Architecture design in global and model-centric software development

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Chapter 2

A Comparison of Industrial Process Descriptions for Global Custom Software Development

In this chapter, we analyze how organizations address global software development-specific issues on the process level. To this end, we conduct a comparative analysis of industrial process descriptions for global software development.

2.1   Introduction

Some of the pitfalls associated with GSD, such as the lack of a structured process, unclear tasks, roles and responsibilities, knowledge sharing concerns and general communication issues can be alleviated by using a process description which explicitly addresses these issues (Prikladnicki et al., 2006). A process description is an instance of the description of a software process model. Such a model represents:

> *"a networked sequence of activities, objects, transformations, and events that*

> *embody strategies for accomplishing software evolution. Such models can be used to develop more precise and formalized descriptions of software life cycle activities"* (Marciniak, 2002)

Software Life Cycle Processes are defined in more detail in an international standard (ISO/IEC, 2008). It is generally agreed upon that working according to a well-defined development process is key to software engineering in general (Parnas and Clements, 1985, Royce, 1970). Nevertheless, it is unclear whether organizations tailor their process descriptions for GSD and of what they are comprised.

We report the findings of a comparative study of the GSD process descriptions used for custom software development of three industrial organizations. Section 2.2 describes the objectives of the study, Section 2.3 describes related work and Section 2.4 outlines the method of the study. Section 2.5 reports on the results which are then discussed in Section 2.6. Finally, Sections 2.7 and 2.8 present the conclusions and elaborate on future work.

2.2   Objectives

In this chapter, we address **RQ1** (Section 1.3). This exploratory research question aims (in part) to uncover how software architecture is coordinated in the context of global software development. However, little is known about prescribed processes for GSD in industrial practice in general. Therefore, in order to address the coordination of the software architecture process, we must first examine the GSD process as a whole. To this end, we turn to process descriptions of such processes: What are they comprised of? How are they made? How are they used in practice? Are software process descriptions tailored for GSD-specific issues? What aspects of GSD are focused on? The motivation behind this study is to explore *how software development process descriptions are tailored to accommodate for GSD*. This study analyzes the content of, motivation for and use of three process descriptions currently used in GSD projects within three different organizations. The contribution to scientific GSD literature of this study is three-fold and is divided up into three sub-questions which we will shortly motivate here.

1. The first sub-question relates to the extent to which process descriptions are tailored for GSD in different organizations: *How do different process descriptions for GSD compare?* This question deals with the content of the process descriptions: What is described in each of the process descriptions for GSD? What common and distinct elements can be identified?

2. The second sub-question relates to the rationale behind the build-up of the process descriptions, why is a specific GSD process description made and what is the rationale for including or omitting certain elements? The second sub-question is: *What is the organizational rationale behind the design of a GSD-specific process description?*

3. Lastly, we investigate: *How are these process descriptions meant to be used in actual development projects?*

2.3   Related Work

The lack of process structure is a commonly reported source of GSD process frustration (Salger, 2009). This includes lacking a definition of work units, such as design documentation (Hussey and Hall, 2007), lacking prescriptions on methods of bundling work units (Cusumano, 2008) and lacking prescriptions on procedures for knowledge management (Hussey and Hall, 2007). No previous studies have focused specifically on industrial GSD process descriptions.

The role of process descriptions in GSD has been discussed but not empirically validated in industrial practice. In their report on application of GSD in the large, Battin et al. (2001) discuss various issues, one of which is "differing development process". This issue poses the challenge of coordinating between various development sites that follow different processes. The authors prescribe three solutions for this problem. First, Battin et al. argue not to impose a common process to let each team produce results immediately. Second, they propose to come up with a set of common work products and vocabulary and to make a mapping between the common work products and the specific deliverables of the individual development center. Third, to split a system up in tested subsystems that can be developed independently by each development center. This division by modularity or chunking of work items is one of the strategies that can be taken to global software development (Mockus and Weiss, 2001). However, this strategy can only be applied if both the organization and the software system architecture allow modularization. If not, increased process commonality is imperative.

Coordination in GSD becomes an issue because of process non-uniformities. An example of process non-uniformities is variation in definitions which may cause mismatched expectations. Also, a mismatch in common milestones at one location may affect other development sites, but is often not communicated early enough. In addition, different time zones may lead to more frequent work handovers (Mockus and Herbsleb, 2001).

Commonly regarded as the largest sources of risk in GSD are a lack of clarity and resulting project delay due to strenuous communication across development sites. The decreased amount of opportunity for informal team communication in GSD aggravates the inherent communicative difficulties posed by the distinctly different experience, training, professional backgrounds, cultures and native languages of various team members. This problem is further aggravated by the often rapid changes in team composition on each development site (Herbsleb et al., 2000).

In their systematic review of 170 GSD studies, Jiménez et al. (2009) list ten success factors. At least seven of these, such as 'establishment of an effective communication mechanism' and 'application of maturity models' are related to process descriptions.

In addition, all seven best practices listed in a recent survey of empirical GSD studies literature (Šmite et al., 2010) are facilitated by a process description.

Process descriptions include processes and activities related to knowledge management. In the context of GSD, knowledge management issues become exponentially pertinent as knowledge is spread over development sites and coordination of this knowledge can prove to be difficult (Desouza and Evaristo, 2004). And although the more central role of tools such as the use of distributed software configuration and change management systems (SCCMS) (Carmel, 1999, Grinter, 1997) formalize, and thereby unify work methods, the use of these tools needs to be enforced by a common process.

2.4   Method

In this section the research environment and the study approach are discussed.

2.4.1   Research Environment

We obtained access to process descriptions of three different software development organizations that work with an offshore subsidiary to develop software. The organizations will be referred to as JKL, ABC and XYZ. The first two organizations are large and established information technology service providers that operate on a world-wide scale while the latter is a comparatively small, Dutch Information Technology (IT) service supplier. Table 2.1 outlines relevant data including organization age, size, process scope and organizational maturity (defined as the attained level on the Capability Maturity Model (CMMI, Chrissis et al., 2003). Table 2.1 also mentions whether an organization offshores only to subsidiaries that are part of its own organization ("intra-organizational" offshoring) or whether it also makes use of the services of external organizations ("inter-organizational" offshoring).

Table 2.1: *Organizations Under Study*

Org.	Age (yrs.)	Employ.	Offshore Location	Process Used in	CMMI level	Dev. Process	Offshore Model
JKL	50	50,000	India	Netherlands	3	RUP	*inter*-organiz.
ABC	50	100,000	India	world-wide	2	RUP	intra-organiz.
XYZ	7	70	S. Africa	Netherlands[1]	2	RUP	intra-organiz.

[1] Organization is *only* active in the Netherlands

2.4.2   Approach

The main unit of analysis was the GSD process description document. We studied the target audience, the methods described, the way the process was outlined, the level of detail used and we distilled commonalities and distinctions in the descriptions. As part of the analysis, the workflow and activities of the process descriptions have been remodeled using a uniform third-party modeling language. We used the Business Process Model and Notation language (BPMN, Object Management Group, 2009). Using a common, visual-oriented, modeling language such as BPMN eases comparison of verbal descriptions and notational snippets. An example of one of these translations can be seen in Figure 2.1. After this initial analysis, we interviewed the designers of the process descriptions. The main purpose of these semi-structured interviews was to clarify the findings of the analysis, to understand the process and organization of the "process development" and to gauge the extent to which the descriptions are used in practice. To this end, the interviews were divided into six common sections:

1. *Document purpose*
   Why was the document made?

2. *Communication of the process*
   How is the process communicated to its audience?

3. *Process Construction & Maintenance*
   How is the process made? How is it maintained?

4. *Process management*
   Who is responsible for the process?

5. *Process in practice*
   How is the process description intended to be used?

6. *Document versioning*
   What is the version history of the document we analyzed? Are future versions planned?

In addition, we reserved a section of the interview to discuss the specific process description of a particular organization.

2.5   Results

All processes are based on, or at least rely on, terminology from RUP. The RUP has enjoyed a widespread popularity and is often used in industrial practice. As a result, terminology used in the RUP is commonly understood and used.

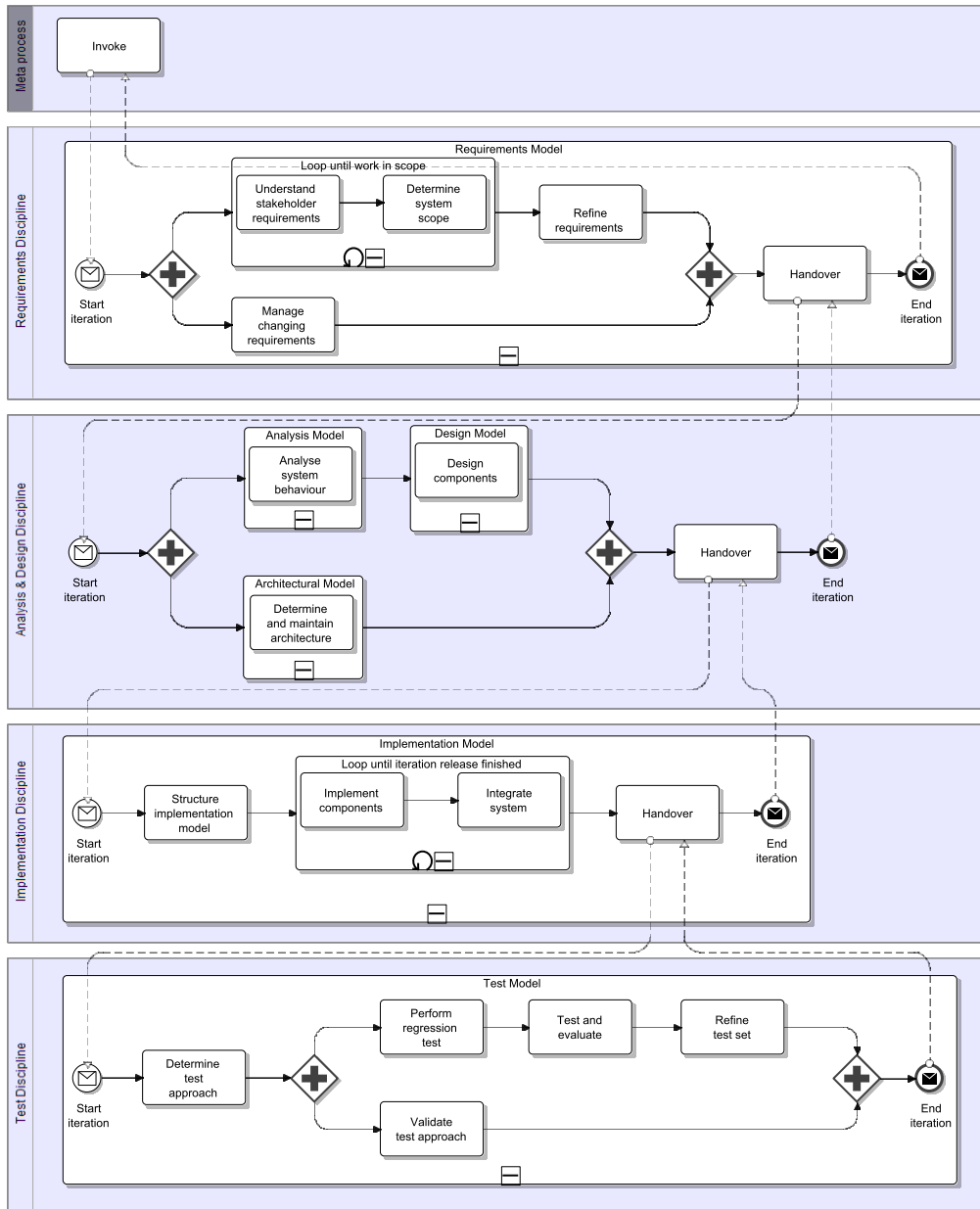**Figure 2.1:** *BPMN diagram for GSD process description of case "XYZ"*

Of the three process descriptions, two were written as chiefly verbal-oriented documents and one as a (detailed) set of slides. XYZ chose the slide format to be able to use the presentation as part of the on-boarding course for new project members or project leaders. XYZ shares the same documentation regarding their process description with all stakeholders, including all team members and clients. In contrast, ABC reserves their process description for higher project management and JKL, while also aiming to only write for higher project management, keeps their process description confidential. Only XYZ uses detailed UML notation to decrease the chances of ambiguity due to the wider audience of their process description. In the case of ABC, additional documentation was used to supplement the "non-onshore" software development process description. The other two organizations tailored their common process descriptions to specifically address GSD-specific issues. All three process specifications are in use at the Dutch subsidiary of each organization.

At the time of writing, JKL's process description was in the later stages of being completely reviewed and renewed. We analyzed a release candidate of version 1.0 which was at that time in use at several projects in the organization. ABC wrote their GSD process description in 2008 and did not intend on updating the GSD aspect of the process description but in 2009 embarked upon a multi-year, organization-wide campaign to further formalize development practices. XYZ's process description was made over the course of several years and reviews or updates were not planned in the foreseeable future.

2.5.1   Process Sections

We identified 13 different, coherent groups of information in the process descriptions. These groups were identified by defining and naming a group based on a set of coherent topics, looking for the same set of coherent topics in the second and third process descriptions and redefining and renaming (often a subset of the initial set of coherent topics) until a set was consistent for as many process descriptions a possible. A summary of these groups can be found in Table 2.2. Only three topics were common to all process descriptions, specifically (1) a description of workflow, (2) an overview of deliverables and (3) a classification of involved roles. In addition, two out of three process descriptions contained sections on (4) activities, (5) organizational objectives, (6) tools and (7) quality control. The other six identified topics were unique to the process description of ABC, namely (8) a description of change request processes, (9) risk analysis and management, (10) communication protocol, (11) resource planning, (12) customer value and (13) knowledge management (Qiu, 2009).

Only two out of three process descriptions describe a detailed process workflow and objectives. ABC approaches their GSD process description as an additive set of rules and practices to any process description and therefore, lacks a step-by-step workflow description. As both JKL and ABC are larger, multi-national organizations, there is a stronger focus on organizational objectives. XYZ is more flexible and defines objectives

per project. Remarkable observations include that while all three organizations find the CM process a key element of their process description, only ABC prescribes a CM process in their process description. JKL did not yet formalize their CM process and XYZ uses a CM tool set which enforces a specific process. Furthermore, JKL does not mention tooling because the organization does not make use of standardized tooling and XYZ describes itself as too small to need to formalize knowledge management procedures. Also, only ABC prescribes a resource planning method. Resource planning for GSD is different from common resource planning because additional effort has to be calculated for communication, travel, increased quality of documentation and knowledge management (Zopf, 2009). GSD is known to add extra risk factors such as missing knowledge or know how and misunderstanding because of language deficiencies, different cultural backgrounds or employee turnover (Zopf, 2009). Only ABC describes risk analysis in their process description.

2.5.2   General Process

The ABC process description mainly highlights the headlines of the process. Most of the description deals with project management issues and deliverable specifications. In the introduction of its process description, ABC defines a project manager which is "usually" located off-site and an overall project manager which is "usually" located on-site. Most of the sections containing project management activities include a reference as to which role is responsible for those activities, leading to an estimation of the distribution of activities on-site versus off-site. For the activities of the software development process, a table has been drafted of clear goals and guidelines regarding the distribution of activities on-site versus off-site. ABC's process description is clear on which activities are performed by which actors on which shore.

The process description submitted by organization XYZ, is less formal in structure, but not less formal in description. The software development process has been clearly defined and specified into activities. Roles and tasks are separated. And while project management activities have also been defined and specified into separate activities, they have not been integrated with the software development activities. This loose connection between project management and software development is illustrative of the informal structure of the process description. Another possible explanation for this lack of integration could be that XYZ is less experienced in GSD and generally less mature than the other two organizations. This process description makes no difference between which activities are performed onshore and, which are performed offshore as XYZ uses the same process description at both locations.

2.5.3   Additional Documentation

In addition to the documentation we analyzed, for at least one organization, XYZ, we found that the CM process was enforced by a tool. This tool obliges team members to

follow certain steps while registering change requests. Moreover, all three organizations make use of an additional set of discipline-specific instructions which are placed on an internal wiki or other type of intranet site. For example, detailed methods for system design and modeling are described. Another example is a set of best practices for setting up a workshop to facilitate requirement elicitation. In all three organizations, these pages are regularly updated by experts.

Table 2.2: *Comparison of GSD process descriptions*

		CASE JKL	CASE XYZ	CASE ABC
Overall	*size*	44 pages	54 slides	44 pages
	content types	text; UML & workflow diagrams; tables	text; UML diagrams; other diagrams	text; other diagrams, tables
	language	English	English	English
	audience	project management	team members, client	engagement management
Workflow	*steps*	yes	yes	no
	lev. of detail	high level of detail (UML)	high level of detail (UML)	low level of detail
	described	roles; responsibilities; deliverables; requirements	responsibilities per role; deliverables per phase	responsibilities per role; deliverables and requirements per step
Activities	*descr. meth.*	step-by-step	absent	a list of important points
	described	activity flows; acceptance criteria; activities per project type	nothing	activity lists for situations; acceptance criteria; on- and off-site activities
Objectives		objectives for steps; general objective of process description	absent ('these differ per project')	objectives for steps; objectives for steps
Deliverables	*descr. meth.*	described with activities description	described as comments in UML diagrams	described in activities description
	described	responsible staff; list acceptance criteria; references links in activities description; product hand-over process; update deliverables process	responsible staff as actors in UML diagrams; list acceptance criteria & show sample deliverables	responsible staff; list acceptance criteria; templates links in table; set deadline for hand-over
Role Classific.	*descr. meth.*	responsibilities per role	roles as actors in UML diagram	responsibilities per role
	described	describe responsibilities in activities description; assign deliverables in table; assign tasks in table	responsibilities in UML diagrams; related deliverables in UML diagrams	list responsibilities ; related deliverables; tasks in activities description

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Table 2.2: *Comparison of GSD process descriptions (continued)*

		CASE JKL	CASE XYZ	CASE ABC
Chg. Req. Process	*descr. meth.*	absent ('not yet formalized)	absent ('process captured in a tool')	change process outlined
	described	nothing	nothing	description of change related activities; description of change related staffs; description of change related tools
Risk Assessm.	*descr. meth.*	requirement	none	list important risk management activities
	described	'require update risk log'	nothing	list requirements of doing RA&M; assign tools for certain RA&M activities
Communic. Protocol	*descr. meth.*	none ('promote informal communication')	none ('organization is too small')	description of communication related activities
	described	nothing	nothing	responsible roles for communication activities; requirement for communication plan; requirement for communication document
Tools	*descr. meth.*	none ('does not use standard tooling')	short tool descriptions	tools are linked to tasks
	described	nothing	list of possible tools	recommended tools; Tasks
Quality Control	*descr. meth.*	quality control per activity	none ('differs per project')	separate quality control section ('but just for reference')
	described	list acceptance criteria; tasks of responsible roles	nothing	list acceptance criteria in activities description; tasks of responsible roles
Resource Plann.	*descr. meth.*	none ('no standard method')	none ('differs per project')	key activities of resourcing planning
	described	nothing	nothing	list requirements of resource planning; assign tasks to responsible people
Customer Value	*descr. meth.*	none ('but we focus on customer intimacy')	enhancing customer text ('shared view of enhancing the customer value')	
	described	nothing	nothing	organizational attitude towards customer value; activities for enhancing customer value

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Table 2.2: *Comparison of GSD process descriptions (continued)*

		CASE JKL	CASE XYZ	CASE ABC
Knowledge Mgmt.	*descr. meth. described*	none ('separate org.-wide process specification') nothing	none ('organization size is too small') nothing	important activities of knowledge management organization's attitude of knowledge sharing; list activities of knowledge management

2.6   Discussion

In the following subsections, we discuss our findings regarding process design comparison, process rationale, intended process use and process maintenance.

2.6.1   Process Design Comparison

We found very different approaches of process description design for the three cases. The most visible are the description methods. ABC mainly uses lists and tables, JKL uses text supported by various types of diagrams including UML and free-form diagrams, and XYZ uses UML diagrams almost exclusively. Also, the level of detail of the process descriptions varies strongly. JKL provides a detailed process description in which process steps are clearly outlined. XYZ provides less detail and ABC provides almost no detail regarding process steps and focuses chiefly on the possible pitfalls of GSD. While these are three different organizations, these process descriptions are to be used for similar types of custom software development projects by software developers of similar education level and expertise. We did not find any particular reason for the choices for using models over text or vice-versa. While answering questions such as, *"Why did you use a UML activity chart to model this process?"*, process designers generally presumed that their chosen method was the only logical method to convey a specific process step or best practice. We observe that, at least in the organizations we studied, the choice for inclusion of specific elements and the methods to describe these elements is at least in part dependent on the expertise and professional background of the process engineers.

2.6.2   Process Rationale

We observed various reasons for designing a GSD process. Various interviewees within the same organization gave different answers to the question, "Why was a process description made for GSD?". Among the reasons were a desire for "repeatability of

approach" (prescriptive) to be able to better predict the development process, to use as course material for on-boarding of new project team members (descriptive) and organizational maturity, to e.g. obtain a certain CMMI level.

Project Management Activity Integration

A distinctive feature was the extent to which the steps of the development process are integrated with project management activities. ABC separated both, providing for a strict separation of tasks and responsibilities. JKL, on the other hand, chose to fully integrate these processes. In the case of JKL, a separation of tasks and responsibilities was achieved by clearly describing the actors within the process description and by providing swim lane diagrams of the sub-processes. The information released by connecting the software development process and the surrounding project management activities can be seen as additional information regarding the process. A more mature organization, e.g. in terms of obtained level of CMMI certification, links various types of activities to one another. The actual process maturity and the intended audience of a GSD process specification dictate the extent to which development process and project management activities are linked. Project management and especially program management is less interested in development activities as it is in management activities but does need to understand how both integrate. XYZ's level of integration of development and management processes can be placed in the middle between companies ABC and JKL. XYZ clearly defined a process view of the project management activities and provided starting points to connect these elements, but a full integration is not achieved.

Tailoring Processes for GSD

With regard to the overall goal of this study to understand how software development processes descriptions are altered to tailor for GSD, we note that the extent to which the process descriptions have been particularly tailored for GSD differs. The larger organizations seem to take different strategies at GSD. JKL focuses on formal processes, whereas ABC intends to shift more responsibility to the individual project manager. This is remarkable as in their respective interviews, process management noted that JKL's organizational strategy is to focus on customer intimacy, whereas ABC aspires to attain operational excellence. And while GSD is a central and an increasingly important activity for both organizations, their organizational strategies are not (yet) apparent from their GSD process descriptions.

2.6.3   Intended Process Use

The intended use of the prescribed process does not necessarily correspond with the provided level of detail. For example, ABC provides a vast list of best practices but

only intends these to be used as a reference, whereas JKL expects projects to follow the process as prescribed in the documentation. We have summarized the organization's approaches to process description use in Table 2.3.

Table 2.3: *Approach to Process Description Use*

	Process Level of Detail	GSD Focus	Process Use	Intended Audience
JKL	high	limited	obligatory	project leader
XYZ	medium	limited	obligatory	all team members
ABC	low	limited	facultative	project leader

If we define a process description plainly as a description of a process, ABC provides a minimal amount of description. However, it provides the most elaborate description of GSD practices, only to merely recommend its use to project leaders. JKL provides a very detailed account of process steps, a more limited focus on GSD specific procedures but obliges project managers to use the description. XYZ provides a description of process steps, the level of detail of which can be placed between that of the process descriptions of JKL and ABC and focuses only sparsely on possible GSD issues while requiring all project members to know the documented process. As shown in Table 2.1, the process scope of ABC is world-wide. ABC's set of rules and best practices, while elaborate, is set up so it can be used with very tailored software development processes. By letting a project manager free to set up a customer development process but providing him with a detailed set of guidelines, ABC combines flexibility and the benefits of applying best practices. This is, however, as mentioned, not in line with ABC's organizational objective of achieving "operational excellence". ABC is in the process of defining a more rigorous process description in which its current GSD process description will be merged.

Both larger organizations, JKL and ABC, have set up departments, which are responsible for (re-)engineering, publishing and distribution of process descriptions. These departments periodically review the existing processes, not only for custom software development (generally Java and Microsoft .Net development) but also for software development for business intelligence systems and Enterprise Resource Planning (ERP) systems such as SAP.

2.6.4 Process Maintenance

Both larger organizations contain business consulting and process engineering department, which are actively involved in (re-)designing processes and process descriptions.

The Dutch subsidiary of JKL uses a system where feedback is continuously asked of project management. Feedback on processes is also incorporated in the standard post-mortem analysis of a software development project. ABC uses a more top-down oriented approach, where an international team of specialists reviews and re-engineers process descriptions.

2.7   Validity

The lack of related work investigating GSD process descriptions in industrial practice warrants an exploratory study. As no industrial, GSD-specific process descriptions are currently available in literature, the three process descriptions we obtained can only be compared to each other. In addition, two organizations in our analysis predominantly engage in intra-organizational GSD while one organization (JKL) also engages in inter-organizational GSD. This might influence the way their respective process description has been designed. As one might expect is required for inter-organizational collaboration, a more detailed process description is required. However, this was not mentioned as a reason for the provided level of detail. In addition, we found that some parts of the processes are captured outside the process description documents we analyzed. (e.g. the CM process of one organization is captured in a CM tool set). These external elements were not available for this study.

2.8   Conclusions and Future Work

The conclusions are structured as answers to the three sub-research questions:

1. *How do different process descriptions for GSD compare?*
   All studied processes are based on, or at least rely on terminology from RUP. The level of detail of the process descriptions varies strongly. Also, the extent to which the process descriptions have been particularly tailored for GSD differs strongly. Particularly the larger organizations seem to take strategies at GSD that are different from one another.

2. *What is the organizational rationale behind the design of a GSD-specific process description?*
   The rationale behind the GSD process description format, structure and content are said to be derived from organizational objectives. Our analysis did not confirm this. GSD process descriptions are made by a multi-disciplinary group of consultants, and it is not yet clear how the processes are used in practice. Design of the process descriptions seems to be partly dependent on the expertise and professional background of the process designers. Other important influences on the design and intended use of the process descriptions are the size of an organization and organizational maturity.

3. *How are these process descriptions meant to be used in actual development projects?*
   The intended audience is sometimes explicitly project management and other times explicitly the entire project team. The use of the process description is facultative in one organization while it is obligatory in others. We found that the intended use of the prescribed process does not necessarily correspond with the provided level of detail.

In order to increase our understanding of GSD process descriptions, the use of the studied process descriptions in actual GSD projects must be studied. Are the specific alterations that organizations make to cope with GSD-specific issues followed by projects in practice? How does this influence project success? Furthermore, the process of engineering a GSD process is not yet clear and the specific impact of GSD process descriptions on the development process is also to be investigated.