpose of this base practice is to fill roles in the SW Process Asset Management and Deployment organization.

Note: This base practice make use of applicable base practices from the process ORG.3 Human Resource Management Process.

Entry Criteria

The entry criteria are:

Item	Criterion	See
Infrastructure Model (for SW Process Asset Management and Deployment / organization and people elements)	Approved	
Process Representation (SW Process Asset Management and Deployment)	Approved	
Staff Records	Available	
Job Application	Available	

Stages

The stages of the base practice are:

Stage	Description
1	Identify human resource needs across the SW Process Asset Management and Deployment organization.
2	Define job profile for an open position, and communicate the open position via appropriate channels.
3	Select individual for the open position by recruiting staff qualified to meet the needs of the role at issue, or by providing opportunity for career development for existing staff.
4	Update Staff Records.

Verification & Validation

Currently, there are no verification or validation activities defined for this base practice, but you should carefully consider whether the new (or updated) work products are critical enough to require some type of formal/informal review.

Exit Criteria

The exit criteria are:

Item	Criterion	See
Staff Records	Updated	

Roles

Related roles are:

Relationship	Role name	See
Responsible	Global SW Process Management Team	
Performing	Global SW Process Asset Manager	
Performing	SW Process Support Team	

ORG.x.BP3 Develop SW Process Asset Management and Deployment Competencies

Purpose

The purpose of this base practice is to ensure adequate competencies for people performing SW Process Asset Management and Deployment activities.

Entry Criteria

The entry criteria are:

Item	Criterion	See
Infrastructure Model (for SW Process Asset Management and Deployment)	Approved	

Process Representation (SW Process Asset Management and Deployment)	Approved	
Staff Records	Available	
Assessment Records (from ORG.x.06 Assess SW Process Asset Management and Deployment Infrastructure)	Approved	

Stages

The stages of the base practice are:

Stage	Description
1	Analyze the skill and knowledge needs from Infrastructure Model, and the Assessment Records (from ORG.x.06 Assess SW Process Asset Management and Deployment Infrastructure).
2	Make a Competence Development Plan for the organization at issue.
3	Develop or acquire training based on needs. **Note:** This stage is performed using the ORG.3.BP2 Develop or Acquire Training in a suitable manner. Training Strategy/Plan, Training Material, and Training Records are
4	Train and coach personnel to have the knowledge and skills needed to perform their roles, and maintain Staff Records. **Note:** This stage is performed using the ORG.3.BP3 Train Personnel and ORG.3.BP7 Maintain Staff Records in a suitable manner.

Verification & Validation

Audits, inspections and reviews

Appropriate stakeholders of the organization at issue shall review the Competence Development Plan. For instance Competence Development Plan for Global SW Process Asset Management organization shall be reviewed at least by the Global SPE Management Team. The Global SPE Management Team approves or disapproves the results.

The references are:

Reference	See
SWQ.4 Perform SW Peer Reviews	

Exit Criteria

The exit criteria are:

Item	Criterion	See
Competence Development Plan	Approved	

Staff Records	Updated	

Roles

Related roles are:

Relationship	Role name	See
Responsible / performing	Global SW Process Asset Manager	
Participating	Local SW Process Asset Responsible	
Participating	SW Process Area Responsible	
Responsible / performing	Local SPI Manager	
Participating	SW Process Support Team	

ORG.x.BP4 Develop and Maintain SW Process Architecture and Process Asset Documentation Standards

Purpose

The purpose of this base practice is to develop and maintain SW process architecture and SW Process Asset Documentation Standards to be used as a framework and as documentation standards for SW Process Asset definition.

Note: It is highly recommended that publicly available references are used as a basis for these activities.

Entry Criteria

The entry criteria are:

Item	Criterion	See
SW Process Engineering Strategy	Approved	
Organizational SW Process Definition	Approved	
Assessment Records	Available	
Change Request	Available	
External Reference Models	Available	

Stages

The stages of the base practice are:

Stage	Description
1	Define SW process architecture elements and relationships between them.
2	Define the information contents of each SW process architecture element.

3	Define the information presentation principles and templates for each SW process architecture element.
4	Define the overall coverage of SW process.
5	Define activity breakdown structure.
6	Document the results as SW Process Asset Documentation Standards and place under configuration control.

Verification & Validation

Audits, inspections and reviews

The results of this base practice shall be reviewed by SW Process Area Responsible and Local SW Process Asset Responsible persons, and Global SPE Management Team. The results can be prototyped by applying those to process definition in a limited process area. The Global SPE Management Team approves the results.

The references are:

Reference	See
SWQ.4 Perform SW Peer Reviews	

Exit Criteria

The exit criteria are:

Item	Criterion	See
SW Process Asset Documentation Standards	approved	

Roles

Related roles are:

Relationship	Role name	See
Responsible / performing	Global SW Process Asset Manager	
Participating	Local SW Process Asset Responsible	
Participating	SW Process Area Responsible	

ORG.x.BP5 Develop and Maintain Technology for SW Process Asset Management and Deployment

Purpose

The purpose of this base practice is to develop and maintain the technology, e.g. tools, supporting the execution of SW Process Asset Management and Deployment activities.

Entry Criteria

The entry criteria are:

Item	Criterion	See
Infrastructure Model (for SW Process Asset Management and Deployment)	Proposal	
Process Representation (SW Process Asset Management and Deployment)	Proposal	
SW Engineering Environment	Available	
Assessment Records	Available	
Change Request	Available	

Stages

The stages of the base practice are:

Stage	Description
1	Analyze the activities and roles that the technology shall support.
2	Analyze current SW engineering environment. Including e.g. what tools are used in other processes, what operating systems are in use, etc.
3	Refine the technology requirements from the Infrastructure Model for SW Process Asset Management and Deployment / Technology.
4	Define the family of required tools and allocate the requirements.
5	Develop or acquire tools.
6	Analyze feedback and change requests.
7	Improve tools.

Verification & Validation

Audits, inspections and reviews

The results of this base practice shall be reviewed by SW Process Area Responsible and Local SW Process Asset Responsible persons. The results can be prototyped by applying those to process definition in a limited process area. The Global SPE Management Team approves the results.

The references are:

Reference	See
SWQ.4 Perform SW Peer Reviews	

Exit Criteria

The exit criteria are:

Item	Criterion	See
SW Process Asset Library	Approved	
SW Process Development Database	Approved	
Project-Specific Process Database	Approved	
Communication Mechanism	Approved	
Tools Supporting SW Engineering Processes (includes also Communication Mechanism, and Process Modeling and Simulation Tools)	Approved	

Roles

Related roles are:

Relationship	Role name	See
Responsible	Global SW Process Asset Manager	
Performing	SW Tool Developer	
Participating	Local SW Process Asset Responsible	
Participating	SW Process Area Responsible	

ORG.x.BP6 Assess SW Process Asset Management and Deployment System

Purpose

The purpose of this base practice is to assess periodically the operational SW Process Asset Management and Deployment system, in order to evaluate the implementation and to improve the related infrastructure and activity models.
Note: If SW Process Asset Management and Deployment do not deliver the expected results, the reason can be e.g.:

- The goals are unrealistic.
- The SW Process Assets are not useful.
- The activity and/or infrastructure models for SW Process Asset Management and Deployment are not implemented properly.
- The process and/or infrastructure models for SW Process Asset Management and Deployment are inappropriate.

Entry Criteria

The entry criteria are:

Item	Criterion	See
Infrastructure Model (SW Process Asset Management and Deployment)	Approved	
Process Representation (SW Process Asset Management and Deployment)	Approved	

SW Process Asset Usage Report	Approved	
SW Process Asset Management Status Report	Available	
Staff Records	Available	
Competence Development Plan	Approved	
SW Process Engineering Strategy	Approved	

Stages

The stages of the base practice are:

Stage	Description
1	Analyze the results from base practice ORG.X.0X Assess the Use of Process Assets.
2	Assess the implementation of SW Process Asset Management infrastructure and process models. **Note:** This stage can be performed using the ORG.2.2 Process Assessment Process in a suitable manner.
3	Document the results.

Verification & Validation

Audits, inspections and reviews

The results of this base practice shall be reviewed by Global SW Process Management Team, SW Process Area Responsible and Local SW Process Asset Responsible persons.

The references are:

Reference	See
SWQ.4 Perform SW Peer Reviews	

Exit Criteria

The exit criteria are:

Item	Criterion	See
Assessment Records		

Roles

Related roles are:

Relationship	Role name	See
Responsible / performing	Global SW Process Asset Manager	
Participating	SW Process Area Responsible	
Responsible / performing	Local SPI Manager	

Participating	Local SW Process Asset Responsible	

Appendix 3: Generic Activities for SW Process Asset Management

Introduction	This attachment describes the generic process ORG.X Manage SW Process Assets, and provides tailoring guidelines for applying them as a reference for process definition purposes.
Roles and Work Products	Base practice descriptions in this appendix include references to all related work products and roles. The role description can be found from Appendix 5: Generic Roles for SW Process Asset Management and Deployment. The full work product descriptions, outputs only, are presented in Appendix 4: Generic Work Products for SW Process Asset Management and Deployment.
Tailoring	The process and base practice descriptions in this appendix can be used as checklists for evaluating and revising , or as a reference model for establishing, process representation in the context of own organization. The breakdown and naming of activities, work products and roles, and used terminology can be tailored to suit organizational context. However, the issues covered by these descriptions are all found essential in the case organization and should not be left uncovered without careful consideration.

ORG.x SW Process Asset Management

Purpose

The purpose of this process is to capture the existing processes, and the improvements and changes to the processes into a set of assets (tools, methods, and process representations) that can be reused in future process instances, to store and maintain these assets, and to make them available for process engineering purposes.

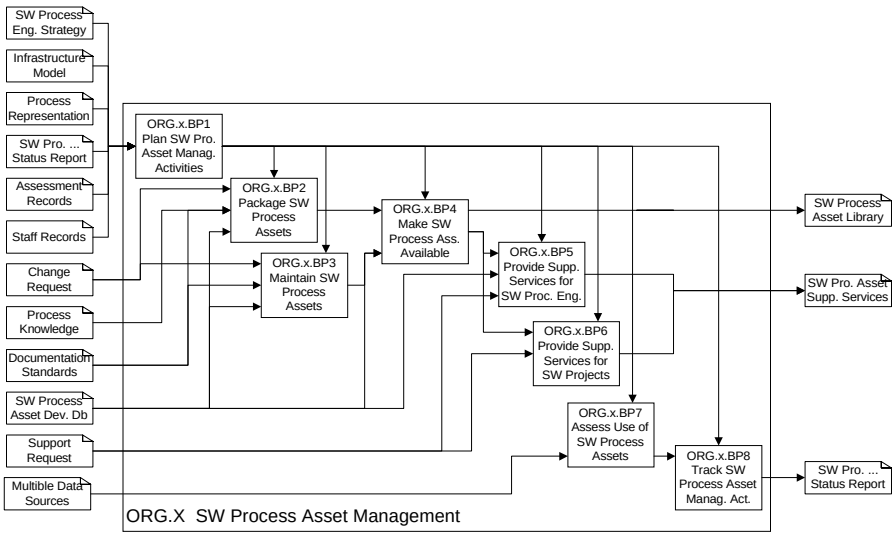
Base practices

The base practices belonging to the process ORG.X SW Process Asset Management are:

Base practices	See
ORG.x.BP1 Plan SW Process Asset Management Activities	
ORG.x.BP2 Package SW Process Assets	
ORG.x.BP3 Maintain SW Process Assets	
ORG.x.BP4 Make SW Process Assets Available	
ORG.x.BP5 Provide Support Services for SW Process Engineering	
ORG.x.BP6 Provide Support Services for SW Projects	
ORG.x.BP7 Assess Use of SW Process Assets	
ORG.x.BP8 Track SW Process Asset Management Activities	

Illustration

Illustration of the process ORG.X SW Process Asset Management:



ORG.x.PB1 Plan SW Process Asset Management Activities

Purpose

The purpose of this base practice is to plan and establish the SW Process Asset Management activities and to take corrective action when targets are not achieved.

Entry Criteria

The entry criteria are:

Item	Criterion	See
SW Process Engineering Strategy	Approved	
Infrastructure Model (SW Process Asset Management)	Approved	
Process Representation (SW Process Asset Management)	Approved	
SW Process Asset Management Status Report	Available	
Assessment Records (SW Process Assessments)	Available	
Staff Records	Available	

Stages

The stages of the base practice are:

Stage	Description
1	Define objectives.
2	Define means to achieve the objectives.
3	Document the results as a SW Process Asset Management Plan.
4	Communicate the plan.

Verification & Validation

Audits, inspections and reviews

The results of this base practice shall be reviewed by Global SW Process Management Team, SW Process Area Responsible and Local SW Process Asset Responsible persons.

The references are:

Reference	See
SWQ.4 Perform SW Peer Reviews	

Exit Criteria

The exit criteria are:

Item	Criterion	See
SW Process Asset Management Plan	Approved	

Roles

Related roles are:

Relationship	Role name	See
Responsible / Performing	Global SW Process Asset Manager	
Participating	SW Process Area Responsible	
Participating	Local SW Process Asset Responsible	

ORG.x.PB2 Package SW Process Assets

Purpose

The purpose of this base practice is to document SW process-related knowledge as reusable SW Process Assets.

The SW Process Assets include:

- Activities
- Work products
- Roles
- Metrics
- Glossary terms
- SW life cycles
- Process tailoring guidelines

Entry Criteria

The entry criteria are:

Item	Criterion	See
SW Process Asset Management Plan	Approved	
Process Knowledge	Available	
Change Request	Detected	
SW Process Asset Documentation Standards	Approved	
SW Process Development Database	Available	

Stages

The stages of the base practice are:

Stage	Description
1	Identify the SW process related knowledge to be packaged.
2	Documents the knowledge as reusable SW Process Asset

	applying SW Process Documentation Standards.
3	Place the results under configuration control.

Verification & Validation

Audits, inspections and reviews

The results of this base practice shall be reviewed by appropriate SW Process Area Responsible, Local SW Process Asset Responsible persons, and domain area experts. The Global SW Process Asset Manager approves the results.

The references are:

Reference	See
SWQ.4 Perform SW Peer Reviews	

Exit Criteria

The exit criteria are:

Item	Criterion	See
SW Process Asset	Approved	

Roles

Related roles are:

Relationship	Role name	See
Performing	SW Process Developer	
Performing	SW Process Area Responsible	
Performing	Local SW Process Asset Responsible	

ORG.x.PB3 Maintain SW Process Assets

Purpose

The purpose of this base practice is to maintain the documented SW Process Assets, including minor content updates of existing SW Process Assets and changes aiming to ensure the integrity and consistency of the structure and contents of the SW Process Asset Library.

Entry Criteria

The entry criteria are:

Item	Criterion	See
SW Process Asset Management Plan	Approved	
SW Process Asset Documentation Standards	Approved	

SW Process Asset	Approved	
Change Request	Detected	
SW Process Asset Development Database	Available	

Stages

The stages of the base practice are:

Stage	Description
1	Analyze Change Request made against existing SW Process Asset(s).
2	Analyze integrity of existing SW Process Assets across different process areas according to the SW Process Asset Documentation Standards.
3	Implement necessary changes.

Verification & Validation

Audits, inspections and reviews

The results of this base practice shall be reviewed by Global SW Process Management Team, SW Process Area Responsible and Local SW Process Asset Responsible persons.

The references are:

Reference	See
SWQ.4 Perform SW Peer Reviews	

Exit Criteria

The exit criteria are:

Item	Criterion	See
SW Process Asset	Updated and Approved	

Roles

Related roles are:

Relationship	Role name	See
Responsible / Performing	Global SW Process Asset Manager	
Performing	SW Process Area Responsible	
Participating	Local SW Process Asset Responsible	
Participating	SW Process Developer	

ORG.x.BP4 Make SW Process Assets Available

Purpose

The purpose of this base practice is to make SW Process Assets available for process engineering purposes.

Entry Criteria

The entry criteria are:

Item	Criterion	See
SW Process Asset Management Plan	Approved	
SW Process Asset	Approved	
SW Process Asset Development Database	Available	

Stages

The stages of the base practice are:

Stage	Description
1	Make a SW Process Asset Library release from the SW Process Asset Development Database. **Note:** The release shall include a SW Process Asset Library Release Note describing all changes since previous release.
2	Make a SW Process Asset Library release available in all SW R&D sites.
3	Inform users about the availability.

The information HOW the stages are performed are described in the following procedures:

Procedure	See
ORG.x.PB4 How to Make SW Process Asset Library Release	

Verification & Validation

Audits, inspections and reviews

The results of this base practice shall be reviewed by The Local SW Process Asset Responsible persons by checking that the new version of SW Process Asset Library is locally available, and that it is working properly.

Exit Criteria

The exit criteria are:

Item	Criterion	See
SW Process Asset Library (including SW Process Asset Library Release Note)	New release available	

	in all sites	

Roles

Related roles are:

Relationship	Role name	See
Responsible / Performing	Global SW Process Asset Manager	
Participating	SW Process Area Responsible	
Participating	Local SW Process Asset Responsible	

ORG.x.BP5 Provide Support Services for SW Process Engineering

Purpose

The purpose of this base practice is to provide support services for other SW Process Engineering activities, for example SW Process Development and SW Process Evaluation.

The form of support can be e.g.:

- Training or consultancy concerning the contents of current SW Process Assets
- Support in SW Process Development
- Support in the use of SW Process Asset Management related technology
- Support in SW Process Engineering Planning

Entry Criteria

The entry criteria are:

Item	Criterion	See
SW Process Asset Management Plan	Approved	
SW Process Asset Library	Available	
SW Process Asset Development Database	Available	
Support Request	Detected	

Stages

The stages of the base practice are:

Stage	Description
1	Identify support needs.
2	Provide support for SW Process Engineering Management activities. **Note:** Support for global level activities is typically provided by Global SW Asset Manager and for local, the

	site, level activities by Local SW Process Asset Responsible.
3	Provide support for SW Process Evaluation activities, the process assessment and process measurement. **Example:** Support in SW process assessment can be e.g. helping in SW Process Documentation Review.
4	Provide support for SW Process Development activities.
5	Provide support for SW Process Deployment activities.

Verification & Validation

Audits, inspections and reviews

The results of this base practice shall be reviewed by Global SW Process Management Team or Local SPI Manager as appropriate.

The references are:

Reference	See
SWQ.4 Perform SW Peer Reviews	

Exit Criteria

The exit criteria are:

Item	Criterion	See
SW Process Asset Support Services	Delivered	

Roles

Related roles are:

Relationship	Role name	See
Responsible / performing	Global SW Process Asset Manager	
Responsible / performing	SW Process Area Responsible	
Responsible / performing	Local SW Process Asset Responsible	

ORG.x.BP6 Provide Support Services for SW Projects

Purpose

The purpose of this base practice is to provide support services for SW projects.

Entry Criteria

The entry criteria are:

Item	Criterion	See
SW Process Asset Management Plan	Approved	
SW Process Asset Library	Approved	
Support Request	Detected	

Stages

The stages of the base practice are:

Stage	Description
1	Identify support needs.
2	Help SW projects to tailor project-specific process using reusable SW Process Assets from the SW Process Asset Library.
3	Act as a SW Process Asset related helpdesk for SW projects.
4	Provide SW Process Asset related training for SW projects.

Verification & Validation

Audits, inspections and reviews

The results of this base practice shall be reviewed by Global SW Process Management Team, SW Process Area Responsible and Local SW Process Asset Responsible persons.

The references are:

Reference	See
SWQ.4 Perform SW Peer Reviews	

Exit Criteria

The exit criteria are:

Item	Criterion	See
SW Process Asset Support Services	Delivered	

Roles

Related roles are:

Relationship	Role name	See
Performing	SW Process Supporter	
Performing	Local SW Process Asset Responsible	

ORG.x.BP7 Assess Use of SW Process Assets

Purpose

The purpose of this base practice is to assess the use of SW Process Assets.

Entry Criteria

The entry criteria are:

Item	Criterion	See
SW Process Asset Management Plan	Approved	
Change Request	Available	
SW Project Plan (SW Quality Plans)	Available / optional	
SW Process Assessment Records	Available / optional	
Audit Report	Available / optional	
Measurement Data	Available / optional	
SW Project Status Report	Available / optional	
SW Project Final Report	Available / optional	
Milestone Review Records	Available / optional	

Stages

The stages of the base practice are:

Stage	Description
1	Collect all relevant data.
2	Analyze data.
3	Report results to all relevant stakeholders.

Verification & Validation

Audits, inspections and reviews

The results of this base practice shall be reviewed by Global SW Process Management Team.

The references are:

Reference	See

SWQ.4 Perform SW Peer Reviews	

Exit Criteria

The exit criteria are:

Item	Criterion	See
SW Process Asset Usage Report	Approved	

Roles

Related roles are:

Relationship	Role name	See
Responsible / Performing	Global SW Process Asset Manager	
Participating	SW Process Area Responsible	
Participating	Local SW Process Asset Responsible	

ORG.x.BP8 Track SW Process Asset Management Activities

Purpose

The purpose of this base practice is to regularly report the status of the SW Asset Management activities and to compare them against plans.

Note: Particular aspects to address include:

- Deliverables
- Effort
- Schedule
- Resources
- Risks

Entry Criteria

The entry criteria are:

Item	Criterion	See
SW Process Asset Management Plan	Approved	
SW Process Asset Usage Report	Approved	

Stages

The stages of the base practice are:

Stage	Description
1	Collect all information about performed SW Process Asset Management activities.
2	Compare results to the SW Process Asset Management Plan.

3	Make a SW Process Asset Management Status Report.
4	Report the status to all relevant stakeholders.

Verification & Validation

Currently, there are no verification or validation activities defined for this base practice, but you should carefully consider whether the new (or updated) work products are critical enough to require some type of formal/informal review.

Exit Criteria

The exit criteria are:

Item	Criterion	See
SW Process Asset Management Status Report	Completed	

Roles

Related roles are:

Relationship	Role name	See
Responsible / Performing	Global SW Process Asset Manager	
Participating	SW Process Area Responsible	
Participating	Local SW Process Asset Responsible	

Appendix 4: Generic Work Products for SW Process Asset Management and Deployment

Introduction

This attachment describes the generic work products which are created in the processes ORG.X Establish and Maintain SW Process Asset Management infrastructure and ORG.X Manage SW Process Assets, and provides tailoring guidelines for applying them as a reference for process definition purposes.

Tailoring

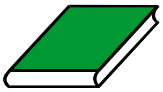
The work product descriptions in this appendix can be used as checklists for evaluating and revising , or as a reference model for establishing, process representation in the context of own organization.

The breakdown and naming of activities, work products and roles, and used terminology can be tailored to suit organizational context. However, the issues covered by these descriptions are all found essential in the case organization and should not be left uncovered without careful consideration.

List of work products

The work products in alphabetical order are:

- Assessment Records
- Competence Development Plan
- Infrastructure Model
- Process Representation
- Project Specific Process Database
- Staff Records
- SW Process Asset
- SW Process Asset Documentation Standards
- SW Process Asset Library
- SW Process Asset Management Plan
- SW Process Asset Management Status Report
- SW Process Asset Support Services
- SW Process Asset Usage Report
- SW Process Development Database
- Tools Supporting SW Engineering Processes



Assessment Records

Purpose

The purpose of this work product is to document the results of an assessment.

Content

The characteristics of this work product typically are:

- States the purpose of assessment
- Describes the method used for assessment
- States the requirements used for the assessment
- Documents assumptions and limitations
- Identifies the context and scope information required:
  - date of assessment
  - organizational unit assessed
  - sponsor information
  - assessment team
  - attendees
  - scope/coverage
  - assessee information
  - assessment instrument (checklist, tool) used
- Records the result:
  - identifies the required corrective actions
  - improvement opportunities

Templates

The templates are:

Item	Scope	See
SW Process Engineering Infrastructure Assessment Report Template	SW Process Engineering Infrastructure	

States

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Relationships

Activities

Related activities are:

Relationship	Activity	See
Created in	ORG.x.BP6 Assess SW Process Asset Management and Deployment System	
Used in	ORG.x.PB1 Develop and Maintain SW Process Asset Management and Deployment Infrastructure and Activity	

	Models	
Used in	ORG.x.BP3 Develop SW Process Asset Management and Deployment Competencies	
Used in	ORG.x.BP4 Develop and Maintain SW Process Architecture and Process Asset Documentation Standards	
Used in	ORG.x.BP5 Develop and Maintain Technology for SW Process Asset Management and Deployment	
Used in	ORG.x.BP1 Plan SW Process Asset Management Activities	
	Note: This work product may have relationships to other activities out of the focus of this study report.	

Work Products

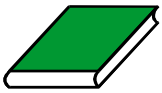
Related work products are:

Relationship	Work Product	See
Is influenced by	SW Process Asset Management and Deployment Status Report	
Is influenced by	SW Process Asset Usage Report	
Has influence on	Process Representation	
Has influence on	Infrastructure Model	
	Note: This work product may have relationships to other work products out of the focus of this study report.	

Roles

Related roles are:

Relationship	Role name	See
Owned By	Global SW Process Asset Manager	
Approved by	Global SW Process Management Team	
	Note: This work product may have relationships to other roles out of the focus of this study report.	



Competence Development Plan

Purpose

The purpose of this work product is to present personnel competence development objectives, and the means to achieve those objectives.

Content

The characteristics of this work product typically are:

- Identification of the plan owner
- Includes the competence development objectives:
  - what is the current level of skills and knowledge
  - what are the strategic areas for development of skills and knowledge of the SW personnel
  - Includes constraints
  - Identifies quality criteria
- Method/approach to accomplish objectives:
  - how the skills and knowledge will be developed
  - what and how much resources are needed on the training and other activities
- Includes tasks to be accomplished:
  - Identifies task ownership
  - Includes schedules, milestones and target dates
  - Includes critical dependencies
- Includes resources to accomplish competence development objectives:
  - time
  - staff
- Includes risks

Templates

The templates are:

Item	Scope	See
Competence Development Plan Template	Competence development	

States

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Relationships

Activities

Related activities are:

Relationship	Activity	See
Created in	ORG.x.BP3 Develop SW Process Asset Management and Deployment Competencies	

Used in	ORG.x.BP6 Assess SW Process Asset Management and Deployment System	
	Note: This work product may have relationships to other activities out of the focus of this study report.	

Work Products

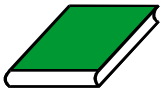
Related work products are:

Relationship	Work product	See
Is influenced by	Infrastructure Model (people)	
Is influenced by	Assessment Records	
	Note: This work product may have relationships to other work products out of the focus of this study report.	

Roles

Related roles are:

Relationship	Role name	See
Owned by / Defined by	Global SW Process Management Team	
Owned by / Defined by	Local SPI Manager	
Approved by	Global SW Process Management Team	
	Note: This work product may have relationships to other roles out of the focus of this study report.	



Infrastructure Model

Purpose

The purpose of this work product is to describe the elements of SW Process Asset Management Infrastructure

Content

The content of this work product typically are:

- Organization
  - structure
  - roles
  - responsibilities
  - communication channels
- People
  - abilities
  - standing
  - time allocation
  - motivation
- Technology
  - support tools
- Knowledge

States

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Relationships

Activities

Related activities are:

Relationship	Activity	See
Created in	ORG.x.PB1 Develop and Maintain SW Process Asset Management and Deployment Infrastructure and Activity Models	
Used in	ORG.x.BP2 Fill the SW Process Asset Management and Deployment Related Roles	
Used in	ORG.x.BP3 Develop SW Process Asset Management and Deployment Competencies	
Used in	ORG.x.BP5 Develop and Maintain Technology for SW Process Asset Management and Deployment	
Used in	ORG.x.BP6 Assess SW Process Asset Management and Deployment System	
Used in	ORG.x.BP1 Plan SW Process Asset Management Activities	

Work Products

Related work products are:

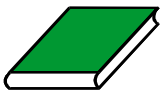
Relationship	Work product	See
Is influenced by	SW Process Engineering Strategy	

Is influenced by	Assessment Records	
Is influenced by	External Reference Models	

Roles

Related roles are:

Relationship	Role name	See
Owned by	Global SW Process Asset Manager	
Approved by	Global SW Process Management Team	



Process Representation

Purpose

The purpose of this work product is to describe a process, including related activities, work products and roles.

Note: See also work products SW Process Asset and SW Process Asset Documentation Standards.

Content

The content of this work product typically are:

- Activities
  - Process Category
  - Process
    - Base Practices
    - Purpose
    - Entry criteria (including input work products)
    - Stages
    - Verification & Validation (including measures)
    - Exit criteria (including output work products)
    - Roles
    - References
- Work Products
- Roles

Can contain as a support process elements:

- Glossary
- Metrics
- Training
- References

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Relationships

Activities Related activities are:

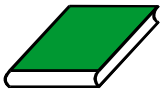
Relationship	Activity	See
Created in	ORG.x.PB1 Develop and Maintain SW Process Asset Management and Deployment Infrastructure and Activity Models	
Used in	ORG.x.BP2 Fill the SW Process Asset Management and Deployment Related Roles	
Used in	ORG.x.BP3 Develop SW Process Asset Management and Deployment Competencies	
Used in	ORG.x.BP5 Develop and Maintain Technology for SW Process Asset Management and Deployment	
Used in	ORG.x.BP6 Assess SW Process Asset Management and Deployment System	
Used in	ORG.x.BP1 Plan SW Process Asset Management Activities	
	Note: This work product may have relationships to other activities out of the focus of this study report.	

Work Products Related work products are:

Relationship	Work product	See
Is part of	SW Process Asset Library	
Is influenced by	Process Knowledge	
Is influenced by	SW Process Asset Documentation Standards	
Is influenced by	Change Request	
Consist of	SW Process Asset	

Roles Related roles are:

Relationship	Role name	See
Owned by	Process Owner	
Approved by	Global SW Process Asset Manager	



SW Process Asset

Purpose

The purpose of this work product is to capture the existing processes, and the improvements and changes to the processes into a set of assets (tools, methods, process representations) that can be reused in future process instances.

Note: See also work product SW Process Asset Documentation Standards

Content

The characteristics of this work product typically are:

- Documented
- Available for reuse
- Maintained

The possible types of the SW Process Assets include:

- Activities
- Work products
- Roles
- Metrics
- Glossary terms
- SW life cycles
- Process tailoring guidelines

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Relationships

Activities

Related activities are:

Relationship	Activity	See
Created in	ORG.x.BP2 Package SW Process Assets	
Updated in	ORG.x.BP3 Maintain SW Process Assets	
Used in	ORG.x.BP4 Make SW Process Assets Available	

Work Products

Related work products are:

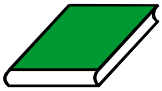
Relationship	Work product	See
Is part of	SW Process Asset Development Database	
Is part of	SW Process Asset Library	
Is part of	Process Representation	

Is influenced by	Process Knowledge	
Is influenced by	Change Request	
Is influenced by	SW Process Asset Documentation Standards	

Roles

Related roles are:

Relationship	Role name	See
Owned by	Global SW Process Asset Manager	
Defined by	SW Process Developer	
Reviewed by / Defined by	SW Process Area Responsible	



Project Specific Process Database

Purpose

The purpose of this work product is to be used as tool for tailoring a SW project specific SW process, making process description available for project personnel and all relevant stakeholders, and capturing and sharing experience gained in the project.

Content

The characteristics of this work product typically are:

- hypertext solution
- allows tailoring
- access control

The information content may include e.g. following:

- Quality Responsibilities
- Quality Objectives
- SW Metrics Plan
- SW Process and its Documentation
- Quality Assurance/Verification
- SW Configuration Management Plan
- Problem Reporting and Corrective Action
- Development Environment
- Supplier Control
- Lessons learned

Templates

The templates are:

Item	Scope	See
Project Database Template	All SW Projects	

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Relationships

Activities Related activities are:

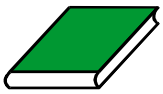
Relationship	Activity	See
Created in (technology)	ORG.x.BP5 Develop and Maintain Technology for SW Process Asset Management and Deployment	
Used in	Most of the SW project activities	-

Work Products Related work products are:

Relationship	Work product	See
Is influenced by	Infrastructure Model (technology)	
Is influenced by	SW Process Asset Library	
Is influenced by	SW Project Type	
Is influenced by	SW Process Tailoring Guidelines	
Is influenced by	SW Process Policy	

Roles Related roles are:

Relationship	Role name	See
Owned by	SW Process Asset Manager	
Developed by	SW Tool Developer	
Used by	All roles in SW project	



Staff Records

Purpose The purpose of this work product is to capture all relevant information about (SW) personnel.

Note: The information about the personnel can be documented in several different records. Those records can be used to several different purposes. Some of the information can be confidential, and therefore excluded from some of the records.

Content This work product contains relevant information about personnel in respect to the purpose of use, including e.g.:

- name, address, date of birth, marital status
- grade, pay, appraisal history
- job role(s)
- education
- skills
- training records

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Relationships

Activities Related activities are:

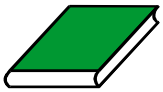
Relationship	Activity	See
Used in / Updated in	ORG.x.BP2 Fill the SW Process Asset Management and Deployment Related Roles	
Used in / Updated in	ORG.x.BP3 Develop SW Process Asset Management and Deployment Competencies	
Used in	ORG.x.BP6 Assess SW Process Asset Management and Deployment System	
Used in	ORG.x.BP1 Plan SW Process Asset Management Activities	
	Note: This work product may have relationships to other activities out of the focus of this study report.	

Work Products Related work products are:

Relationship	Work product	See
Is influenced by	Infrastructure Model (organization and people)	
Is influenced by	Process Representation	
Is influenced by / Has influence on	Assessment Records	
	Note: This work product may have relationships to other work products out of the focus of this study report.	

Roles Related roles are:

Relationship	Role name	See
Owned by	SW Line	



SW Process Asset Documentation Standards

Purpose The purpose of this work product is to provide minimum requirements on the structure, content and stylistic considerations of the created SW Process Asset documentation.

Content The content of this work product typically are:

- Identification of who/what standards apply to
- Documentation principles
- Structure of documents
- Document content, sections etc.
- Document templates
- Rules, checklists
- Documentation process

Templates The templates are:

Item	Scope	See
SW Process Asset Documentation Guidelines (includes also defined templates for different process elements)	SW Process Assets	

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Relationships

Activities Related activities are:

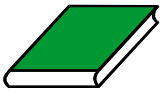
Relationship	Activity	See
Created in	ORG.x.BP4 Develop and Maintain SW Process Architecture and Process Asset Documentation Standards	
Used in	ORG.x.BP2 Package SW Process Assets	
Used in	ORG.x.BP3 Maintain SW Process Assets	

Work Products Related work products are:

Relationship	Work product	See
Is influenced by	External Reference Models	
Has influence on	SW Process Assets	

Roles Related roles are:

Relationship	Role name	See
Owned by	Global SW Process Asset Manager	



SW Process Asset Library

Purpose The purpose of this work product is to serve as media to make SW Process Assets available.

Content The characteristics of this work product typically are:

- database
- hypertext solution
- support for navigation
- search functionality
- access control
- ability to provide feedback

Templates The templates are:

Item	Scope	See
SW Engineering Process Manual Design Template	SW Engineering	

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Relationships

Activities Related activities are:

Relationship	Activity	See
Created in (technological solution)	ORG.x.BP5 Develop and Maintain Technology for SW Process Asset Management and Deployment	

Created in	ORG.x.BP4 Make SW Process Assets Available	
Used in	ORG.x.BP5 Provide Support Services for SW Process Engineering	
Used in	ORG.x.BP6 Provide Support Services for SW Projects	
Used in	Most of the SW Engineering and SW Process Engineering activities	-

Work Products

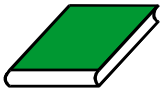
Related work products are:

Relationship	Work product	See
Is influenced by	SW Process Development Database	
Has influence on	Project Specific Process Database	
Consist of	SW Process Asset	

Roles

Related roles are:

Relationship	Role name	See
Owned by	Global SW Process Asset Manager	
Used by	All SW roles	-



SW Process Asset Management Plan

Purpose

The purpose of this work product is to present the objectives of SW Process Asset Management, and the means to achieve those objectives

Content

The contents of this work product typically are:

- Identification of the plan owner
- SW Process Asset Management objectives:
  - Includes constraints
  - Identifies quality criteria
- Method/approach to accomplish objectives:
- Tasks to be accomplished:
  - Identifies task ownership
  - Includes schedules, milestones and target dates
  - Includes critical dependencies
- Resources to accomplish the objectives:
  - time
  - staff
  - materials/equipment
  - budget
- contingency plan for non-completed tasks

Templates

The templates are:

Item	Scope	See
SW Process Asset Management Plan Template	SW Process Asset Management	

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Relationships

Activities

Related activities are:

Relationship	Activity	See
Created in	ORG.x.BP1 Plan SW Process Asset Management Activities	
Used in	ORG.x.BP2 Package SW Process Assets	
Used in	ORG.x.BP3 Maintain SW Process Assets	
Used in	ORG.x.BP4 Make SW Process Assets Available	
Used in	ORG.x.BP5 Provide Support Services for SW Process Engineering	
Used in	ORG.x.BP6 Provide Support Services for SW Projects	
Used in	ORG.x.BP7 Assess Use of SW Process Assets	

Used in	ORG.x.BP8 Track SW Process Asset Management Activities	

Work Products

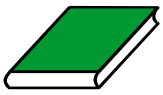
Related work products are:

Relationship	Work product	See
Is part of	SW Process Engineering Plan	
Is influenced by	SW Process Engineering Strategy	
Is influenced by	SW Process Asset Management Status Report	
Is influenced by	Infrastructure Model (SW Process Asset Management)	
Is influenced by	Process Presentation (SW Process Asset Management)	
Is influenced by	Assessment Records	
Is influenced by	Staff Records	

Roles

Related roles are:

Relationship	Role name	See
Owned by / Defined by	Global SW Process Asset Manager	
Reviewed by	SW Process Area Responsible	
Reviewed by	Local SW Process Asset Responsible	
Approved by	Global SW Process Management Team	



SW Process Asset Management Status Report

Purpose

The purpose of this work product is to describe how the SW Asset Management activities have been progressing lately and to compare the current status to the planned status in the SW Process Asset Management Plan.

Content

This work product typically, contains:

- Record of the status of a plan(s) (actual against planned) such as:
  - status of actual tasks against planned tasks
  - status of actual results against established objectives/goals;
  - status of actual resource allocation against planned resources
  - status of actual time and milestone dates against planned schedule
  - status of actual quality against planned quality, including:
- Reasons for deviations from planned
- SW Process Asset Management analysis, e.g. modifications to the plan, description of activities that has been progressing well, activities that has not
- Global SW Process Asset Manager's comments
- SW Process Asset Management related problems, both external & internal

Templates

The templates are:

Item	Scope	See
SW Process Asset Management Status Report Template	SW Process Asset Management Activities	

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Relationships

Activities

Related activities are:

Relationship	Activity	See
Created in	ORG.x.BP8 Track SW Process Asset Management Activities	
Used in	ORG.x.BP1 Plan SW Process Asset Management Activities	
Used in	ORG.x.BP6 Assess SW Process Asset Management and Deployment System	
Used in	Different other activities in SW Process Engineering Management	

Work Products

Related work products are:

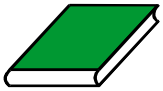
Relationship	Work product	See
Is part of	SW Process Engineering Status Report	

Is influenced by	SW Process Asset Usage Report	
Is influenced by / Has influence on	SW Process Asset Management Plan	

Roles

Related roles are:

Relationship	Role name	See
Owned by / defined by	Global SW Process Asset Manager	
Reviewed by	SW Process Area Responsible	
Reviewed by	Local SW Process Asset Responsible	



SW Process Asset Support Services

Purpose

The purpose of this work product is to provide SW Process Asset related support services for other SW Process Engineering activities, and for SW Projects.

Content

The services may include e.g.:

- hot-line
- consulting
- training
  - process modeling
  - process tailoring
- support for process tailoring

States

None, delivered

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Relationships

Activities

Related activities are:

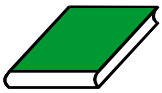
Relationship	Activity	See
Created in	ORG.x.BP5 Provide Support Services for SW Process Engineering	
Created in	ORG.x.BP6 Provide Support Services for SW	
Used in	Several other SW Process Engineering activities	-

Work Products Related work products are:

Relationship	Work product	See
Is influenced by	Support Request	
Has influence on	SW Process Asset Management Status Report	

Roles Related roles are:

Relationship	Role name	See
Provided by	Global SW Process Asset Manager	
Provided by	SW Process Area Responsible	
Provided by	SW Process Supporter	



SW Process Asset Usage Report

Purpose The purpose of this work product is to document the analysis results of SW Process Asset usage.

Content The information contents of this work product typically include some of the following:

- Number of sessions (e.g. per site, release, month, person), absolute figures and/or relative to personnel
- Number of different users (e.g. per site, release, month), (also the role of the user in the organization can be found out.), absolute figures and/or relative to personnel
- Number of reads (e.g. per session, person, month), average, distribution graph
- Number of change requests (e.g. per site, release, month, person)
- Number of feedback (e.g. per site, release, month, person)
- Amount of improvements (e.g. per release, site)
- Analysis of most used documents, and typical use cases
- Analysis of user population: which roles are most active users? What type of information they use?

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Relationships

Activities Related activities are:

Relationship	Activity	See
Created in	ORG.x.BP7 Assess Use of SW Process	
Used in	ORG.x.BP8 Track SW Process Asset Management Activities	
Used in	ORG.x.BP6 Assess SW Process Asset Management and Deployment System	

Work Products

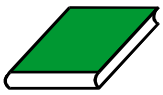
Related work products are:

Relationship	Work product	See
Is influenced by	Change Request	
Is influenced by	SW Project Plan (SW Quality Plan)	
Is influenced by	SW Process Assessment Records	
Is influenced by	Audit Report	
Is influenced by	Measurement Data	
Is influenced by	SW Project Status Report	
Is influenced by	SW Project Final Report	
Is influenced by	Milestone Review Records	
Has influence on	SW Process Asset Management Status Report	

Roles

Related roles are:

Relationship	Role name	See
Owned by / Defined by	Global SW Process Asset Manager	
Defined by	SW Process Area Responsible	
Defined by	Local SW Process Asset Responsible	



SW Process Development Database

Purpose

The purpose of this work product is to provide development environment for SW Process Assets, and support the development and maintenance process of SW Process Assets.

Content

The characteristics of this work product typically are:

- Database
- Provides at least basic configuration management functionality, like:
  - revisions and versions
  - change requests
  - life-cycles for documents and change requests
  - roles
  - access control
  - Views supporting different roles and activities

Templates

The templates are:

Item	Scope	See
SWEP Development Database		

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Relationships

Activities

Related activities are:

Relationship	Activity	See
Created in	ORG.x.BP5 Develop and Maintain Technology for SW Process Asset Management and Deployment	
Used in	ORG.x.BP2 Package SW Process Assets	
Used in	ORG.x.BP3 Maintain SW Process Assets	
Used in	ORG.x.BP4 Make SW Process Assets Available	
Used in	ORG.x.BP5 Provide Support Services for SW Process Engineering	

Work Products

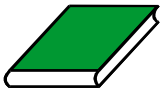
Related work products are:

Relationship	Work product	See
Is influenced by	Infrastructure Model (Technology)	
Is influenced by	Change Request	
Has influence on	SW Process Asset Library	

Roles

Related roles are:

Relationship	Role name	See
Owned by	Global SW Process Asset Manager	
Used by	All SW Process Engineering Roles	-



Tools Supporting SW Engineering Processes

Purpose

The purpose of this work product, or instances of it, is to provide support for performing different SW Engineering activities.

Note: This work product covers large variety of SW engineering tools, for example project management tool, configuration management tool, modeling tool, communication mechanism, and requirement management tool.

Note: This work product can be broken down to more specific tool related work products when applicable.

Content

The characteristics of this work product typically are:

- Support SW specific activities
- Is supported

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Relationships

Activities

Related activities are:

Relationship	Activity	See
Created in	ORG.x.BP5 Develop and Maintain Technology for SW Process Asset Management and Deployment	
Created in	ORG.4 Infrastructure Process (ISO 15504)	
Used in	Several SW Engineering and SW Process Engineering activities	-

Work Products

Related work products are:

Relationship	Work product	See
Is influenced by	Infrastructure Model (Technology)	

Is influenced by	Change Request	
Is influenced by	Process Representation	

Roles Related roles are:

Relationship	Role name	See
Owned by	SW Line	
Used by	All SW Roles	-

Appendix 5: Generic Roles for SW Process Asset Management and Deployment

Introduction	This attachment describes the generic roles which perform the activities in the processes ORG.X Establish and Maintain SW Process Asset Management infrastructure and ORG.X Manage SW Process Assets, and provides tailoring guidelines for applying them as a reference for process definition purposes.
Tailoring	The role descriptions in this appendix can be used as checklists for evaluating and revising, or as a reference model for establishing, process representation in the context of own organization. The breakdown and naming of activities, work products and roles, and used terminology can be tailored to suit organizational context. However, the issues covered by these descriptions are all found essential in the case organization and should not be left uncovered without careful consideration.
List of roles	The roles in alphabetical order are: • Global SW Process Asset Manager • Local SW Process Asset Responsible • SW Process Area Responsible • SW Process Developer • SW Process Supporter • SW Tool Developer

Global SW Process Asset Manager

Definition

A Global SW Process Asset Manager is a person who is responsible for coordinating all SW Process Asset Management-related activities globally.

Note: He or she is a member of the Global SW Process Management Team and chairperson of the SW Process Asset Forum.

Activities

The following activities are related to this role:

Relationship	Activity	See
Responsible / Performing	ORG.x.PB1 Develop and Maintain SW Process Asset Management and Deployment Infrastructure and Activity Models	
Performing	ORG.x.BP2 Fill the SW Process Asset Management and Deployment Related Roles	
Responsible / Performing	ORG.x.BP3 Develop SW Process Asset Management and Deployment Competencies	
Responsible / Performing	ORG.x.BP4 Develop and Maintain SW Process Architecture and Process Asset Documentation Standards	
Responsible	ORG.x.BP5 Develop and Maintain Technology for SW Process Asset Management and Deployment	
Performing	ORG.x.BP6 Assess SW Process Asset Management and Deployment System	
Responsible / Performing	ORG.x.BP1 Plan SW Process Asset Management Activities	
Responsible / Performing	ORG.x.BP3 Maintain SW Process Assets	
Responsible / Performing	ORG.x.BP4 Make SW Process Assets Available	
Responsible / Performing	ORG.x.BP5 Provide Support Services for SW Process Engineering	
Responsible / Performing	ORG.x.BP7 Assess Use of SW Process	
Responsible /	ORG.x.BP8 Track SW Process Asset	

Performing	Management Activities	

Typical scope

The scope of the Global SW Process Asset Manager's proficiency typically includes one or more of the following:

- Organization SW Engineering Process / procedures
- Any SW Engineering Process related issues (such as document repositories, etc.)
- Any SW Process Engineering related issues
- SW Engineering Process goals at global level

Abilities

The technical skills and knowledge that should be possessed by the Global SW Process Asset Manager to be up to standard are:

Skill	Skill Level
Organization's SW Engineering Process	Good
SW Process Engineering	Master
• SW Process Asset Management	Master
• Organization's SW Process Documentation Standards	Master
• SW Process reference models (SW-CMM, ISO 15504, etc.)	Good
Project management	Good

The soft skills and knowledge that should be possessed by Global SW Process Asset Manager to be up to standard are:

Skill	Skill Level
Change management skills	Master
Communication skills	Master
Consulting skills	Master
Facilitation skills	Master
Interviewing skills	Good
Team work skills	Master

Local SW Process Asset Responsible

Definition

A Local SW Process Asset Responsible is a person who is locally responsible for SW Process Asset Management-related activities.

Local SW Process Asset Responsible responsibilities include:

- SW Process Asset Library-related training and support for local SW projects
- SW Process Asset Library-related support for local SW Process Engineering activities
- Actively seeking SW process improvement needs and opportunities
- Actively seeking company experts from the site
- Participation in SW Process Asset Forum meetings

Activities

The following activities are related to this role:

Relationship	Activity	See
Participates in	ORG.x.PB1 Develop and Maintain SW Process Asset Management and Deployment Infrastructure and Activity Models	
Participates in	ORG.x.BP3 Develop SW Process Asset Management and Deployment Competencies	
Participates in	ORG.x.BP4 Develop and Maintain SW Process Architecture and Process Asset Documentation Standards	
Participates in	ORG.x.BP5 Develop and Maintain Technology for SW Process Asset Management and Deployment	
Participates in	ORG.x.BP6 Assess SW Process Asset Management and Deployment System	
Participates in	ORG.x.BP1 Plan SW Process Asset Management Activities	
Performing	ORG.x.BP2 Package SW Process Assets	
Participates in	ORG.x.BP3 Maintain SW Process Assets	
Participates in	ORG.x.BP4 Make SW Process Assets Available	
Performing	ORG.x.BP5 Provide Support Services for SW Process Engineering	
Performing	ORG.x.BP6 Provide Support Services for	

	SW	
Participates in	ORG.x.BP7 Assess Use of SW Process	
Participates in	ORG.x.BP8 Track SW Process Asset Management Activities	

Typical scope

The scope of the Local SW Process Asset Responsible person's proficiency typically includes one or more of the following:

- Organization SW Engineering Process / procedures
- Any process related issues (such as document repositories, etc.)
- Project's SW processes
- Project's quality goals
- SW Engineering Process goals at local level
- (Local) SW projects

Abilities

The technical skills and knowledge that should be possessed by the Local SW Process Asset Responsible to be up to standard are:

Skill	Skill Level
Organization's SW Engineering Process	Good
SW Process Engineering	Good
• SW Process Asset Management	Good
• Organization's SW Process Documentation Standards	Master
• SW Process reference models (SW-CMM, ISO 15504, etc.)	Good
Project management	Basic
Local SW line and SW projects	Good

The soft skills and knowledge that should be possessed by Local SW Process Asset Responsible to be up to standard are:

Skill	Skill Level
Change management skills	Good
Communication skills	Master
Consulting skills	Master
Team work skills	Good

SW Process Area Responsible

Definition

A SW Process Area Responsible is a an individual responsible for coordinating the improvement and maintenance of SW Process Assets in a defined sub-area of the whole SW process at the global level.

Local SW Process Asset Responsible responsibilities include:

- Analyze and track change requests and feedback
- Actively seek improvement needs and opportunities
- Actively seek company experts (possible authors and reviewers)
- Improve the descriptions of assets at process and base practice level (with the help of experts)
- Support authors and reviewers (at procedure and template level)
- Follow-up of local SW Process Improvement activities
- Road-mapping of future improvement using input from local SW Process Improvement activities
- Acting as a 'process area helpdesk'

Activities

The following activities are related to this role:

Relationship	Activity	See
Participates in	ORG.x.PB1 Develop and Maintain SW Process Asset Management and Deployment Infrastructure and Activity Models	
Participates in	ORG.x.BP3 Develop SW Process Asset Management and Deployment Competencies	
Participates in	ORG.x.BP4 Develop and Maintain SW Process Architecture and Process Asset Documentation Standards	
Participates in	ORG.x.BP5 Develop and Maintain Technology for SW Process Asset Management and Deployment	
Participates in	ORG.x.BP6 Assess SW Process Asset Management and Deployment System	
Participates in	ORG.x.BP1 Plan SW Process Asset Management Activities	
Performing	ORG.x.BP2 Package SW Process Assets	
Participates in	ORG.x.BP3 Maintain SW Process Assets	
Participates in	ORG.x.BP4 Make SW Process Assets Available	

Performing	ORG.x.BP5 Provide Support Services for SW Process Engineering	
Performing	ORG.x.BP6 Provide Support Services for SW	
Participates in	ORG.x.BP7 Assess Use of SW Process	
Participates in	ORG.x.BP8 Track SW Process Asset Management Activities	

Typical scope

The scope of the SW Process Area Responsible person's proficiency typically includes one or more of the following:

- Organization SW Engineering Process / procedures
- Process domain that the individual is responsible for
- Any SW Process Engineering related issues, especially process modeling
- SW Engineering Process goals at global level

Abilities

The technical skills and knowledge that should be possessed by the SW Process Area Responsible to be up to standard are:

Skill	Skill Level
Organization's SW Engineering Process	Good
SW Process Engineering	Good
• SW Process Asset Management	Master
• Organization's SW Process Documentation Standards	Master
• SW Process reference models (SW-CMM, ISO 15504, etc.)	Basic
Project management	Basic
Process responsibility area	Master

The soft skills and knowledge that should be possessed by the SW Process Area Responsible to be up to standard are:

Skill	Skill Level
Change management skills	Basic
Communication skills	Good
Consulting skills	Good
Facilitation skills	Good
Interviewing skills	Good
Team work skills	Good

SW Process Developer

Definition

A SW Process Developer is a person whose responsibility is to perform SW process definition and improvement activities.

Note: This role is linked with SW Document Owner, concerning all SW Process Documentation applicable to scope. Also, SW Process Supporter role is closely related to this role.

Examples: An SW Design Engineer acts as Process Developer when he creates a release procedure for a project.

Note: People in the role are often from SW projects, because it is critical for process deployment that the right individuals are involved in process change. If project personnel are not taking part in process development, it is very hard to convince them that the results will be suitable for them.

Activities

The following activities are related to this role:

Relationship	Activity	See
Performing	SWM.2 Define SW Engineering Process	
Performing	SWM.3 Improve SW Engineering Process	
Performing	ORG.x.BP2 Package SW Process Assets	
Participates in	ORG.x.BP3 Maintain SW Process Assets	

Typical scope

The scope of the SW Process Developer's proficiency typically includes one or more of the following:

- SW Engineering Processes (including documentation)
- (Local) SW projects
- Local SW line and its groups
- Organization SW Engineering Process goals

Abilities

The technical skills and knowledge that should be possessed by SW Process Developer to be up to standard are:

Skill	Skill Level
Organization's SW Engineering Process	Good
SW Process Engineering	Good
• SW Process Asset Management	Master
• Organization's SW Process Documentation Standards	Master

• SW Process reference models (SW-CMM, ISO 15504, etc.)	Basic
• Process assessment and audit (group member)	Basic
Project management	Basic
Process responsibility area	Master

The soft skills and knowledge that should be possessed by SW Process Developer to be up to standard are:

Skill	Skill Level
Change management skills	Good
Communication skills	Good
Consulting skills	Good
Facilitation skills	Good
Interviewing skills	Good
Team work skills	Good

SW Process Supporter

Definition

A SW Process Supporter is a person who is responsible for supporting the SW Project tailoring the project's SW development process and ensuring conformance to SW processes.

Notes:

- SW Process Supporter and **SW Tool Supporter** often have also **SW Trainer role**.
- The SW Process Supporter provides an internal quality viewpoint into a SW project.

Activities

The following activities are related to this role:

Relationship	Activity	See
Performing	ORG.x.BP6 Provide Support Services for SW	
Performing	SWP1.03 Tailor Process	
Performing	SWP.2 Manage SW Quality (except 2.06)	
Performing	SWQ.4.01 Create Peer Review Plan	
Participates in	SWQ.4.02 Conduct Peer Review Meeting	
Participates in	SWP.1 Manage SW Project (except 1.03)	

Participates in	SWP.2.06 Decide Corrective Action	
Participates in	SWP.3 Manage SW Risks	
Participates in	SWQ.3.01 Select Project Standards	

Typical scope

The scope of the SW Process Supporter's proficiency typically includes one or more of the following:

- Organization SW Engineering Process / procedures
- Any process related issues (such as document repositories, etc.)
- Project's SW processes
- Project's quality goals
- Local (SW) quality goals
- (Local) SW projects

Abilities

The technical skills and knowledge that should be possessed by the SW Process Supporter to be up to standard are:

Skill	Skill Level
Organization's SW Engineering Process	Good
SW Process Engineering	Good
• SW Process Asset Management	Good
• Organization's SW Process Documentation Standards	Good
• SW Process reference models (SW-CMM, ISO 15504, etc.)	Basic
• Process assessment and audit (group member)	Basic
Project management	Basic
Local SW line and SW projects	Master

The soft skills and knowledge that should be possessed by SW Process Supporter to be up to standard are:

Skill	Skill Level
Change management skills	Master
Communication skills	Good
Consulting skills	Good
Facilitation skills	Good
Team work skills	Good

SW Tool Developer

Definition

A SW Tool Developer is a person whose responsibility is to evaluate and develop SW development tools and environment. Developing includes tailoring the tools for the organization SW process and environment needs.

Note: This role exists both at a global and local level.

Activities

The following activities are related to this role:

Relationship	Activity	See
Performing	SWM.5.01 Identify SW Engineering Environment Requirements	
Performing	SWM.5.02 Provide SW Engineering Environment	
Performing	ORG.x.BP5 Develop and Maintain Technology for SW Process Asset Management and Deployment	
Participates in	SWM.2 Define SW Engineering Process	
Participates in	SWM.3 Improve SW Engineering Process	
Participates in	SWM.5.03 Provide Support for SW Developers	
Participates in	SWM.5.04 Maintain SW Engineering Environment	

Typical scope

The scope of the SW Tool Developer's proficiency typically includes one or more of the following:

- SW Engineering Process
- SW Process Engineering
- SW projects
- Local SW line
- Global co-operation with tool support and development

Abilities

The technical skills and knowledge that should be possessed by the SW Tool Developer to be up to standard are:

Skill	Skill Level
Organization's SW Engineering Process	Basic
SW Process Engineering	Basic
Project management	Basic

Programming environments and languages	Good
SW Engineering skills	Good
Specific SW tool skills	Good
Embedded system programming	Basic/Good
Operating systems	Basic/Good
Networking (TCP/IP)	Basic/Good
Knowledge of different tool vendors	Basic
Current SW Engineering environment	Good

The soft skills and knowledge that should be possessed by SW Tool Developer to be up to standard are:

Skill	**Skill Level**
Change management skills	Good
Communication skills	Good
Consulting skills	Basic
Interviewing skills	Basic
Team work skills	Good

Appendix 6: Architectural design model for Software Process Engineering system by Kinnula (1999)

This appendix contains a description of an architectural design model for Software Process Engineering (SPE) system by Kinnula as a quotation (Kinnula 1999, 102-104):

"This model gives a comprehensive overview of the static elements of the process engineering domain but does not include a dynamic aspect, e.g. the life cycles of the SPE activities.

The architecture model consists of three elements, or sub-models; the Hierarchy Model for SPE architecture, the SPE Infrastructure Model and the SPE Process Model. In addition the model identifies two main uses or purposes for Software Process Engineering and a set of items that influence the need to use the SPE for a particular purpose.

The SPE Process Model identifies the main tasks or activities that fall within the scope of Software Process Engineering. The SPE Infrastructure Model identifies the structural elements that are needed to support the SPE processes and keep the system operational. The Hierarchy Model for SPE architecture identifies the organizational layers where the SPE activities are carried out and thus where infrastructure must exist. A graphical representation of the architectural model is presented in Fig. A6 - 1.

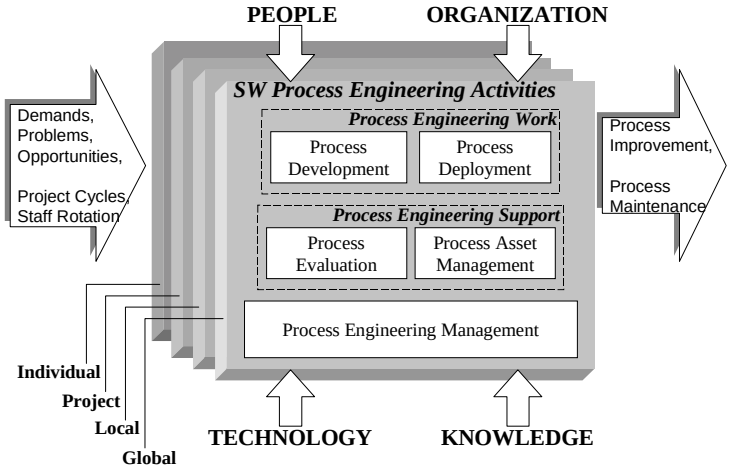

Fig. A6 - 1. An Architectural model for a Software Process Engineering system

In the figure, the grey box represents the activity or task within the domain, in this case the entire Software Process Engineering process. The white rectangles within the grey box represent the SPE Process Model, identifying the main processes which are needed for achieving the purposes of the activity. The four small arrows flanking the grey box represent the SPE Infrastructure Model, identifying the main structural elements needed to make the process operational. The layering of the boxes on the top of each others represents the Hierarchy Model for SPE architecture, identifying the four organizational levels that the SPE system must cover, in order to be comprehensive and provide added value to the company in a multi-site environment. The two large arrows to the left and right of the set of boxes represent the purposes for Software Process Engineering, and the set of items that determine the need to apply the SPE for a particular purpose, respectively.

The SPE system architecture model presented above has certain advantages over the other related models currently available. First of all, it is more comprehensive than any of the models found from the literature. Although the elements can be found from different models, no single model present all of them in one compact package. Second, it is the only model which takes a look at the processes explicitly from the SPE viewpoint and thus is more readily usable for those who are responsible for establishing an managing a SPE system in their organizations. Third, the model presents fundamental concepts, rather than suggests some sort of a design for the system. This helps to get an overview of the elements that need to be established for a SPE system and can be used as a checklist to establish, evaluate and revise existing such systems. The abstraction level also help to address the issues of scale (McFeeley 1996, 8) and to map responsibilities to the host organization when the SPE system is being tailored from an existing implementation model.

The eventual implementation of the entire Software Process Engineering system depends on the organizational preferences, resources, maturity, structure, existing functions, etc. For instance software tool acquisition, support and maintenance is in some companies within the realm of Information Technology support, although conceptually it is within the scope of process asset management. When establishing the SPE system, it is more sensible to adjust to the prevailing practice rather than force the issue for the sake of the model. If another existing organizational entity already has the responsibility of some SPE -related issues it is sufficient that the SPE system builds an interface to this entity and works together with it to ensure that all the issues are taken care of and no overlapping or conflicting initiatives and approaches exist."