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AN APPROACH TO SOFTWARE PRODUCT LINE REVIEWS FOR A MEDIUM-SIZED ORGANIZATION

by

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A thesis submitted to the Faculty of Graduate Studies and Research in partial fulfillment of the requirements for the degree of **Master of Science**.

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Edmonton, Alberta
Spring 2005

Abstract

A product line is an established concept in manufacturing, but is still a relatively new concept in software development. Three major Software Product Line (SPL) research outcomes of the Software Engineering Institute (SEI) are their Framework for Software Product Line Practice (SPLP), their Product Line Technical Probe (PLTP) and their Patterns. Other European research describes SPLs as a Business, Architecture, Process and Organization (BAPO) paradigm. This thesis undertakes a case study of a medium-sized enterprise where the case for SPL adoption is plausible but not obvious, provides a method to conduct an SPL review based on SEI's SPLP framework and PLTP, and compares SEI's SPLP framework and a BAPO evaluation framework for base-lining an organization's current practices. It also develops a new pattern for organizations that want to better position themselves for SPL adoption. Finally, directions for future research activities in the SPL development area are identified.

Acknowledgements

First and foremost I thank Dr. Paul Sorenson who acted as my supervisor. He provided valuable guidance during this process. I am grateful he took me on as one of his graduate students. I would also like to thank John Shillington who in addition to editing my reports for the medium-sized enterprise, also provided valuable feedback and additional support, such as rides. I would also like to thank the members of the Steering Committee. Thank you very much for allowing me to conduct research at your company. In addition, thanks go to those employees of the medium-sized enterprise that participated in the study. Without you this thesis would not have been possible.

I would also like to thank Dr. Jim Hoover and Dr. Marek Reformat for serving on my committee.

Special thanks to Dr. Jan Bosch for providing his software product family evaluation question set and developing a set of questions with me for a lightweight BAPO evaluation.

On a personal note I would like to thank my family members for their support during the course of my degree. Finally I want to thank my friends Johan and Steve, for their support as well.

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Chapter 1

Introduction

1.1 Motivation

This thesis is about assessing the applicability of product lines for a medium-sized enterprise. Product lines is an established concept in manufacturing, but is still relatively new for software development. Software Product Lines (SPLs) place an emphasis on reuse. Reuse of software has been identified by a number of researchers as "the biggest opportunity area for improving software productivity, quality and cycle time" [14]. Research has found that development of reusable software components costs more than single-use components [14]. This can result in project teams that are focused on just their own products, not on making reusable components. Through a focus on creation of large scale reusable components, SPLs allow the creation of entire product families, for around the cost of developing a couple one-time products the traditional way.

This thesis will address several questions.

1. How do two current SPL assessment techniques compare?
2. What are some obstacles a medium-sized enterprise faces when adopting SPLs?
3. What can a medium-sized organization do if it cannot adopt a full product line strategy, but wants to be in a better position to adopt such a strategy?
4. How can a medium-sized enterprise assess its current product line practice state?

A new SPL assessment technique will be presented in this thesis and compared to two present techniques in the current literature. The two previously published techniques have not been compared and contrasted with each other. This work will help a medium-sized enterprise in deciding among assessment techniques.

Most of the current case studies and research for software product lines has focused on large enterprises. There is need, however, for research into obstacles faced by medium-sized enterprises when they first encounter software product lines. By performing the study in this thesis we will further our understanding of SPL adoption barriers faced by these organizations.

Another question this work addresses is how a medium-sized organization can benefit from SPL practices without a full launch. In many cases medium-sized organizations are not able to adopt a full product line. This thesis will explore ways in which they can segue into SPL development.

Finally, obstacles faced by medium-sized organizations, may also prevent them from doing an assessment of their current product line practice. The cost of a professional assessments can be

high. Costs may not be a problem for large organizations with dedicated research and development budgets, but for medium-sized enterprises consulting fees can be prohibited. This thesis will provide techniques a medium-sized enterprise can use to perform a low-cost assessment.

SPLs is an emerging technique to enhance software product development within organizations. SPLs were designed with the goals of faster market releases of products, mindshare, quality, large-scale customization, efficient use of resources, and low maintenance and production costs [51]. An SPL is "a set of software-intensive systems sharing a common, managed set of features that satisfy the specific needs of a particular market segment or mission and that are developed from a common set of core assets in a prescribed way" [15].

The Software Engineering Institute (SEI) has conducted a large amount of research in software product lines. Three major outcomes of this research are a Framework for Software Product Line Practice (SPLP), their Product Line Technical Probe (PLTP) and their Product Line Patterns [14]. The SPLP framework consists of 29 practice areas organized into three categories: software engineering, technical management and organizational management. The PLTP is an assessment method for base-lining an organization's current product line effort. Patterns provide guidance on how to steer a product line effort for a given organizational situation. Many case studies exist of successful software product lines in large organizations, but there are few for small-to-medium-sized enterprises (SMEs). Even fewer case studies of software product line assessments have been published. There exist no published case studies of SEI's product line technical probe, for example.

A Software Product Family Engineering Evaluation Framework has also been developed by several researchers involved in the ITEA (Information Technology for European Advancement) FAMILIES (FAct-based Maturity through Institutionalisation Lessons-learned and Involved Exploration of System-family engineering) project. FAMILIES is the third project in a line of similar projects, ESAPS and CAFÉ. ESAPS occurred from 1999 to 2001 with the goal of providing an approach to software product families. "A consortium of 22 companies and research institutes in 6 European countries performed the ESAPS project (Engineering Software Architectures Processes and Platforms for System families)" [13]. CAFÉ (Concepts to Application in system-Family Engineering) took place during 2001 to 2003 [60] involving most of the companies from the ESAPS project. CAFÉ expanded on the concepts from ESAPS and applied them. CAFÉ introduced the BAPO (Business, Architecture, Process and Organization) paradigm [21]. A Software Product Family (SPF) Engineering Four-dimensional Evaluation Framework (FEF) [60] describes a product line effort as the four BAPO concerns. The FEF researchers have either participated in all or at least one of the previously mentioned ESAPS, CAFÉ or FAMILIES projects [61].

This thesis builds on work done by SEI on software product lines and by others on BAPO FEF. Both of these initiatives are described in more detail in Section 2.3. It will compare an organization's practices to those in SEI's SPLP framework to provide a case study where the decision to adopt a software product line approach is not clear from the outset for a medium-sized enterprise. An example of a Product Line Technical Review (PLTR) is developed and applied in this thesis. The PLTR demonstrates how an individual can perform an assessment based on the SEI SPLP framework. PLTR is influenced by SEI's PLTP (Product Line Technical Probe) approach. The PLTR uses SEI's SPLP framework to baseline a company's current effort. The outcome of the PLTR is a presentation to and a report for the company that is reviewed. Information is gathered from the company primarily through interviews and the examination of existing documentation. From this

information, this thesis also provides a lightweight BAPO FEF evaluation.

The thesis also gives a comparative analysis of using SEI's SPLP framework and BAPO FEF to baseline an organization's current software development effort. The advantages and disadvantages of each framework are discussed in a manner useful to others wishing to conduct SPL reviews. PuLSE™ (Product Line Software Engineering) is another framework that was initially reviewed. Published work and case studies for PuLSE™ focuses mainly on software engineering practices, with little emphasis on business and organizational issues and for this reason was not included in the comparative study of this thesis.

A new pattern is presented in this thesis. The pattern applies to organizations that want to transition to product lines, but cannot form a business case for full adoption.

To summarize, the results of this thesis focus on

1. conducting a case study of a medium-sized enterprise, where the case for product line adoption is not obvious,
2. developing and deploying a method for an individual to conduct a PLTR based on SEI's SPLP framework and PLTP,
3. comparing the use of SEI's SPLP framework and BAPO FEF for base-lining an organization's current product line effort, and
4. providing a new pattern for organizations that cannot adopt a full product line, but want to better position themselves when a business case can be made in the future.

1.2 Roadmap of the Thesis

Chapter 2 provides an overview of background material and related work. The third chapter provides details on the software product line practice and evaluation models that will be the focus of this study. Details are given on SEI's SPLP framework, PLTP and patterns. BAPO FEF is also elaborated upon. Finally, Chapter 3 will outline how PLTR questions sets were derived from the SPLP framework.

Chapter 4 outlines the PLTR process that was developed and used by the author. This chapter will describe the company studied and the phases of the PLTR.

The results of the study and the PLTR are presented in Chapter 5. The company's current maturity with respect to the 29 practice areas of the SPLP framework is described, together with the improvement opportunities for each area. Next, applicable patterns for the company are discussed. A new pattern is developed that is applicable for organizations that do not have resources for full product line adoption, but want to take advantage of some product line practices.

Results related to the effectiveness of this study are also reported in Chapter 5. These results come primarily from two surveys done at the end of the PLTR. Thirteen participants performed a self assessment of their company for each of the 29 areas in the SPLP framework. Those results are compared to the author's assessment which is based on interviews and documentation. Results are provided for a second anonymous survey that was given to participants to assess how useful they felt the PLTR was, and to provide feedback on how the PLTR process can be improved.

The results of lightweight BAPO evaluation analysis are given, followed by a comparison of an SEI SPL-based assessment with a BAPO SPF evaluation. The final section presents the lessons learned from the PLTR.

Chapter 6 provides the conclusions of this research and directions for future work.

Chapter 2

Background, Related Work and Thesis Approach

This chapter presents several models and frameworks that have contributed to the development of software product lines or software process improvement. Section 2.1 briefly discusses the foundational material relevant to quality assessment. Section 2.2 gives an overview of methods to achieve software quality and Section 2.3 discusses current approaches to software product lines.

2.1 Introduction

The Software Engineering Institute (SEI) was the first major endeavor to bring together, in an institute, research into how to improve software development. It has provided guidelines and evaluation techniques to assist in the creation of high quality software development processes and understanding of well-defined reusable processes. It started in 1984 when the United States Federal Government awarded a contract to establish SEI at Carnegie Mellon University. SEI began its work on a Process Maturity Framework in 1985, which evolved into the Capability Maturity Model (CMM). Version 1 of CMM was released in August 1991 [16]. CMM resulted in several offshoots for different disciplines. Applying many different CMM models became difficult and complex so a new project, Capability Maturity Model Integration (CMMI) was formed involving the SEI, industry representatives and the US government. "The CMMI project was initiated based on a 1997 review of Software Engineering Institute (SEI) activities by the Office of the Under Secretary of Defense (OSD) and interest expressed to the SEI by the CMM user community" [15]. Project members belonged to one or more groups, including the Steering Group, product team, stakeholders/reviewers, configuration control board, and CMMI steward.

"ISO (International Organization for Standardization) is the world's largest developer of standards" [27]. The goal of reduced costs and increased levels of efficiency, safety, quality, interchangeability and reliability is achieved through the creation of standards. One influential series of standards produced is ISO 9000 which provides "a framework for developing quality systems" [58]. SEI CMMI and ISO 9001 (part of the ISO 9000 series) are assessment models for development and implementation.

Section 2.2 discusses software quality in terms of more recent assessment approaches that are relevant to software product lines: Bootstrap, ISO 9001, CMMI and ISO 15504. Section 2.3 de-

scribes approaches to software product lines.

2.2 Software Quality

There is strong evidence that improved software quality can be achieved through adoption of well-understood processes [25]. The Bootstrap project provided some initial work in Europe on an assessment method for software engineering processes. ISO 9001 and ISO 15504 are current ISO standards for process models and CMMI is a current process improvement model [15] predominately used in the United States.

2.2.1 Bootstrap

In 1993 the Bootstrap project was completed by the European Strategic Program for Research in Information Technology (ESPRIT). The project's "goal was to develop a method for software-process assessment, quantitative measurement, and improvement" [24]. The early CMM research, the Software Engineering Standards of the European Space Agency (ESA) and the ISO 9000 series formed the basis of Bootstrap. There are three main elements of Bootstrap. 1) A process-quality attribute hierarchy based on the ESA's PSS05 software-engineering standards and ISO 9000-3 guidelines for software-quality assurance [24]. 2) An algorithm for maturity level calculation refined from early SEI CMM research [52]. 3) A questionnaire enhanced from one produced by SEI in 1994 on process maturity [24].

2.2.2 ISO 9001

ISO 9001 is a standard of the International Organization for Standardization (ISO) for developing a Quality Management System. The goal is to provide the same quality assurance methods that can be applied across different companies with the expectation of producing more reliable and less costly products [62]. By following ISO 9001 standards an organization is managed as a system of "interrelated processes" [54]. ISO 9001 requires the definition and implementation of effective processes that focus on customer satisfaction, measurement of processes and customer satisfaction, improvement on customer requirements and processes, and demonstrated commitment by top management [23].

ISO 9001 was first released by ISO in 1987. In 1991, ISO released ISO 9000-3 which are guidelines on how to apply ISO 9001 [3]. ISO 9001 was then revised in 1994 and again in 2000 by ISO Technical Committee 176 [44].

2.2.3 CMMI

A key element in CMMI is the process area. "A process area is a group of related activities that are performed collectively to achieve a set of goals" [30]. The CMMI model has two representations: staged and continuous. These representations organize practices, goals and process areas differently. The staged representation has maturity levels, which indicate the institutionalization and implementation of a set of process areas.

- **1. Initial:** Process control is ad hoc and no institutionalization of process areas.
- **2. Managed:** Standardized processes within single projects.

- **3. Defined:** Process standardization across different projects.
- **4. Quantitatively Managed:** Processes can be measured quantitatively and directed.
- **5. Optimized:** Processes are improved on an ongoing basis.

The continuous representation uses the same maturity levels as the staged representation but they are applied to individual process areas. The staged representation provides a process order to focus on. The continuous representation may be useful for focusing on process areas due to "business needs" [30] or priorities.

2.2.4 ISO 15504

ISO 15504 "is a framework for the assessment of software processes" [63]. The SPICE (Software Process Improvement and Capability dEtermination) project was "an ancillary effort" [15] done concurrently with ISO 15504. SPICE was "an international collaborative project under the auspices of the International Committee on Software Engineering ISO/IEC JTC1/SC7 [1] through the software process assessment group, Working Group (WG10)" [62]. The SPICE project began in 1993 and had three main goals:

- "to develop a working draft for a standard for software process assessment.
- to conduct industry trials of the emerging standard.
- to promote the technology transfer of software process assessment into the software industry world-wide" [50].

ISO 15504 deals with customer-supplier, engineering, support, management and organization processes. There are six capability levels:

- **0. Incomplete:** Process outputs and work products are not easy to identify.
- **1. Performed:** General achievement of the process, but it may not rigorously be tracked and planned.
- **2. Managed:** Tracked and planned process according to defined procedures.
- **3. Established:** Standard processes are used to manage and plan the process.
- **4. Predicable:** The process can be controlled and understood in a quantified manner.
- **5. Optimizing:** The process's performance is monitored and optimized through refinements on a continuous basis [10][18].

2.2.5 Other Software Quality Standards and Models

Other standards and models for software quality have been developed as well. Trillium [2] by Bell Canada is a customer focused model designed to provide key practices to improve existing processes [42] in the telecommunication domain. The TickIT program [2] by the British Standards Institute was an attempt to improve software quality. TickIT turns ISO 9000-3 into a compliant standard [47] for software development.

[1] "International Organization for Standards/International Electrotechnical Commission Joint Technical Committee 1 (responsible for Information Technology)/Sub Committee 7 (responsible for Software Engineering)" [62].

2.3 Software Product Line Approaches

Several frameworks and approaches for software product lines have been developed. ITEA (Information Technology for European Advancement) FAMILIES (FAct-based Maturity through Institutionalisation Lessons-learned and Involved Exploration of System-family engineering) is a project in progress to develop a framework for software product lines in Europe [21]. PuLSE™ (**P**roduct **L**ine **S**oftware **E**ngineering) is a methodology for software product line development by the Fraunhofer Institute for Experimental Software Engineering (IESE) [4]. SEI's Framework for Software Product Line Practice [15] is a collection of best practices derived from successful case studies. A Software Product Family Engineering Evaluation Framework has also been developed by several researchers involved in the FAMILIES project. That framework can be used for benchmarking an organization's effort [60].

2.3.1 FAMILIES

In 1985 the Eureka initiative was created with an aim "to enhance European competitiveness through its support to businesses, research centres and universities who carry out pan-European projects to develop innovative products, processes and services" [19]. An eight year "Eureka strategic cluster programme" [28], ITEA began in 1999. ITEA FAMILIES is the third project in a line of similar projects; the other two are ESAPS and CAFÉ. Through "a consortium of leading European companies, research and technology transfer institutions and universities" [21], FAMILIES provides research and results about adoption, institutionalization and standardization of system families. ESAPS (Engineering Software Architectures, Processes, and Platforms for System families) took place from 1999 to 2001 [60]. ESAPS developed concepts for product family engineering that would be later brought to maturity in CAFÉ (Concepts to Application in system-Family Engineering) [20]. CAFÉ took place during 2001 to 2003 [60] and introduced the BAPO (Business, Architecture, Process and Organization) paradigm [21]. The FAMILIES project consists of six work packages each having a different deliverable. Work package 1's objective is a consolidation of economic and technical issues for the transition and adoption of system families. Work Package 2's goal is to merge CAFÉ and CMMI into a single maturity framework. The goal of Work Package 3 is to provide methods and techniques that assure quality in system families. Work package 4's deliverable is a methodology that provides practices for application and domain modeling, and models to support family engineering. The objective of work package 5 is the development of an approach for merging assets into a system family. Finally, work package 6's goal is distribution of the results of the FAMILIES project. From this effort standards will be developed for the participating companies in FAMILIES and publications will be made to allow other companies to adopt the FAMILIES framework. FAMILIES began in 2003 and is scheduled to finish in 2005 [60].

2.3.2 PuLSE™

The Fraunhofer IESE has developed the PuLSE™ methodology for software product lines [4]. Some work on PuLSE™ received funding from the ESAPS project [45]. There are five components essential to the PuLSE™ framework:

1. "Baselining the organization and customizing the framework.

2. Scoping the application area based on a sound economic analysis.
3. Modeling that area in terms of concepts and their relationships.
4. Transitioning the domain model into a fully reusable design (a reference architecture).
5. Specifying an application engineering process that makes use of the reference architecture and maintains it over time" [22].

There are four maturity levels of PuLSE™:

- "Initial: PuLSE™ components are applied independently of one another and customized as necessary.
- Full: all PuLSE™ components are applied. The degree of integration between them may vary.
- Controlled: PuLSE™ is applied as a full development cycle. Full integration and traceability of the different components is ensured.
- Optimizing: the PuLSE™-based development cycle is refined over a number of product developments using controlled optimization techniques" [22].

PuLSE-BC (Baselining and Customization) is the technical component responsible for baselining an organization's current practices. A concept of PuLSE-BC is the "customization factor" [46] which is organizational information such as existing processes. Relevant customization factors act as guidelines that can be used to baseline the state of an organization's product line practices [9]. Customization factors include

- "Project Entry Points: customize PuLSE to major project types" [4]. For example creation of shared assets between projects or mining of legacy system assets [4].
- "Maturity Scale:" [4] indicates a path for adoption of product lines [4].
- "Organizational Issues:" [4] structuring of the organization for adopting product lines [4].

The IESE has not published all of its customization factors or the "baselining strategies" [46], which are questionnaires that assign levels to customization factors. The "domain experience" customization factor questionnaire is the only one that has been made public. Depending on answers to the questions in its baselining strategy, it could be assigned a level of "low", "medium" or "high" [46]. Several other specific customization factors have been mentioned but they are only for software engineering.

The main focus of public and published work on PuLSE-BC has been on software engineering aspects to the exclusion of organizational aspects. It was decided to limit the study to SPL frameworks with sufficient guidance on how to baseline business and organizational practices, such as SEI's Framework for Software Product Line Practice, which we now discuss in the next section.

2.3.3 Framework for Software Product Line Practice

SEI's work on software product lines was initiated by two events in 1995. First they discovered a software product line at CelsiusTech Systems AB and second SEI "funded an effort dedicated to improving the practice of software product lines" [14].

SEI now defines a product line as "a set of software-intensive systems sharing a common, managed set of features that satisfy the specific needs of a particular market segment or mission and that are developed from a common set of core assets in a prescribed way" [15]. A product line effort consists of three iterative activities that interact with each other: core asset development, product development and management. These activities each have related practice areas, which are classified into three groups: software engineering, technical management, organizational management. SEI's framework consists of 29 practice areas spread across these three groups. For software engineering they are:

- Architecture Definition
- Architecture Evaluation
- Component Development
- Common Off The Shelf (COTS) Utilization
- Mining Existing Assets
- Requirements Engineering
- Software System Integration
- Testing
- Understanding Relevant Domains

For technical management:

- Configuration Management
- Data Collection, Metrics, and Tracking
- Make/Buy/Mine/Commission Analysis
- Process Definition
- Scoping
- Technical Planning
- Technical Risk Management
- Tool Support

For the third set, organizational management:

- Building a Business Case
- Customer Interface Management
- Developing an Acquisition Strategy
- Funding
- Launching and Institutionalizing
- Market Analysis
- Operations
- Organizational Planning
- Organizational Risk Management
- Structuring the Organization

- Technology Forecasting
- Training

2.3.4 Software Product Family Engineering Evaluation Framework

A Software Product Family Engineering Evaluation Framework [60] describes a product line effort as four BAPO (Business, Architecture, Process, Organizational) concerns. This framework was initially developed during CAFÉ [60]. Applying the framework to a family will result in a maturity level (1, 2, 3, 4 or 5) rating for each concern. The business concern is about making a profit through forecasting and steering development. Architecture deals with a product family as opposed to a single product. Commonality through a software platform, and variability through variation points of a group of products, have to be addressed in the architecture concern. Process deals with responsibilities, relationships and roles within development. The current framework considers CMMI a *de-facto* standard for process evaluation and relies on the fact that its five level model maps nicely to CMMI. Finally the organizational concern deals with responsibilities and relationships within the organization. The maturity level is based on how the organization is structured.

2.4 Summary

Most research on software product lines has been done for large organizations. "Many of the best-known and most publicized software product lines come with pedigrees written in large script: Nokia, Motorola, Hewlett-Packard, CelsiusTech, Phillips, and others" [14]. There have been few case studies that demonstrate how appropriate the SEI framework is for Small to Medium-sized Enterprises (SMEs) hence the motivation for and need to conduct the case study associated with this thesis.

The next chapter will show how questions can be derived from the SEI framework to perform an assessment and discuss the FAMILIES BAPO approach of software product lines.

Chapter 3

Software Product Line Practice Models

This chapter provides the motivation and technical background for the study in this thesis. Section 3.1 presents further rationale of why the SEI Framework for Software Product Line Practice was chosen. An overview of SEI's Framework for Software Product Line Practice is given in Section 3.2, along with SEI's Product Line Practice Patterns and Product Line Technical Probe. A BAPO-based [59] Software Product Family Engineering Evaluation Framework [60] is then given in Section 3.3. Finally Section 3.4 provides a short summary of this chapter.

3.1 Motivation

The SEI Framework for Software Product Line Practice (SPLP), as introduced in Section 2.3.3, was chosen for this study for several reasons. It has a significant focus on organizational management, in contrast to current models and standards for software process improvement such as CMMI, ISO 9001 and ISO 15504 which mainly focus on the software engineering and technical aspects. In addition CMMI does not provide specific information for implementing process improvement, unlike the SEI for SPLP framework which provides examples on implementing practice areas [30]. ISO 9001 and ISO 15504 are international standards and CMMI is a *de-facto* standard [38]. The SEI Framework for SPLP is new and is not currently considered a *de-facto* standard [30] and the need to study its effectiveness is great. Finally, most of the success stories for SEI's framework involve large enterprises [14] so there is an even greater need for more research into its applicability for SMEs.

It was decided to limit the study to practice models that cover all aspects of SPLs: software engineering, technical, business and organizational. PuLSE (Product Line Software Engineering) is another product line practice model, but it was not incorporated into this study. The main focus of public and published work on PuLSE has been on software engineering aspects with very little information about organizational aspects. Because of this, PuLSE was not closely examined when the study was developed. Also, BigLever Software, Inc. [5], is a consulting agency that performs software product line assessments, however, they have not published anything on their methodology so they had no impact on this study.

3.2 Framework for Software Product Line Practice

The SEI framework has three essential activities: core asset development, product development and management. Figure 3.1 demonstrates the relationships between these three activities. These activities are interrelated and highly iterative. Core asset development fuels product development. Core assets are updated as products are developed and early products may contribute to the core asset base. Management support is key in order to provide the support and vision to invest in core asset development, and champion the change in culture of considering new products opportunities based on the core asset base. Behind these essential activities are essential practices that fall into 29 practice areas as listed in Section 2.3.3. These practices provide guidance for creating a product line to develop core assets and products, along with the management of processes. The 29 practice areas are divided into software engineering, technical management and organizational management. SEI defines a practice area as "a body of work or a collection of activities that an organization must master to successfully carry out the essential work of a software product line" [15]. Each practice area contains

- an introduction that describes the practice area
- aspects that relate to software product lines
- aspects that are specific to core asset development
- aspects that are specific to product development
- a sample of practices that may be applied
- risks
- references [30]

3.2.1 Product Line Practice Patterns

Unlike CMMI, the SEI framework does not have capability or maturity levels. Instead SEI has developed software product line practice patterns [14] for the framework. An organization's product line may be mapped to one or more patterns. A mapping will identify a patten the product line effort fits and can provide guidance as to how to steer the effort. Patterns can be used to improve upon a product line or solve a problem currently faced by the effort. Patterns evoke practice areas and other patterns in order to provide a solution. Each pattern conforms to a template with the following fields:

- **Name:** The pattern name and description.
- **Example:** At least one example of a scenario in which the pattern may be applied.
- **Context:** At least one applicable organizational situation for the pattern.
- **Problem:** A problem the pattern aims to solve.
- **Solution:** Outlines the applicable practice areas and/or patterns within this pattern.
- **Static:** Breaks applicable practice areas and/or patterns into groups.
- **Dynamics:** The relationship of the static groupings is described.
- **Application:** Provides guidance on using the pattern.

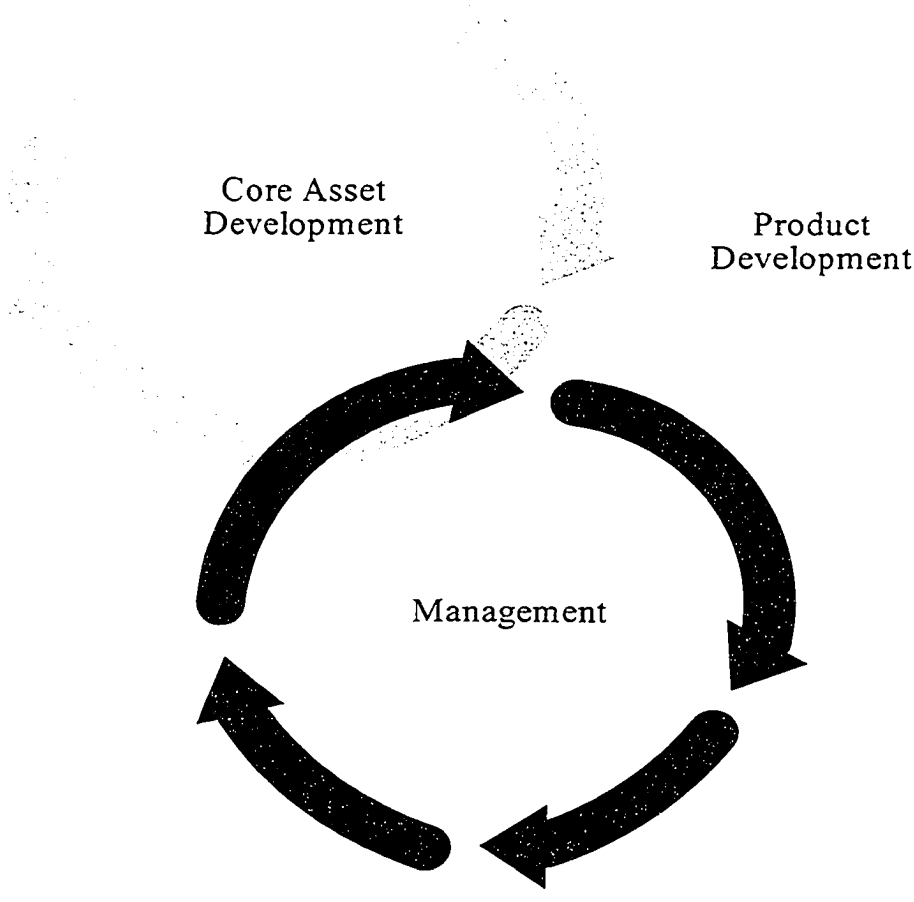


Figure 3.1: *Three Essential Activities [15]*

- **Variants:** Some patterns have variants (for example a variant may have an extra practice area), and these are described here rather than creating a brand new pattern.
- **Consequences:** Limitations and benefits of the pattern [14].

3.2.2 Product Line Technical Probe

The "diagnostic method" [30] for the SEI framework is the Product Line Technical Probe [14]. The probe may be useful if the none of the existing patterns apply or an organization is unable to determine which patterns it fits into. It can also be used to diagnose problems within a current product line effort, locate improvement opportunities or even help determine whether or not to launch a product line. A probe's results will include findings of the weaknesses and strengths of an organization, along with recommendations [14]. The probe is conducted through a series of peer group interviews. Each of the 29 practices areas of the framework has a set of probe questions. Before an interview with a peer group, questions sets are preselected that are related to the group's activities. Usually all practice areas are covered in a probe, but exceptions may be made if an area is not practiced by the organization. To reduce biases, each question set must be asked to at least two groups. Also some questions may not be asked if they were answered in a previous question.

The SEI probe requires a "probe team and representatives from the organization's product line stakeholder groups" [14]. The probe team, in addition to having question sets, must also be software product line experts. The "typical" [14] size of the probe team is four.

The process of a probe has three phases: Preliminary, Technical Probe and Follow-On. The first two phases of the probe are required but the third is optional. During the Preliminary Phase the probe team meets with the sponsor(s) of the probe and a few others that are able to provide context of the organization. This phase is to be wrapped up in a day. From it, applicable practice areas are decided, groups for interviews are chosen, documentation requests are made, and the schedule and details of the Technical Probe Phase are determined [14]. A kickoff meeting with all groups present launches the Technical Probe Phase. This meeting provides background information about software product lines and outlines the probe. After the kickoff several days of interviews with various groups take place. Each interview is one and a half hours. One of the probe team members asks the questions and the others write down the responses from the interviewees. Immediately following each interview session, the data is analyzed, and strengths and weaknesses are determined. After the interviews are conducted, there is a "Final Findings" [14] presentation for all the groups where the probe team presents their recommendations and can field questions. The typical time for the Technical Probe Phase is four days on-site. A final report, however, is produced for the organization after several weeks. Finally the optional Follow-On Phase may be used if the organization wants guidance in implementing the recommendations with a planning team. During this phase, action plans are implemented and assistance may be offered by the planning team.

3.2.3 Product Line Technical Review

For the case study of this thesis, a Product Line Technical Review (PLTR) was conducted of a medium-sized enterprise. SEI's Product Line Technical Probe was used a basis for this PLTR. Like the SEI Probe, question sets for each of the 29 practice areas were created. This section will provide an example of the question-derivation process by looking at the question set for the Architecture

Evaluation practice area. SEI has not published their Probe question sets except for a very small sample [14].

Deriving A Question Set from the Architecture Evaluation Practice Area

Before the study was conducted at a medium-sized enterprise, a smaller study was conducted at a small enterprise that consisted of three interviews for three practice areas to develop the question set templates. Within a framework practice area are statements which imply what SEI expects an ideal company to practice or have documented. In the Architecture Evaluation practice area it states

> "before an evaluation can proceed, the behavioral and quality-attribute goals against which an architecture is to be evaluated must be made explicit. These quality-attribute goals support the business goals. For example, if a business goal is that the system should be long-lived, modifiability becomes an important quality-attribute goal" [15].

A question derived from this excerpt was "what are the business goals of the system?" [35] because business goals influence quality-attribute goals, which are used during an architecture evaluation. Questions were created based on what SEI considered ideal for the practice area. A set of example questions derived for architecture evaluation is provided in Appendix A. When the first three practice area sets were developed it was discovered there were some common questions, such as "who are the relevant stakeholders for the practice area", "when is this area practiced", "what is the time spent on this practice", "what are the artifacts" and "what are the risks". Because of this, a template was developed for each practice area, with a "Questions" section that had specific questions for that area. This process was repeated for the remaining practice areas.

3.3 Software Product Family Evaluation Framework

The Software Product Family (SPF) Evaluation Framework [61] is a means to assess the maturity level of a software product line with respect to BAPO (Business, Architecture, Process, Organizational) concerns. A BAPO evaluation is done through interviews and examination of an organization's documentation and results in an "evaluation profile" [60]. In addition to SEI's framework, the BAPO evaluation framework influenced the interview question sets for this study. A meeting with Jan Bosch, one of the BAPO evaluation framework developers, occurred and some questions were developed to gauge maturity levels based on ones [6] he used for the evaluation framework. The additional questions were added to relevant practice area questions sets.

The evaluation framework adds aspects to each BAPO concern. Each of these aspects can be assigned a maturity level. Because an aspect partially depends on another aspect, the framework suggests that often aspect levels will be similar. This allows easy mapping of the set of aspects to a maturity level, because it is not expected that one aspect of a concern may be highly mature and other very immature. For example the Business concern has four aspects: Identity, Vision, Objectives and Strategic Planning. Identity relates to how the organization identifies itself to its product family. This identification may be implicit, in that the organization makes products in an ad hoc way and does not consider itself producing product families. The most mature level would then be when the family is known at the marketing level and is managed. The Vision aspect is how far ahead the company forecasts for its product family. Objectives refer to the marketing roadmap of the product family. At

a low level, a company would be marketing single one-of-a-kind products, and at a higher level a company would be marketing members of a family. Finally the Strategic Planning aspect refers to the development roadmap of the family. At a lower level there is no planning and at a higher level a roadmap of the family's development is made.

3.3.1 Business Questions Derived from Evaluation Framework

The following are questions that were derived from meeting with Jan Bosch for the Business concern:

> "Level 1: Reactive. Does the organization explicitly manage the SPF (Software Product Family)? If not confirm that it handles it in an implicit manner.
>
> Level 2: Awareness. To what extent is the SPF based on the business goals of organization? (Do they know they have a family but are not exploiting it?)
>
> Level 3: Extrapolate. To what extent are the objects expressed in a quantitative form? (If object are not quantitatively expressed, then the organization is extrapolating on the results of software family engineering.)
>
> Level 4: Proactive. How does the organization proactively manage software product family engineering? What are decisions based on?
>
> Level 5: Strategic. How institutionalized are the processes of the organization? How are quantitative predictions made?
>
> Level 3, 4 and 5: Extrapolate, Proactive and Strategic. How far ahead does the organization plan? (Long term, medium term and short term. Short term is extrapolative [Level 3], Medium is just proactive [Level 4], Long term is strategic [Level 5].)" [7].

These questions were appended to an appropriate practice area question set. In this case these questions were placed in the Organization Management: Organizational Planning question set.

3.4 Summary

This chapter provided more details of the two product line models used in this study. Although the SEI Product Line Technical Probe formed the basis for the PLTR conducted in this study, aspects of the BAPO evaluation framework was also incorporated. The next chapter will provide details on how the PLTR differed from SEI's probe and describe how the case study was conducted.

Chapter 4

Case Study

In this chapter which describes our case study, the first section provides an overview of the company that was involved in the case study. Section 4.2 describes the product line technical review that took place and Section 4.3 provides a summary.

4.1 Medium-sized Enterprise Profile

Because of a non-disclosure agreement, the company involved in this study cannot be named. Also some additional details that may identify the company such as their areas of domain have also been omitted. A division of a subsidiary of the company was studied. The subsidiary has several divisions within it. Because this division was approximately the same size as a medium-sized enterprise, it will be referred to as "ME". Figure 4.1 shows a partial hierarchy of the International Company (IC) that ME is part of. The IC consists of several subsidiaries, including S1 (Subsidiary 1). ME is a division of S1 which consists of three divisions in total (ME, D2, and D3). Although, ME is a division of a larger enterprise, it develops its products independently from the parent company. Because of this ME, was considered a medium-sized enterprise for the purpose of this study. ME has approximately 40 employees. At the time of the study, 41 products existed under the brands in ME but it was only responsible for the development of 40 of those products.

4.1.1 ME's Products

ME produces desktop software and provides web services. Products can be purchased in shrink-wrapped boxes, downloaded off an online store or provided online through a web browser. ME (not including its parent company) sold over one million products and services per year at the time of the study. ME has five distinct brands for its products. The products under ME's brands are listed in Table 4.1. "Code Base" refers to the source code repository for a particular product or products. "Marketing Product Family" is a grouping of products by ME's marketing department. This grouping is called a family however, the products in a family may not share any core or code assets. Each Marketing Product Family corresponds to one of the ME's brands. "Product Name" is an alias of a real product. "Platform" refers to the system the product runs in. For example a platform may be an operating system such as Linux, a virtual environment like the Java Virtual Machine or even a web browser. "Market Variability Point 1 (V1)" and "Market Variability Point 2 (V2)" are significant variation points. These points may be resolved at run or compile time and

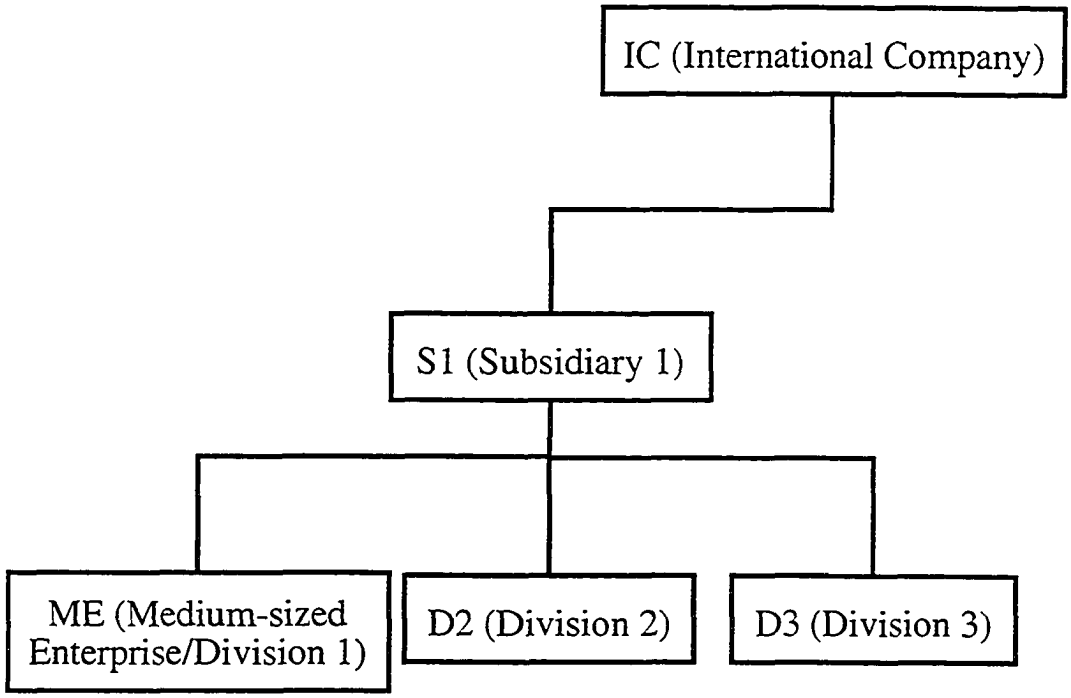


Figure 4.1: *Company Hierarchy*

affect the branding of products.

To provide an illustrative example of what Table 4.1 means, we will look at the family of Mozilla-based products [37]. Table 4.2 lists five current Mozilla-based products as of November 29, 2004. In this example Market Variability Point 1 implies "Browser". If a product has this, then it has a web browser used to view web pages. Market Variability Point 2 implies "Email" and products with this can act as an email client. The Mozilla foundation has a trunk that contains the code for all their products. When a major product(s) are developed such as Firefox 1.0 and Thunderbird 0.9 a branch is created off the main trunk for development. "AVIARY_1_0_20040515_BRANCH is the Firefox/Thunderbird 1.0 Branch" [56] which was shortened to "Aviary Branch" in Table 4.2. "MOZILLA_1_7_BRANCH" [57] ("Mozilla 1.7 Branch" in Table 4.2) is the branch that contains the code for Mozilla 1.7 and Netscape 7.2 [17][36]. Camino does not have its own branch so its code is developed as a module of the trunk [55]. After a branch product is released its changes are then added to the trunk. The next version of a branched product will be derived from the trunk, not from a previous branch. From the web sites surveyed [17][36] it was not clear if propriety Netscape technology such as AOL mail and Netscape WebMail support is merged into the main Mozilla trunk.

Figure 4.2 provides a diagram of ME's Marketing Product Family Variability. The products from Table 4.1 are grouped together first into their Domain Area. "Area 1" contains products that are made on a yearly cycle. "Area 2" is a different domain than Area 1 and contains only one product, P2. P2 does not operate on a yearly cycle like the products in Area 1 and no future versions are planned. The next level in Figure 4.2 is the Marketing Product Family. A Marketing Product Family consists of products grouped under the same marketing brand. Within a Marketing Product Family, products are grouped into their Platform, and then by Market Variability Point (V1, V2 or Both - Runtime). An example of a Market Variability Point could be a product that has a US and Canadian version. In

Code Base	*Marketing Product Family*	*Product Name (Acronym spelled out)*	*Platform*	*Market Variability Point 1 (V1)*	*Market Variability Point 2 (V2)*
1	F1	P1 (Product 1)	Platform1	√	√
1	F1	P1F1 (Product 1 Flavour 1)	Platform1	√	
1	F1	P1F2 (Product 1 Flavour 2)	Platform1	√	
1	F1	P1F3 (Product 1 Flavour 3)	Platform1	√	
1	F1	P1F4 (Product 1 Flavour 4)	Platform1	√	
1	F1	P1F5 (Product 1 Flavour 5)	Platform1	√	
1	F1	P1F6 (Product 1 Flavour 6)	Platform1	√	√
1	F1	P1F7 (Product 1 Flavour 7)	Platform1	√	√
1	F1	P1F8 (Product 1 Flavour 8)	Platform1	√	√
1	F1	P1F9 (Product 1 Flavour 9)	Platform1	√	√
1	F1	P1P2 (Product 1 Platform 2)	Platform2	√	√
2	F1	P1F10 (Product 1 Flavour 10)	Platform1	√	
3	F1	P1P3 (Product 1 Platform 3)	Platform3	√	√
3	F1	P1P3F1 (Product 1 Platform 3 Flavour 1)	Platform3	√	√
3	F1	P1P3F2 (Product 1 Platform 3 Flavour 2)	Platform3	√	√
4	F2	A1 (Acquisition 1)	Platform1	√	√
4	F2	A1F2 (Acquisition 1 Flavour 2)	Platform1	√	√
4	F3	A1F3 (Acquisition 1 Flavour 3)	Platform1	√	
5	F4	P1B1 (Product 1 Branch 1)	Platform1	√	
6	F5	P2 (Product 2)	Platform1	√	

Table 4.1: Table of ME's Products

Code Base	*Marketing Product Family*	*Product Name*	*Platform*	*Market Variability Point 1 (Browser)*	*Market Variability Point 2 (Email)*
Trunk	Mozilla	Camino 0.8.1	MacOS	√	
Aviary Branch	Mozilla	Firefox 1.0	Windows	√	
Aviary Branch	Mozilla	Firefox 1.0	MacOS	√	
Aviary Branch	Mozilla	Firefox 1.0	Linux	√	
Aviary Branch	Mozilla	Thunderbird 0.9	Windows		√
Aviary Branch	Mozilla	Thunderbird 0.9	MacOS		√
Aviary Branch	Mozilla	Thunderbird 0.9	Linux		√
Mozilla 1.7 Branch	Mozilla	Mozilla 1.7.3	Windows	√	√
Mozilla 1.7 Branch	Mozilla	Mozilla 1.7.3	MacOS	√	√
Mozilla 1.7 Branch	Mozilla	Mozilla 1.7.3	Linux	√	√
Mozilla 1.7 Branch	Netscape	Netscape 7.2	Windows	√	√
Mozilla 1.7 Branch	Netscape	Netscape 7.2	MacOS	√	√
Mozilla 1.7 Branch	Netscape	Netscape 7.2	Linux	√	√

Table 4.2: Table of Mozilla-Based Products

this example V1 could be US version and V2 could be Canadian. This variability would be resolved at compile time and the product's branding would reflect this. A product that resolves this variability at runtime would be classified as "Both - Runtime". From the Market Variability there are Market Segments. Products grouped together in market segments are very similar. Some segments may also be very trivial. For example a segment may consist of a shrink-wrapped product and a web downloadable product.

A special product is P1F10. This product is only associated with Family F1 through branding as indicated in Table 4.1. It has its own code base (2). P1F10 is a variant of a product in another division of ME's parent company. ME is not responsible for the development of P1F10 so this product is only mentioned because of shared branding.

Product A1 (Acquisition 1) was acquired through the merger of a company with ME. A1 has a trivial flavour A1F2 and a more complex flavour A1F3. A1F3 has its own brand F3 and is not associated with A1 and A1F2's brand F2.

P1B1 (Product 1 Branch 1) is taken from an older version of P1. P1 and P1B1 are derived from the same code base but exist as separate branches and are never re-merged.

Finally P2 (Product 2) stands out as the only one time product. It shares code assets with F1.

The organizational structure of relevant positions for the ME study is given in Figure 4.3. From Figure 4.1, S1, the subsidiary that contains ME was lead by a Chief Executive Officer (CEO).

4.2 Product Line Technical Review

The study was conducted by the author from January to August 2004 as indicated by the Gantt chart in Figure 4.4. It consisted of a series of interviews, surveys, and requests for documentation, which formed the basis for a review report produced for ME.

After the nature and scope of the study was approved by ME, a Steering Committee was formed in January 2004 to oversee the direction of the project. The Steering Committee had three ME

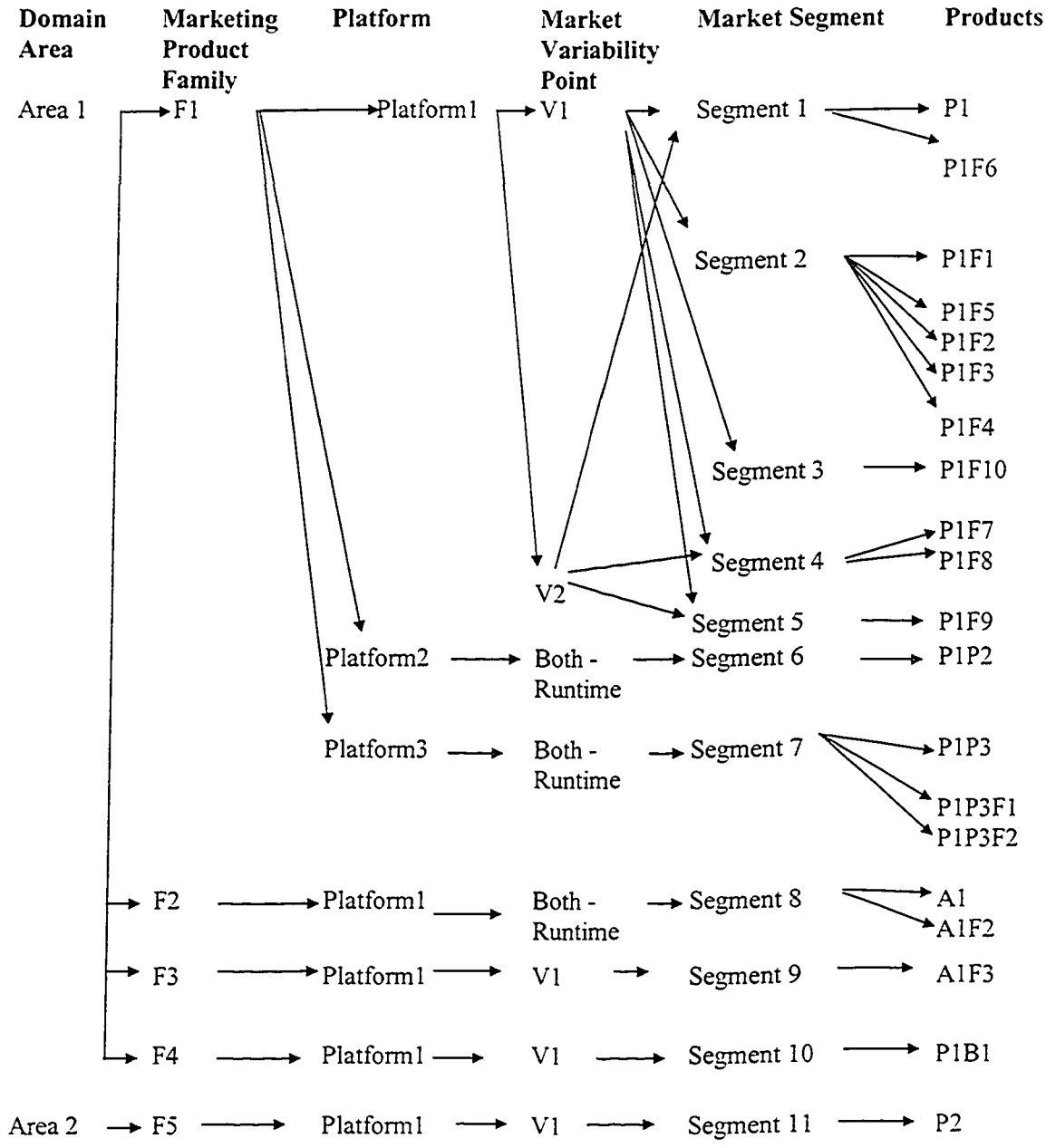


Figure 4.2: *Marketing Product Family Variability Diagram*

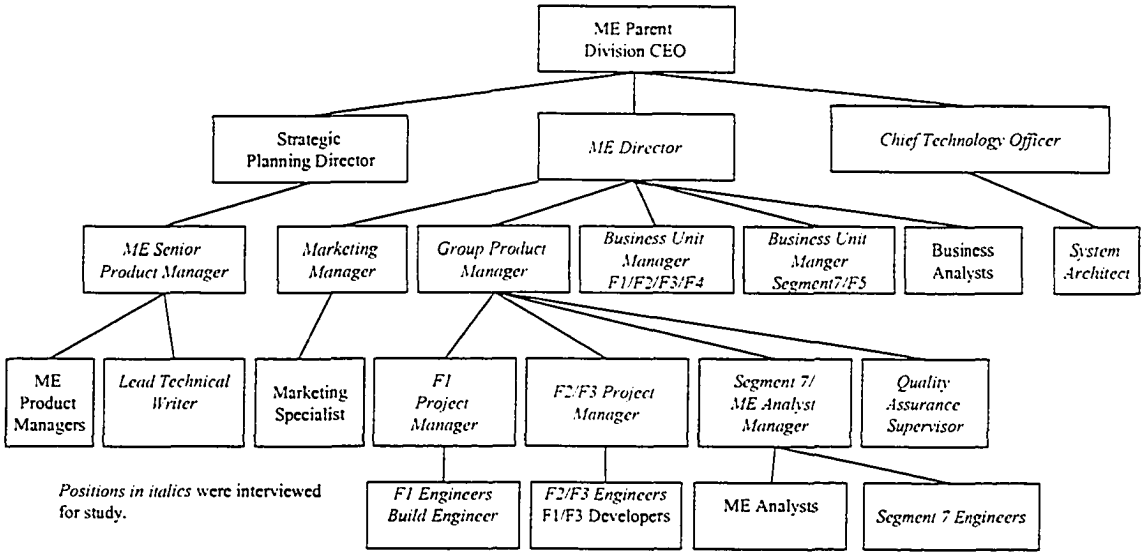


Figure 4.3: *ME Organizational Chart*

members and three University of Alberta members. The ME members were a Non-ME Division Group Product Manager, the CTO and the ME Group Product Manager. The University members were William Luthi, John Shillington, Director of the LINC Project, and Paul Sorenson, Professor and thesis supervisor.

Note, some tasks in Figure 4.4 take place before January 2004. On November 12, 2003 we asked ME to provide an organizational chart, which was provided on January 10, 2004. On December 1, 2003 the author began the creation of three practice area question sets. They were created for three interviews with a small enterprise. These interviews gave some preliminary ideas of what to expect when studying ME. Also on December 12, 2003 an earlier version of the practice area survey shown in Figure 4.5 was sent to the Steering Committee to complete. The study is considered to have started in January, because that was the first month the author was on-site at ME.

Participants of the study were staff members of ME. Each staff member who participated signed a consent form that explained their rights as a participant of the study according to University of Alberta ethics guidelines.

A presentation of the study was given on January 19, 2004 to the study participants. After the presentation a survey was conducted of engineering and management stakeholders using the questionnaire given in Figure 4.5. The survey asked participants to rate from 1 to 5 each of the Software Engineering Institute's (SEI) 29 practice areas, where 1 is "not important", 2 is "not really important", 3 is "somewhat important", 4 is "important" and 5 is "very important". Respondents were asked how important they thought the practice area was to ME right now, and how important it should be to ME in the future. A report of this survey was made and presented to the Steering Committee on February 5, 2004.

The survey results of the participants are given in Tables 4.3 and 4.4. Average Difference is the Average Desired Importance minus the Average Actual Importance. Sixteen surveys were filled out. Three of the surveys only contained check marks. These were integrated into the results as the respondent's desired importance, as opposed to where ME is now with respect to the practice area. Nine of the respondents were classified as management and seven were classified as engineers.

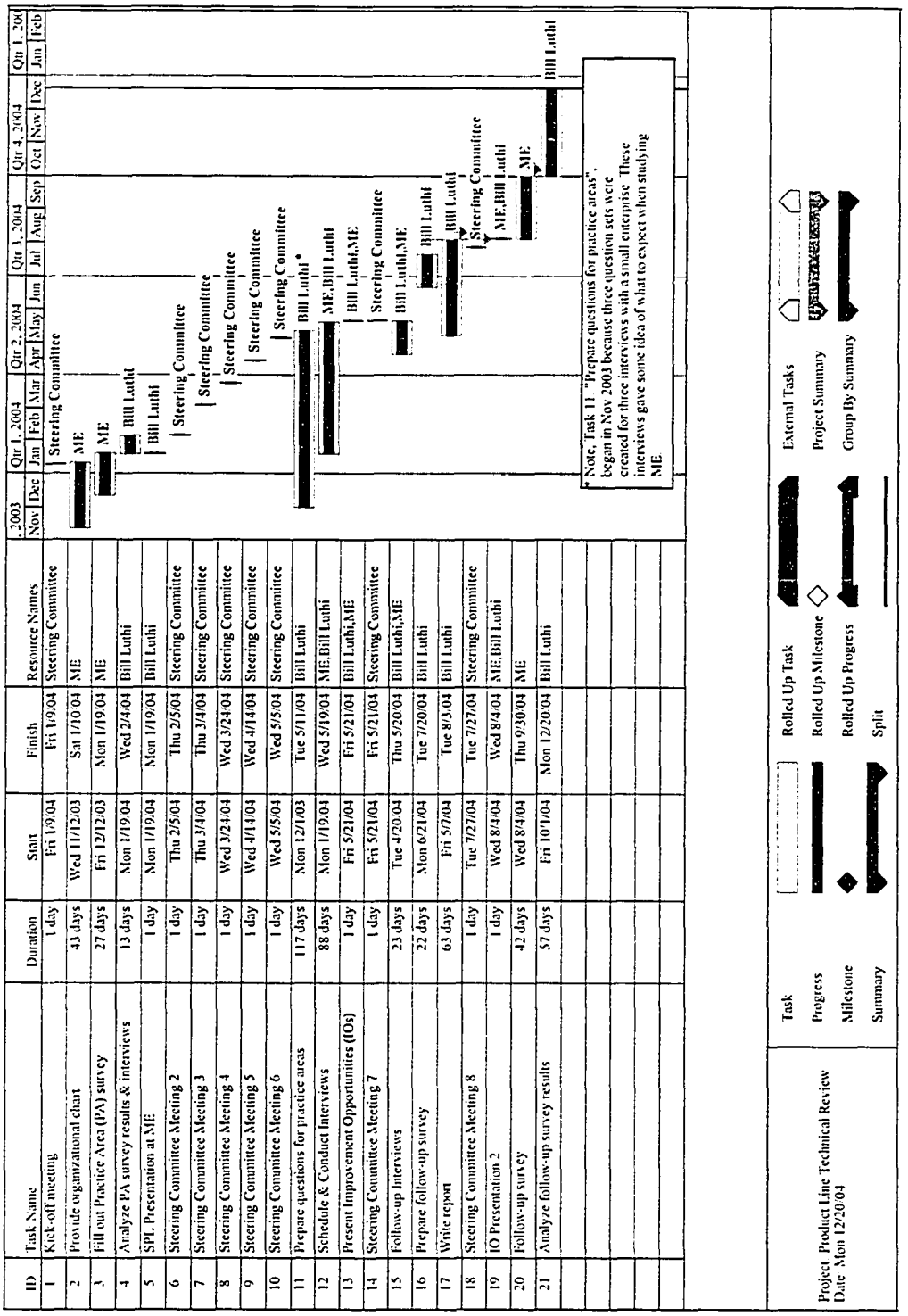


Figure 4.4: *Product Line Technical Review Gantt Chart*

Practice Area	1	2	3	4	5
Software Engineering Practice Areas					
Architecture Definition					
Architecture Evaluation					
Component Development					
Commercial Off-The-Shelf Utilization					
Mining Existing Assets					
Requirements Engineering					
Software System Integration					
Testing					
Understanding Relevant Domains					
Technical Management Practice Areas					
Configuration Management					
Data Collection, Metrics, and Tracking					
Make/Buy/Mine/Commission Analysis					
Process Definition					
Scoping					
Technical Planning					
Technical Risk Management					
Tool Support					
Organizational Management Practice Areas					
Building a Business Case					
Customer Interface Management					
Developing an Acquisition Strategy					
Funding					
Launching and Institutionalizing					
Market Analysis					
Operations					
Organizational Planning					
Organizational Risk Management					
Structuring the Organization					
Technology Forecasting					
Training					

29 Practice Areas Questionnaire

For Internal Distribution Only

Name:

Job Title:

Please rank the following practice areas by checking off the value that is most appropriate.

Legend

- 1: Not important to our company at this time and unlikely to be important in the future.
- 2: Not really important at this time, but it is possible the company will spend time on this area in the future.
- 3: Somewhat important. The company may spend time on this now or in the near future.
- 4: Important. The company will spend time on this area either now or in the near future.
- 5: Extremely important and the company spends time on this area now or will in the near future.

If at all possible please send the completed form back by Monday January 19, 2004.

Figure 4.5: *Practice Area Importance Survey*

Rank	*Average Actual Importance*		*Average Desired Importance*		*Average Difference*	
	Practice Area	*Value*	*Practice Area*	*Value*	*Practice Area*	*Value*
1	8. Testing	4.00	8. Testing	4.63	1. Architecture Definition	1.83
2	9. Understanding Relevant Domains	3.50	1. Architecture Definition	4.33	2. Architecture Evaluation	1.79
3	3. Component Development	3.42	3. Component Development	4.33	29. Training	1.60
4	5. Mining Existing Assets	3.40	9. Understanding Relevant Domains	4.15	13. Process Definition	1.40
5	10. Configuration Management	3.33	19. Customer Interface Management	4.14	15. Technical Planning	1.40
6	7. Software System Integration	3.25	15. Technical Planning	4.13	21. Funding	1.36
7	17. Tool Support	3.17	13. Process Definition	4.07	27. Structuring the Organization	1.33
8	16. Technical Risk Management	3.08	14. Scoping	4.00	18. Building a Business Case	1.20
9	23. Market Analysis	3.08	27. Structuring the Organization	4.00	28. Technology Forecasting	1.19
10	14. Scoping	3.00	16. Technical Risk Management	3.94	25. Organizational Planning	1.18
11	19. Customer Interface Management	3.00	10. Configuration Management	3.93	19. Customer Interface Management	1.14
12	24. Operations	3.00	11. Data Collection, Metrics, and Tracking	3.93	11. Data Collection, Metrics, and Tracking	1.01
13	6. Requirements Engineering	2.92	29. Training	3.93	22. Launching and Institutionalizing	1.01
14	11. Data Collection, Metrics, and Tracking	2.92	22. Launching and Institutionalizing	3.92	14. Scoping	1.00
15	22. Launching and Institutionalizing	2.92	23. Market Analysis	3.92	24. Operations	0.92
16	20. Developing an Acquisition Strategy	2.82	24. Operations	3.92	3. Component Development	0.92
17	15. Technical Planning	2.73	2. Architecture Evaluation	3.88	26. Organizational Risk Management	0.92
18	13. Process Definition	2.67	25. Organizational Planning	3.85	6. Requirements Engineering	0.90
19	25. Organizational Planning	2.67	6. Requirements Engineering	3.81	16. Technical Risk Management	0.85

Table 4.3: Practice Area Importance Rank 1 to 19

Rank	*Average Actual Importance*		*Average Desired Importance*		*Average Difference*	
	Practice Area	*Value*	*Practice Area*	*Value*	*Practice Area*	*Value*
20	27. Structuring the Organization	2.67	17. Tool Support	3.79	23. Market Analysis	0.84
21	12. Make/Buy/Mine/ Commission Analysis	2.64	18. Building a Business Case	3.79	9. Understanding Relevant Domains	0.65
22	18. Building a Business Case	2.58	7. Software System Integration	3.71	8. Testing	0.63
23	26. Organizational Risk Management	2.58	21. Funding	3.69	17. Tool Support	0.62
24	1. Architecture Definition	2.50	26. Organizational Risk Management	3.50	10. Configuration Management	0.60
25	4. Commercial Off-The-Shelf Utilization	2.45	5. Mining Existing Assets	3.44	12. Make/Buy/Mine/ Commission Analysis	0.51
26	21. Funding	2.33	28. Technology Forecasting	3.36	7. Software System Integration	0.46
27	29. Training	2.33	12. Make/Buy/Mine/ Commission Analysis	3.14	4. Commercial Off-The-Shelf Utilization	0.35
28	28. Technology Forecasting	2.17	20. Developing an Acquisition Strategy	3.00	20. Developing an Acquisition Strategy	0.18
29	2. Architecture Evaluation	2.08	4. Commercial Off-The-Shelf Utilization	2.80	5. Mining Existing Assets	0.04

Table 4.4: Practice Area Importance Rank 20 to 29

Originally it was planned to focus on practice areas that were most important or that had the largest average difference. At the February 5, 2004 Steering Committee meeting, the ME Group Product Manager felt that using the survey results to prioritize practice areas may not be meaningful. His concern was that the respondents may not have had an understanding of what the practice areas meant so they may not have provided useful feedback. This was a valid concern since the ME employees were not familiar with the SEI framework. It was therefore agreed that the survey results would not be used to prioritize practice areas. Instead the ME Steering Committee members came up with a prioritized list. However, even this list was not used to focus practice area priority. Instead interviews were conducted based on when the interviewees were available. In addition, because practice area questions sets had yet to be developed, interviews took place as sets were created.

To kick-start the study and get a feel for the context of the organization before the February 5, 2004 Steering Committee meeting, the University of Alberta Steering Committee members chose three practice areas to conduct interviews in: Architecture Definition, Tool Support and Technology Forecasting. The ME Group Product Manager recommended interviewees for these areas. Preliminary draft reports on the company's conformance to the SEI ideal were also produced for the Architecture Definition and Technology Forecasting areas.

The second phase of the study began after the February 5 meeting. It consisted of more interviews and documentation requests. This phase lasted from February to May 2004. The roles and the practice areas for each interviewee are listed in Table 4.5. Throughout this phase, reports were produced on several practice areas and presented to the Steering Committee for feedback. This feedback was then incorporated into the reports and in some cases resulted in additional interviews. During one Steering Committee meeting the ME Group Product Manager indicated he wanted to release the reports on Architecture and Testing on May 21, 2004. This was agreed to by the Steering Committee and these reports were released before the entire draft report was completed.

The third phase began with the completion of first drafts of the 29 practice area reports and a presentation of preliminary findings on May 21, 2004 with ME employees. Feedback from this meeting influenced the final report. After this time period Paul Sorenson and John Shillington reviewed the reports and provided feedback to William Luthi to develop the first draft of the report.

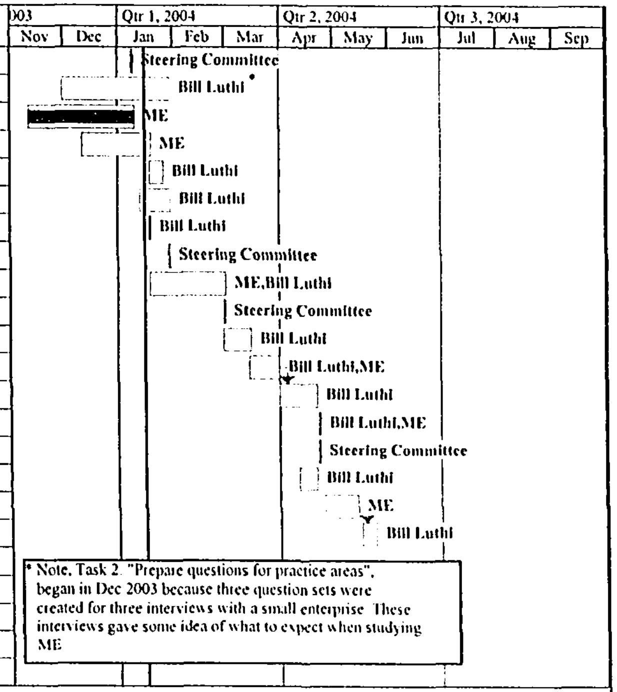
This first full draft of the report was released to the Steering Committee members of this study on July 23, 2004. It was discussed at the final Steering Committee meeting on July 27, 2004. On August 4, 2004 a second presentation of the final report took place and two surveys were given out. The first survey was similar to the one given on January 19th. The purpose of that survey was to see if the perception of practice area importance had changed since January. The second was an anonymous survey participants filled out about the study itself. The purpose of the second survey was to aid in evaluating how useful the report and presentations were to the company and what needs to be improved if such a similar study is to be repeated.

The schedule presented in Figure 4.4 was not originally predicted. Figure 4.6 shows the task time predictions from January 16, 2004. The project took longer than expected for several reasons. One of them, not listed on either Gantt chart is the time the author spent doing teaching assistant work from January to April. The author spent 221.5 hours working part time which severely reduced the amount of time he was allowed to work on the study. The "preparing questions for practice areas" task was originally predicted to be completed in 45 days and ended up taking 117 days. This was due to a change in the original expectations of the study. Originally the author planned to write

	Architecture Definition	*Architecture Evaluation*	*Component Development*	*COTS Utilization*	*Mining Existing Assets*	*Requirements Engineering*	*Software System Integration*	*Testing*	*Understanding Relevant Domains*	*Configuration Management*	*Data Collection, Metrics and Tracking*	*Make/Buy/Mine/Commission Analysis*	*Process Definition*	*Scoping*	*Technical Planning*	*Technical Risk Management*	*Tool Support*	*Building A Business Case*	*Customer Interface Management*	*Developing An Acquisition Strategy*	*Funding*	*Launching and Institutionalizing*	*Market Analysis*	*Operations*	*Organizational Planning*	*Organizational Risk Management*	*Structuring the Organization*	*Technical Forecasting*	*Training*		**Total**
Build Engineer										1																				1
Business Unit Manager F1/F2/F3/F4																		1												1
Business Unit Manger Segment 7/F5																		1												1
Chief Technology Officer																											1			1
F1 Engineer 1	1	1	1	1	1			1								1	1													8
F1 Engineer 2	2	2	1	1				1																						5
F1 Engineer 3			2		1		1	1																						4
F1 Engineer 4					1			1																						2
F1 Engineer 5	1	1													1															3
F1 Project Manager						1					1					1														3
F2/F3 Engineer 1	1	1					1	1																						4
F2/F3 Engineer 2	1	1																												2
F2/F3 Project Manager									1		1				1	1														4
Group Product Manager											1		1			1					1	1		1	1			1		9
Lead Technical Writer									1																					1
Marketing Manager																						1								1
ME Director																					1						1			2
ME Senior Product Manager							1							1					1			1								4
Quality Assurance Supervisor								1			1																			2
Segment 7 Engineer 1	1	1					1	1									1													5
Segment 7 Engineer 2	1	1													1															3
Segment 7 Engineer 3												1																		1
Segment 7/ ME Analyst Manager									1						1															2
System Architect								1																			1			2
Total	7	7	3	2	3	2	3	8	3	1	4	1	1	1	4	4	2	2	1	0	2	1	2	1	1	1	1	2	1	

Table 4.5: Employee and Practice Area Interviews

ID	Task Name	Duration	Start	Finish	Resource Names
1	Kick-off meeting	1 day	Fri 1/9 04	Fri 1/9/04	Steering Committee
2	Prepare questions for practice areas (PAs)	45 days?	Mon 12/1/03	Fri 1/30/04	Bill Luthi
3	Provide organizational chart	43 days	Wed 11/12/03	Sat 1/10/04	ME
4	Fill out practice area survey	27 days?	Fri 12/12/03	Mon 1/19/04	ME
5	Analyze PA survey results and interviews	6 days?	Mon 1/19/04	Mon 1/26/04	Bill Luthi
6	Schedule interviews	13 days?	Wed 1/14/04	Fri 1/30/04	Bill Luthi
7	SPL Presentation at ME	1 day?	Mon 1/19/04	Mon 1/19/04	Bill Luthi
8	Steering Committee Meeting 2	1 day?	Fri 1/30/04	Fri 1/30/04	Steering Committee
9	Conduct Interviews	31 days?	Mon 1/19/04	Mon 3/1/04	ME,Bill Luthi
10	Steering Committee Meeting 3	1 day?	Mon 3/1/04	Mon 3/1/04	Steering Committee
11	Review Results	11 days?	Mon 3/1/04	Mon 3/15/04	Bill Luthi
12	Follow-up Interviews	13 days?	Mon 3/15/04	Wed 3/31/04	Bill Luthi,ME
13	Write report	15 days?	Thu 4/1/04	Wed 4/21/04	Bill Luthi
14	Present Report	1 day?	Fri 4/23/04	Fri 4/23/04	Bill Luthi,ME
15	Steering Committee Meeting 4	1 day?	Fri 4/23/04	Fri 4/23/04	Steering Committee
16	Prepare follow-up survey	8 days?	Mon 4/12/04	Wed 4/21/04	Bill Luthi
17	Follow-up survey	15 days?	Mon 4/26/04	Fri 5/14/04	ME
18	Analyze follow-up survey results	6 days?	Mon 5/17/04	Mon 5/24/04	Bill Luthi



Project Product Line Technical Review
Date Fri 01/16/04

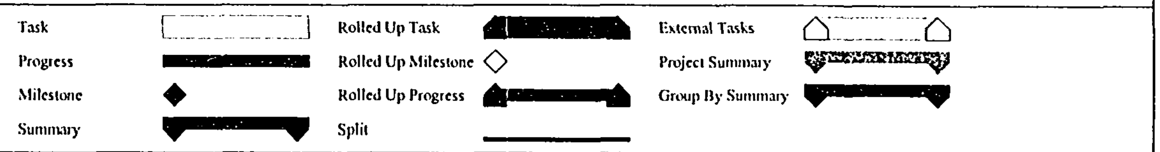


Figure 4.6: *Product Line Technical Review January 16, 2004 Gantt Chart Estimates*

the final report after the interview period. It was not expected individual practice area reports be written concurrently while interviews took place. Because of this the creation of questions sets were postponed while reports were written. This report writing requirement resulted in interviews taking place over a long period. Also, it was initially expected that follow-up interviews would be required for most interviewees. It turned out that follow-up questions of interviewees could be asked when they were interviewed for a different practice area or even by asking another interviewee the follow-up questions. Group interviews were another expectation, however due to scheduling difficulties and because the interviewer had to ask and record questions at the same time this was not done. After the first group interview it was felt that one-on-one was the best way to ensure accurate information was recorded. Report writing also took longer than originally expected. The author found it took a long time to understand and research the SEI SPLP framework and patterns. Also, to gain some understanding of the specific practices mention in each practice area, the author had to follow up on many of the references and case studies given by SEI. Because the study was now going to take place over a longer period, more steering committee meetings became necessary. Also Paul Sorenson and John Shillington were gone for most of the month of June and unable to provide feedback during that period. This resulted in a period of inactivity, extending the report writing time.

4.3 Summary

The study had several expectations that were changed through the process. Issues arose in areas of scheduling with respect to serializing the interviews. Another expectation was the usefulness of the initial survey shown in Figure 4.5. It became apparent during interviews, that some of the respondents were not clear on the meanings of certain practice areas. For example, many respondents felt that the testing level was adequate because of they had a QA department. They did not take into account proper and sufficient unit testing, which some developers were not doing. Also some thought customer interface management meant user interface design. However, for the more intuitive titles such as architecture definition and architecture definition, respondents did appear to grasp the meaning. The respondents were given a handout that briefly described each of the 29 practice areas and attended a presentation by the author. They conducted a self-assessment without much education about the SEI SPLP framework. The author feels the self-assessment was useful, because it gave a rough feel for the organizations. It showed some biases that some respondents had toward certain areas. However, if the study had just focused on practice areas with the greatest improvement opportunity gap, there may have been risk of missing the assessment of key areas. Even though the review went ahead this way, it should not preclude a variant approach that spends more time upfront training the staff to set more focus on the study. The next chapter will show the results this study found.

Chapter 5

Results

This chapter reports on the results of this study. Section 5.1 outlines how ME practices compared to the ideal of the SEI framework. Section 5.2 explores relevant SEI patterns that could be applied to the organization. Section 5.3 presents the "Slow Start" pattern. The results of the second practice area importance survey are shown in Section 5.4. The anonymous survey results on the value of the study are then shown in Section 5.5. A breakdown of the hours spent on the study is given in Section 5.6. Section 5.7 provides an analysis of the BAPO "evaluation profile" [61] of the organization. A comparison of the SEI Product Line Technical Probe and the BAPO four-dimensional evaluation framework is given in Section 5.8. Finally, Section 5.9 provides an overview of what lessons have been learned during the course of this study.

5.1 Comparison to SEI Framework

The research found that ME develops software in a product centric way. Specifically, ME is organized so specific teams handle specific products. It does not do core asset development formally, but it does have the potential for it. The company is primarily focused on customer satisfaction of current products. A change in process or structure would only be supported by upper management if there is a direct correlation with customer satisfaction or a return on investment analysis with real cost savings.

Based on the interviews conducted each practice area has been assigned a current maturity level ('C') and an improvement opportunity level ('I') as shown in Table 5.1. A level from 1 to 5 was given to each practice area:

- 1) Not practiced.
- 2) Practiced on an ad hoc basis.
- 3) Practiced and may not be mature.
- 4) Practiced and some identified and defined processes.
- 5) Practiced, effective and has defined processes that are part of the culture.

Table 5.1 has been created to illustrate what the author feels ME's current maturity level is and which practice areas have improvement opportunities. An area with a higher improvement opportunity level than current level means productivity and efficiency gains can be made in that area.

Practice Area	*1*	*2*	*3*	*4*	*5*
1. Architecture Definition		C		I	
2. Architecture Evaluation		C		I	
3. Component Development		C		I	
4. Commercial Off-The-Shelf Utilization		C	I		
5. Mining Existing Assets		C	I		
6. Requirements Engineering		C		I	
7. Software System Integration		C		I	
8. Testing			C	I	
9. Understanding Relevant Domains			C	I	
10. Configuration Management				C	I
11. Data Collection, Metrics, and Tracking			C	I	
12. Make/Buy/Mine/Commission Analysis		C	I		
13. Process Definition			C	I	
14. Scoping	C			I	
15. Technical Planning		C	I		
16. Technical Risk Management		C	I		
17. Tool Support		C	I		
18. Building a Business Case	C			I	
19. Customer Interface Management	CI				
20. Developing an Acquisition Strategy	CI				
21. Funding	C			I	
22. Launching and Institutionalizing		C	I		
23. Market Analysis				C	I
24. Operations			C	I	
25. Organizational Planning				C	I
26. Organizational Risk Management			C	I	
27. Structuring the Organization		C		I	
28. Technology Forecasting			C	I	
29. Training		C		I	

Table 5.1: Current and Improvement Opportunity Maturity Level of Practice Areas

5.1.1 Architecture Definition

Architecture Definition is given a current maturity level of 2 because it is handled informally by the company. The engineers want it be defined more formally. Up to date documentation is mainly in the source code, rather than non-source code documents. There are no explicit goals regarding architecture set by the business unit. Variability has been handled very informally. Finally, core assets are not developed separately from the products.

The improvement opportunity level was assessed at 4 for several reasons, one of them being the desire from various software engineering interviewees for more time to work on architecture. Also there were opportunities for the creation of core assets. A business case would be needed to explore the return-on-investment of moving to an architecture-centric core asset approach.

5.1.2 Architecture Evaluation

ME does not conduct formal architecture evaluations so the Architecture Evaluation area is assessed at level 2. There presently is no incentive from the business unit to do architecture evaluations. The software engineers want architecture evaluations, but the company rewards them primarily based on released products.

This improvement opportunity level was set at 4. ME's software engineers have expressed a desire for more time to do architecture evaluations and believe it will pay-off in the long run. Also the organization does not have a formal method for architecture evaluations. A pilot project with a formal method such as ATAM^{SM} (Architecture Tradeoff Analysis Method) or SAAM (Software Architecture Analysis Method) [15] would only take a moderate amount of effort and cost for ME.

5.1.3 Component Development

Core asset component development does not take place, but there is a culture of reuse in place so Component Development is at a current maturity of level 2. The SEI SPL framework states "if a developed component is to be a core component, it must have an attached process associated with it that explains how any built-in component-level variability can be exercised in order to produce an instantiated version for a particular product" [15]. Build documentation defines the attached processes for some components in the F1 line. In general, the attached process for instantiating a component's variability is documented in the source code.

The improvement opportunity level was assessed at level 4. This would involve continuing to make new components modular and documenting how to instantiate variability. If core assets begin to be developed, then they will require attached processes that explain how to exercise variability [15].

5.1.4 Commercial Off-The-Shelf Utilization

ME makes some use of Open Source and COTS software as tools and as product components. However, the use of such components is not an instilled practice in the company and therefore this area has been assigned a level 2. The process used for evaluation of COTS software varies depending on the circumstances. For example if many have to be trained on the COTS software, a feature matrix may be created. Less formally, evaluation may take place on ME's newsgroup server with threaded discussions about COTS assets. SEI does not provide any specific guidance to

choosing Open Source components in its framework, but the process would probably be similar to the COTS one.

SEI recommends its own COTS-based systems (CBS) practices. They suggest a three-step process: plan the evaluation, design the evaluation instrument and apply the evaluation instrument. A pilot project with CBS practices would represent an improvement opportunity to level 3.

5.1.5 Mining Existing Assets

Mining occurs and is not considered a risky activity. Besides comments in the source code, little documentation is produced about mining. Wrapping is a technique commonly used by ME to support the reuse of mined components by hiding or changing the interface of components, but not the components themselves. Mining of designs also takes place. Mining Existing Assets is ranked level 2 because it is done in an ad hoc manner.

The improvement opportunity level for mining is rate as level 3. This would require looking for opportunities for mining using more formal practices, including, techniques such as Options Analysis for Reengineering (OAR) and Mining Architectures.

5.1.6 Requirements Engineering

Requirements engineering is done on a per-product basis for the short term (the current version to be released). Use-case modeling is a technique employed in ME. No core asset development takes place so there has not been a need to do requirements engineering for an entire product line. Product line requirements engineering is assessed currently at level 2.

A level 4 improvement opportunity has been given to requirements engineering. This would require the construction of a requirements document for a product line. Such a document would contain variabilities and commonalities of the line, and help determine if moving to a product line approach is worthwhile.

5.1.7 Software System Integration

Most component documentation is about the syntactic interface and is contained in the source code. The main reason is there is not enough time to do more documentation due to the deadlines on deliverables that must be met. Software System Integration is therefore given a level 2.

The improvement opportunity level is assessed at 4. More than just the syntactic interface of components would need to be documented. For example, assumptions about component behavior, how to instantiate the variability, and rationale for creation could be recorded. SEI suggests documenting the set of assumptions programmers can make about components. This includes "its behavior, the resources it consumes, how it acts in the face of an error, and other assumptions" [15]. This documentation would be useful in training new developers and for other divisions (D2 and D3 in Figure 4.1) to see if ME has components it can use.

5.1.8 Testing

Unit testing is done in an ad hoc way and there are presently no standards or defined processes for how it should be conducted. F2/F3 has no infrastructure to support it. The QA Team does most of the testing for the F1 line. The specifications they use appear to be adequate for their testing

purposes, however keeping specifications up to date after the business unit signs them off is not a high priority during development. There is no test infrastructure in place that would allow for continuous integration or automatic build testing. The code base 3 and code base 4 architectures were not designed to reduce the effort required for testing. For example both architectures do not have "special test interfaces that allow a self-test functionality to be invoked and special access to certain state types which are stored (maintained internally) by the program" [15]. Therefore testing is placed at a current level 3 for maturity.

The improvement opportunity level is assessed at 4. ME can watch the market and open source community for new tools developed for subsystem integration and conformance testing. None of the engineers interviewed could identify a tool for this purpose but, it is possible an applicable one may be available in the future. Another type of tool to look out for is one that performs structural unit testing (unit tests that ensure the code does not abort, destroy files, or lock up the system). ME can also research possible test infrastructures/frameworks for continuous integration, unit testing and automated testing. The F2/F3 team can investigate if any unit testing frameworks can be used with their development environment. Additionally developing a set of unit testing standards for developers would help ensure consistency.

5.1.9 Understanding Relevant Domains

Domain analysis is taken very seriously for the F1 product line. A team of analysts is dedicated for the F1 product line. For the F2/F3 product line, the products are simpler and have less features than F1 products, so there is less need for as many domain analysis resources. ME has already identified the areas of domain expertise useful for building the current line of products. The "mental model" [15] however, has not been translated into a documented domain model. As a result ME may be vulnerable with a loss of experts. Understanding Relevant Domains is given a current maturity level of 3.

Level 4 is the improvement opportunity assessment. This would start with a relatively quick, broad exploration of commonality and variability to gain an understanding of the issues and their effect on the product line. A more advanced activity would then be recording the "mental model" into a domain model.

> "Assumptions and decisions about what is common, what is variable, and what is excluded from the product line should be documented, plus some justification of these *sic* that ties *sic* to the business case. Recording this information will also mitigate the risk of having key people leave the project, taking their domain understanding with them" [15].

The cost of making this documentation needs to be weighed against the potential cost of losing a domain expert. Finally, a formal SCV (Scope, Commonality and Variability) analysis would be useful for ME if it considers moving to a core-asset based architecture. This should be done to assist in justifying such a change but, it would require a fair amount of time and personnel because the products of the ME line are very mature.

5.1.10 Configuration Management

F1's current configuration management (CM) processes are defined, practiced and effective to handle multiple versions of the different products of the line and branching. F2/F3's less formal processes also appear adequate given the team's small size and the fact that new products will not be derived from the F2/F3 line. Neither of the specific practices in the SEI framework such as IEEE/ANSI standard for CM plans and CMMI step for CM are utilized by the company. However, some elements of each are present in the F1 Platform1 line. Compared to the IEEE/ANSI standard, the current documentation does contain change control policies and describes organization roles (build engineer and software engineers). It does not however, define the artifact life cycles. In contrast to the CMMI steps, the current documentation does identify configuration items (such as scripts), components, and related work products. An established change management system is used to track changes and maintain records. What the current approach lacks are processes for tracking change requests and performing configuration audits. Because of this Configuration Management is currently at level 4.

The improvement opportunity level is 5. This would require the development of a core asset CM policy. If a core asset development approach was ever taken, the current CM policy would have to be adjusted. Currently COTS core assets are replicated in each of the product repositories.

5.1.11 Data Collection, Metrics and Tracking

Data collection, metrics and tracking practices are based on the goals of the organization. ME's goals are prioritized differently than the typical SEI goals. Three typical goals are listed by SEI for a data collection, metrics and tracking program: "better quality", "improved profitability of product development" and shorter time to market [15]. Shorter time to market is not applicable to ME, because they are dependent on an external organization to provide domain information and ME cannot control or influence when that information is provided. Also, time to market is currently not a goal of ME. Increased productivity is also not a major goal of ME because there is a feeling that measuring productivity would be too costly. A general goal for the ME is higher quality, especially if it increases customer satisfaction measured by a "net promoter score" [53]. The main goals of the F1 project unit are number of features implemented, quality, reliability and ease of use. No metrics have been developed by F1 project managers to measure quality during development. Quality is measured by the QA team. The F2/F3 team does their own quality measurement, but this is done after the product is released in the market when customer feedback data becomes available. During development, project managers use simple metrics, such as "on time" or "not on time". With respect to quality and customer satisfaction, ME appears to be aligned with SEI practices. Quality, however, is measured mainly after a market release when customer feedback comes in. Should the company's goals change, new metrics would need to be developed to measure and track the progress of those goals. Data Collection, Metrics and Tracking is currently at level 3.

The assessed improvement opportunity level is at 4. ME would have to find several new metrics to measure efficiency, compliance to internal processes, size of software assets, decreased development time, decreased development cost and higher level of software reuse. With the present prioritized goals of quality, reliability, and customer satisfaction the current metrics appear adequate at the project unit and group product manager level. However, if a new process or an improvement opportunity from another practice area (such as trying out a unit testing framework for all devel-

opers) became a pilot project then there may be an opportunity to apply more extensively SEI's practices for measurement activities.

5.1.12 Make/Buy/Mine/Commission Analysis

Feature matrices and requirements documents are used in make/buy/mine/commission analysis. Typical choices for ME tend to be buy or make when a more formal analysis is performed. ME does not have a standard set of questions to ask when it goes through the tool selection process. Also, spreadsheets are the most sophisticated decision analysis software tool used. Make/Buy/Mine/Commission Analysis is at level 2.

The improvement opportunity level is assessed at 3. ME could try a tool selection pilot project with the SEI question set. The SEI question set could act as a starting point that could be used to develop and evolve a process for choosing new tools.

5.1.13 Process Definition

At the organizational level a Process Excellence [41] process supports process management and process improvement. This is defined, well-understood and considered effective at the management level. It has recently been put into practice so it has not been proven effective in the organization yet. At this time, formal processes to facilitate human understanding and communication within ME are not used primarily because informal communication is viewed as sufficient given ME's small size. At the development level though, where processes may be more low level, there is a risk the stakeholders do not understand a process. For example, when use cases for requirements were introduced, some of the managers acting as customers did not understand the granularity of them or missed several cases. A generic process definition could aid in the explanation of use cases. This definition would also be beneficial in the training of new personal. Otherwise, process management through analysis of impacts and process improvement through postmortems appear to be adequate for the development level process model. Process Definition practices are currently at level 3.

The improvement opportunity level is 4 and would involve the creation of a generic process definition. There are process definitions already in place, but not a generic one that defines the processes for building a class of products. A generic process definition would be useful for training and provide documentation about the possible variabilities in the product line.

5.1.14 Scoping

High-level scoping definition documentation exists in the marketing literature; however, there is no subsystem level scoping documentation. Current documentation does not describe which subsystems will interact. There is also no single scope definition document; instead scoping information is scattered in various document forms (web pages, PowerPoint slides, Word documents, et cetera). Scoping is given currently at level 1.

The improvement opportunity level is 4. This level would require construction of a scope definition document. Scoping information about commonalities and variabilities exists in various forms. Bringing it all together would be useful in deciding whether or not to adopt a product line approach. Also ME would need to hold an organization-wide workshop to further understand product line goals and products. If a product line approach is being considered, bringing the various stakeholders

(product management, development, marketing, et cetera) together in a workshop would be useful in setting direction.

5.1.15 Technical Planning

ME has tools that influence technical planning but nothing that explicitly defines the planning process or what needs to go in plans. Reuse is not formally planned because core asset development does not take place. Improvement plans are made for each of ME's products. Although ME does not explicitly plan for process improvement, its Process Excellence tools measure current process performance and analyze and implement changes to improve current processes. Process Excellence is integrated into the day-to-day operations. Technical Planning is currently at level 2.

An improvement opportunity level of 3 is recommended. ME would need to define explicitly the characteristics of a good plan, such that these characteristics complement and support its already existing tools. The characteristics listed in this practice area could be used as a starting point. With the current no-core-asset-team structure of ME, core asset production plans do not provide any improvement opportunities. If a core asset team is formed, or if a product development team produces a core asset, this area may provide some guidance. For example if a specific product's library becomes a core asset candidate, specific reuse processes can be developed and attached to it. These processes would explain how it is to be reused; the processes could then be used in production plans for future products that use the library.

5.1.16 Technical Risk Management

At the project unit level, practice area specific risks are stored and used later for analysis by the group product manager. There is not very much sharing of code assets. This is because the products do not have many interdependencies with each other so there is less risk of one affecting the other. The disadvantage is in replicated effort. These risks are well known by all stakeholders and they are already dealt with informally. Technical Risk Management is assessed to be at level 2, mainly because a software product line effort is not underway.

The improvement opportunity level is 3. ME would need to make a prioritized list of risk statements with respect to architecture. This could aid in deciding how worthwhile it is to move to a core asset based architecture approach. Also this year F2/F3 will build in functionality in order to use QA's F1 scenarios for the first time ever. Right now, F2/F3 testing is done manually. Quality assurance of the F2/F3 family is done by the team itself. In the future, as more sharing is done it may be worthwhile to look at risk management paradigms, such as SEI's Continuous Risk Management [15], to identify and mitigate related risks. SEI does, however, suggest starting small when starting a new risk management program to see how it fits in the organization.

5.1.17 Tool Support

Tools are chosen informally on an ad hoc basis and evaluation is also done informally. A lot of the tools for development have been chosen for the long term (several years) and are not likely to change. Tool Support is currently at level 2.

The improvement opportunity was assessed at level 3. This would involve development of an in-house tools inventory and a process to manage it. This may make it easier to communicate about

them during the training process or if ME goes through another process similar to this product line technical review. Further maturity would involve doing a pilot trial of a CASE tool(s) for analysis and design, to see if it can increase productivity or product quality. Also, having new engineers use CASE tool(s) may be useful in their training of the architecture. Finally an analysis of all current tools and their fitness to a product line effort could be performed. Such an analysis would by useful to see if any new tools are needed to move to a product line approach.

5.1.18 Building a Business Case

ME has never made a product line adoption business case. Also, new products are proposed by the business unit of each division. There is no company-wide business unit that comes up with product ideas and decides to implement them in already existing product lines or create a new product line (division). Therefore building a business case is ranked 2 for a product line.

The improvement opportunity level is 4. To start, ME can develop a business case or "business case lite" [15] for some of SEI practices or other improvement opportunities (architecture definition and/or evaluation for example) mentioned in other practice areas in the report [34] produced. Implementing some practices now will allow ME to be in a better position for future product line adoption. At a more mature level, ME could build a business case about the return-on-investment of moving to an SEI-like product line for it or one of its families. This would be difficult because of the need to link directly customer satisfaction to product lines or the need to provide real cost savings and benefit numbers.

5.1.19 Customer Interface Management

The only relevant SEI customer interface practice done by ME is providing central product support to customers. Establishing users groups is not done, but metrics and surveys already give the marketing group a customer voice. The rest of the practices specified by SEI such as communicating "the product line strategy to the customer", establishing a "customer interface process", training "product line marketers and product managers" and having "product line customer representatives" [15], are more applicable to "low volume, high cost" product lines. Customer Interface Management was not found to be applicable to ME so its current and improvement opportunity are both at level 1.

5.1.20 Developing an Acquisition Strategy

ME hires very few contractors, and they do not hire them to make core assets or even components that will be reused, such as libraries. SEI's practices appear to be too heavy for SMEs in this area. This area could provide guidance if the division does more outsourcing, but right now an improvement opportunity is not present in this area. The risks SEI lays out are not an issue because ME avoids outsourcing. Because Developing an Acquisition Strategy is not applicable its current and improvement opportunity are both at level 1.

5.1.21 Funding

Architecture is not funded directly. Non-software core assets such as the formal process of the revising budget, are funded by the finance department of the organization. In order to justify adopting an SEI product line approach, a business case would need to be developed. In SEI's discussion of

product lines, customer satisfaction is an indirect result. SEI product lines allow for better quality software through emphasis on architecture. This better quality software then, leads to improved customer satisfaction. ME already has a fairly stable code base. Furthermore, to ensure quality in existing products, measures such as new configuration management software and processes, and quality assurance were adopted. A business case would need to show that a product line would lead to a faster development cycle and better quality code. These benefits would then need to be linked to improved customer satisfaction and lowering of operating costs due to better quality of software. Funding is currently at level 1 because ME's model is based on a per product basis.

The funding improvement opportunity level is assessed at 4. In order to move to a product line funding model the first step would be to develop a business case. Due to ME's current priority of customer satisfaction of existing products this would be difficult. At present there are no studies that directly link adopting a software product line to customer satisfaction for an organization with existing mature products. It is possible though that sometime in the future a correlation may be found, but this may take many years.

5.1.22 Launching and Institutionalizing

Choosing to adopt a product line approach for ME is not an obvious decision, as it was in the CelsiusTech [8] case study. There are arguments for and against it. Even if it turns out the product line approach is not right for ME, there are still practices that it can use to augment and improve the current effort. If ME wants to consider going forward with a product line approach, it should develop a set of product line goals and strategies. It needs to get a picture of where it currently is with respect to its product line maturity, and map a future direction. One tool suggested by SEI for launching a product line is the iterative IDEAL (Initiating, Diagnosing, Establishing, Acting and Learning) model. The IDEAL model consists of three cycles: IDEAL cycle 0: (concept exploration), IDEAL cycle 1 (concept and initial implementation) and IDEAL cycle 2 (furthering the implementation) [15]. Each cycle has different phases (Initiating, Diagnosing, Establishing, Acting and Learning). ME currently fits into the Diagnosing phase of IDEAL cycle 0. Launching and Institutionalizing is given a level of 2.

ME is assessed with an improvement opportunity level of 3 for this practice area. They can continue the diagnosing phase of IDEAL cycle 0 by exploring further the benefits of a product line approach. If the benefits are sufficiently compelling, the effort to move to a product line approach could be justified. ME can also develop a set of product line goals, objectives and strategies. Establishing a set of goals with appropriate rationale, will aid in the decision to move forward on a product line path. Finally, ME would need to develop some pilot projects to create a common suit of tools or core assets to learn more about technical and organizational product line issues.

5.1.23 Market Analysis

Most of the SEI specific practices for market analysis are already undertaken by ME. The market analysis is maintained and updated as the product line evolves. Marketing Analysis is used in business cases for considering the addition of new products to the line. Market Analysis is given a level of 4.

The improvement opportunity level is 5. ME could use its market analysis to obtain a first-order approximation of its product line's commonality and variability. This approximation may be used to

influence the architecture definition practice area. More difficult, ME could attempt a pilot project to try out core asset development. It could try to experiment with core asset development in order to produce prototypes faster. This would mitigate any risk should they move to a more aggressive marketing strategy, looking for new products to add to their product line. A moderate term move to software product lines would not be expensive if they plan now.

5.1.24 Operations

ME does not have a documented operational concept. An operational concept

- "describes the processes for fielding and maintaining the products from an operational perspective
- describes how the organizational units work together to execute these processes
- defines the role that acquisition will play and points to defined acquisition strategies and policies
- facilitates a common understanding among members of the organization as to how products are fielded and how the production capability is evolved and maintained
- serves as a baseline when the organization considers alternatives in its approach as warranted by changing conditions" [15].

An ME operating plan is the closest thing to such a document, but it does not discuss operations. Processes are documented at varying levels but not in a unified document. Operations is given a rank of 3.

The improvement opportunity level is assessed at 4 and would involve producing a product line concept of operations. In the future, if ME moves to product line development such a document will be useful. Producing the document as an exercise will help make explicit many of the considerations for adopting a product line. This will help to shape and identify what kind of processes and impact a product line strategy would have on the organization.

5.1.25 Organizational Planning

ME has tools and methods that influence organizational planning but nothing that explicitly defines the planning process or what typically constitutes a plan. Organizational plan dependencies currently are not hard to determine. Its Process Excellence, tools measure current process performance, analyzes them and implement changes to improve the current process. There is a culture of practicing Process Excellence within the organization day-to-day, however, there is no real measurement of how much it is practiced. Organizational Planning is at level 3. Process Excellence appears similar to SEI's improvement plans and it has identified and defined processes. However, Organizational Planning for product lines also depends on the outputs of other practice areas such as Launching and Institutionalizing, and Funding. The low maturity in those areas has brought down the current level to 3.

The improvement opportunity level is assessed at 4 because SPL adoption and funding plans could be created. This practice area will be more relevant to ME if they were to move closer to the SEI SPLP framework. In that case, it would raise some issues (like identifying dependencies), that may require additional considerations to the current organizational processes. If ME decides

in the future to move closer toward the SEI SPLP framework, they will need to develop a product line adoption plan and/or a core asset funding plan. A product line adoption plan will describe how to transition from the current way of doing things. Core asset funding plans are listed in SEI's Funding practice area. For example, "multiple projects banded together to share costs" and "taxing of participating projects" [15] would be radically different than current funding plans.

5.1.26 Organizational Risk Management

A strength of ME is that its small size allows for easy, open communication among its project units, the business unit and QA. For larger organizations, the SEI practices suggest that heavyweight processes have to be applied to facilitate communication. SEI defines seven principles of an effective risk management program: open communications, integrated management, teamwork, continuous process, forward-looking view, global perspective and shared product vision. They appear to be followed, albeit in a lightweight, non-formal manner. Since no core asset development is done, projects are not heavily interrelated. If more code assets are shared among products, ME may want to experiment with adding some formality from Team Risk Management [15] to their processes. Organizational Risk Management is ranked as 3.

The improvement opportunity level is 4. A relatively easy improvement for ME would be ensuring the developers and engineers know the "global perspective of success" and "shared product vision" [15]. A more difficult one would involve the use of Team Risk Management. If a core asset development team is created this could be applicable. Since product teams do not appear have many interdependencies Team Risk Management may be too heavyweight at the moment. If the product teams do become more interdependent, adopting some of its processes will be useful.

5.1.27 Structuring the Organization

ME's organizational structure is based on the business unit model. Products are clustered together by similarity into product families. There is some sharing of assets, such as libraries. The analysis and justification for the creation of a dedicated core asset team has not been undertaken and a return on investment analysis should be considered by ME. One possible benefit of the creation of a core asset team would be less duplication of effort. Structuring the Organization is ranked as 2.

An improvement opportunity level of 4 was given to this area. This would involve exploration of core asset candidates for sharing between the F1 team (code base 1) and Segment 7 team (code base 3). If ME decides to go the route of a core asset development it may want to consider the pros and cons of a core asset team. Some factors in this area are in favor of it and some are not. It may be worth exploring through a pilot project that creates a core asset team between the F1 and Segment 7 teams. The first step would be to establish potential core asset candidates and then weighing those against each of the factors in this practice area. There may be other opportunities as well with other subsidiaries of IC.

5.1.28 Technical Forecasting

Technical forecasting is done from a customer perspective. ME invests significant resources into customer solution forecasting; however, very few resources are put into internal development forecasting. For customer solutions, ME employs most of SEI's specific practices for technology fore-

casting. If developing architecture becomes a focus, a process for forecasting its evolution will need to be developed. Technical Forecasting is given a rank of 3 because it is practiced but on an individual product level.

This area is given an improvement opportunity level of 4. Assuming ME's architecture is to be handled more formally, a process for forecasting its direction will need to be developed.

5.1.29 Training

Training does take place within ME in various forms. Training is fairly informal and personalized for the individual trainee. If a product line approach was adopted, some training would have to take place. A new training plan may require

- "augmenting current training activities to support product lines
- replacing existing training activities
- adding new training activities" [15].

Training is practiced on an ad hoc basis so it is at level 2.

The improvement opportunity level is 4. If ME decides to pursue a software product line approach, even incrementally, training about product line concepts must be introduced.

5.1.30 Summary

A table that ranked the author's impression of the current state of a practice area, similar to Table 5.1, was not included in the final report [34] given to ME, because it was felt that could influence the results of an exit survey about practice area importance.

It was found that two practice areas were not applicable to this organization. Those areas were Customer Interface Management and Developing an Acquisition Strategy. Also there is no case study that is similar enough to ME's situation that provides clear justification of a product line approach. Although, there is no easy answer as to whether or not a product line approach is right for ME, there are several things ME can do to place itself in a better position for product line adoption in the future.

At present ME does not formally document commonality and variability, document component interfaces at a high level, perform formal architecture evaluations, provide training on product line practices and concepts, or encourage other product groups to consider product line approaches. During the interview phase of the study, the F2/F3 team also had not investigated or adopted a unit testing framework. These were recommend in the final report [34] as improvement opportunities ME can explore while transitioning to software product lines. Table 5.2 lists the difficulty level of the main improvement opportunities. The report recommend that the easy ones be done first followed by the moderate ones.

Reinforce importance of modular development

Modular development relates to the architecture definition (C2 I4, current level 2 and improvement opportunity level 4) and component development (C2 I3) practice areas. All the engineers interviewed said they already do this. However, it is difficult and sometimes impossible to do modular development with code base 1 because it has high coupling. Also sometimes when deadlines are

Improvement Opportunity	*Difficulty Level*
1. Reinforce importance of modular development	Easy
2. Investigate and adopt unit testing frameworks	Difficult
3. Architecture evaluations	Moderate
4. Documenting component interfaces at a high level	Difficult
5. Training on product line practices and concepts	Easy
6. Documenting commonality and variability	Moderate
7. Encouraging other product groups to consider product line approaches	Difficult

Table 5.2: Main Improvement Opportunities

close modular development may slip for shortcut solutions. When possible, more time should be spent ensuring new code is modular. Having modular code bases will ensure an easier transition to software product lines.

Investigate and adopt unit testing frameworks

This improvement opportunity is mainly for the F2/F3 team, because at the time of interviews they did not have a unit testing framework in place. The benefit of more testing will mean less bugs will creep into a market release. The related practice area is testing (C3 I4).

Architecture evaluations

Engineers interviewed indicated they wanted more time to do software architecture evaluations. The effort can be justified if the evaluations result in changes that enhance the code by making future modifications easier. This may be difficult to measure because many changes are directly related to domain knowledge by a third party. The benefits of early architecture evaluations during design will allow for earlier error correction and substantial savings. The related practice area is architecture evaluation (C2 I4).

A SAAM or ATAM exercise would take less than a week of ME's time and can be done during one of the down cycles. Doing this type of exercise may provide insight into whether it is worthwhile to move to a core asset based development approach. At least one employee would need to become familiar with SAAM or ATAM in order to "champion" the evaluation. Since there are more employees in the F1 line, a SAAM or ATAM exercise could first be conducted on the F2/F3 architecture. The F2/F3 line does not share core assets with the F1 line with the exception of one COTS component. Less employees would be needed to conduct the evaluation for the F2/F3 line compared to the F1 line. After performing the exercise once, ME will be in a good position to decide whether or not it was worthwhile.

Documenting component interfaces at a high level

The importance of documenting component interfaces is emphasized in the software system integration practice area (C2 I4). This form of documentation is more than just the syntactic interface of components. SEI suggests documenting the set of assumptions programmers can make about components. This includes "its behavior, the resources it consumes, how it acts in the face of an error, and other assumptions" [15]. This documentation would also be useful in training new developers and in assisting other product groups to see if ME has components that can be accessed.

Training on product line practices and concepts

The training practice area (C2 I4) provides some guidance on how to do provide background knowledge of software product lines to employees. Training staff about product lines will properly prepare them to give constructive feedback on software product lines and prepare them for a SPL adoption.

Documenting commonality and variability

Documenting commonality and variability is done in the architecture definition (C2 I4) and scoping (C1 I4) practice areas. This documentation would then be useful in the requirements engineering practice area (C2 I4) in determining product line requirements. This improvement opportunity is important in deciding whether or not to launch a software product line because it will help determine potential core assets. If there is enough commonality then that code could become a core asset. Benefits will also occur for training new employees, producing this documentation will identify common functionality and how to instantiate variability.

Encouraging other product groups to consider product line approaches

This opportunity encompasses all the previous ones. Product lines promote large scale reuse. This means if other divisions (for example ME, D2 and D3) adopt similar practices, ME will be able to easily see if they have assets they can use. Likewise other divisions will be able to see what assets ME has to offer. This related to the launching and institutionalizing practice area (C2 I3).

Other Improvement Opportunity Gaps

This section will look at the remaining practice areas with perceived opportunity gaps of two or three.

The building a business case practice area was given an assessment of C2 I4. This gap did not translate into a main improvement opportunity such as "make a business case to move to product lines." It would be extremely difficult to do this given ME's current goal of improved customer satisfaction of existing products. Documenting commonality and variability could be used in a business case to help justifying to move to product line practices so that opportunity is somewhat related.

The funding practice area had an assessment of C1 I4 but no main improvement opportunity materialized. From interviews, it was made clear that ME did not expect to get any additional funding to launch a product line. Because of this it proved difficult to recommend any practices based on the funding practice area. In the final report [34], the improvement opportunity listed was the building of a business case for adopting an SEI product line approach.

The structuring the organization area was assessed at C2 I4. A possible improvement opportunity for this area is "create a pilot project with a core asset team." A small pilot project to do this could be possible within ME. This would have been closer to making the list of main improvement opportunities compared to building a business case for product line adoption. It was omitted because the current culture of teams based on products seemed strong and implementing the other opportunities first would make a pilot of this nature easier.

5.2 Applicable Patterns

Several relevant SEI patterns for ME were identified: Curriculum, Essentials Coverage, Each Asset, Evolve Each Asset, Product Parts, Plowed Field and Cold Start. Curriculum and Essentials Coverage will be relevant for training personal in software product lines. Each Asset, Evolve Each Asset, Product Parts and Plowed Field focus on the creation of core assets which are key to an SEI product line architecture. Finally Cold Start provides some guidance how to launch, structure the organization and fund a product line effort.

The *Curriculum pattern* involves the process of learning about product lines. This pattern indicates that to train an employee one can assign them one or more of the three groups that is relevant to their skill set or interests: Software Engineering, Technical Management and/or Organizational Management.

The *Essentials Coverage pattern* splits up the 29 practice areas into the three essential activities and then lists the practice areas that apply to those three and their main subgroups

- Core Asset Development
  - Product Line Scope
  - Core Assets
  - Production Plan
- Product Development
  - Products
- Management
  - Technical Management
  - Organizational Management

ME does not do core asset development so some core asset development practice areas (for example architecture definition) are applied in ME's product development practices. If a product line approach is adopted then it is likely only one essential activity will be tackled at a time. This pattern would tell one what practice areas to focus on for that activity.

The *Each Asset pattern* is applicable, but after the decision to develop core assets and a product line scope is determined. Before applying this pattern, the product line's scope needs to be defined. Once the scope is defined, this pattern can be implemented by applying the appropriate practice areas. This pattern is evoked when a core asset is developed. "PA*" [14] denotes a variable practice area and is determined by the type of core asset being developed. For example, one would use Architecture Definition if the asset in development was the product line architecture. Other possible values for PA* are Component Development, Building a Business Case, and Requirements Engineering. By referring to the appropriate practice areas, the appropriate tools, work plan, attached processes, testing methods and other necessities are found and then utilized to develop the asset. The associated areas will also provide methods on how to collect data about the asset and its development and provide a measurement plan.

The *Evolve Each Asset pattern* is a variant of the Each Asset pattern, and is for evolving assets into the core asset base. It differs from Each Asset in that the focus is in changing assets, not developing new assets. This area would involve the Process Definition area because it would change

the attached process of an asset. This may be applicable, for example, if one of ME's code assets evolved into a core asset. Implementing this pattern would start with a commonality and variability analysis of the existing code bases.

The *Product Parts pattern* is a composite pattern consisting of practices and other patterns that should be used to develop the core assets that will be part of the products in the product line. There are four SPL practice patterns and seven practice areas that address the solution and provide the structure of the Product Parts pattern. Implementing this pattern would begin with the implementation of the Each Asset pattern for requirements. An Each Asset for architecture would then be required. A Make/Buy/Mine/Commission analysis would have to be done which could lead to several paths.

The *Plowed Field pattern* is a variant of Product Parts pattern. The difference is that existing core assets must be utilized. It is like Products Parts with the Developing An Acquisition Strategy area removed. Mining Existing Assets would be a key area of this pattern. Implementing this would require identifying commonality and variability of products. From this list code assets may be molded into core assets.

The *Cold Start pattern* applies to a company that wants to move to an SEI SPL from a non-SEI product line. This practice area outlines several practice areas to focus on when starting a product line. "The practice areas associated with the Cold Start pattern are

- Launching and Institutionalizing
- Funding
- Customer Interface Management
- Developing an Acquisition Strategy
- Operations
- Organizational Planning
- Organizational Risk Management
- Structuring the Organization
- Training" [14].

In terms of implementing this pattern, Customer Interface Management (CIM) and Developing an Acquisition Strategy (DAAS) probably do not need to be focused on as much. SEI's CIM is geared more toward low-volume, high-cost systems and currently ME does very little outsourcing so DAAS does not currently appear relevant. More training would need to take place on what SPL means to the staff. A pilot project with a core asset team could also take place. How to approach this would be addressed in the Launching and Institutionalizing, Funding, Operations, Organizational Planning, Organizational Risk Management and Structuring the Organization practice areas.

The newest pattern from SEI is the *Adoption Factory pattern*, a variant of the Factory pattern. "The *Adoption Factory* pattern provides a roadmap for phased, product line adoption" [12]. This pattern had not been published when the report for ME was submitted on August 4, 2004. If it had it may have been mentioned in the report [34] made for ME. Currently there are no publications that provide details about this pattern, but there was a tutorial on it at the Third Software Product Line Conference by Linda Northrop and Lawrence Jones. According to a post by "Linda Northrop" on the SoftwareProductLines.com [32] discussion board, the adoption factory pattern "will be described in

an upcoming SEI technical report ...and will also be covered in a new course the SEI is offering entitled Adopting Software Product Lines" [39]. The course will take place February 15-16, 2005 at SEI in Pittsburgh, Pennsylvania at an cost of $1800 (International) [11]. When more details of this pattern emerge it could be worth examining for application within ME.

5.3 New Pattern

Based on the SEI Pattern format, a new pattern, "Slow Start" was developed for a scenario similar to ME's. The Slow Start pattern is for organizations that want to better position themselves for product line adoption. This may sound similar to the Adoption Factory pattern, which "provides a roadmap for phased, product line adoption" [12]. *Slow Start is not a pattern for product line adoption, whereas* Adoption Factor is. Very little has been published about Adoption Factory, so we do not know for sure how similar it is to the Slow Start pattern. Adoption Factory is a variant of the Factory pattern, whereas Slow Start is not.

5.3.1 Slow Start Pattern

- **Name:** The Slow Start pattern consists of patterns and practices that should be focused on for organizations that want to transition to product lines. The organization will be producing products on an annual cycle and would like to determine if it should develop core assets for its products.
- **Example:** A company that produces a product(s) on a yearly cycle is unable to adopt a software product line approach immediately. This company has also merged with other companies and has similar products that do not share resources. Formal architecture evaluations have not taken place in the past. Resources such as extra staff and funding are not available and production cannot be halted for a SPL launching.
- **Context:** An organization is exploring improvement opportunities based on SEI's product line framework and the viability of adopting product line practices.
- **Problem:** To compare the current effort to SEI's ideal product line practices.
- **Solution:** The problem involves taking a snapshot of the organization's current practices and evaluating them with respect to SEI's model. SEI's Curriculum Pattern provides a basis to the background knowledge for this pattern. A review takes place to determine the current maturity of several practice areas. The outcome of this review is a report that shows what practice areas will provide guidance on better positioning the organization to adopt software product lines.
- **Static:** The pattern involved for the Slow Start pattern is
  - Curriculum Pattern

  The following practice areas are used in the Slow Start pattern
  - Architecture Definition
  - Architecture Evaluation
  - Software System Integration
  - Requirements Engineering
  - Testing

- Scoping
- Launching and Institutionalizing
- Training

- **Dynamics:** Figure 5.1 shows how the practice areas contribute to the solution of this pattern.
  - The Curriculum pattern provides the basis for this pattern by providing the background knowledge.
  - Launching and Institutionalizing provides methods to investigate the feasibility of adopting the SPL framework.
  - Scoping defines the scope of the SPL.
  - Requirements Engineering will define product line requirements.
  - Training provides knowledge to staff about SPL practices.
  - Architecture Definition practices define the architecture of the SPL.
  - Architecture Evaluation provides methods to evaluate the architecture.
  - Software System Integration practices define the component interfaces.
  - Testing defines how to test assets of the SPL.

- **Application:** Applying the Curriculum pattern may be done concurrently with the practices of Launching and Institutionalizing. Some of the specific practices like the Product Line Technical Probe may be used to determine the organizations readiness to adopt. The information determined from this can be used to guide training and determining the product line's scope. From the scope, detailed requirements are made. This will lead to defining the architecture. While defining the architecture, interfaces can be specified through the practices of software system integration. Intermediate architecture evaluations should also take place while the product line architecture is being defined. Based on the information from the previous practices testing strategies can then be defined.
- **Variants:** None.
- **Consequences:** This pattern assumes an organization can gradually transition to software product lines. The payoffs will not be immediate because of the slow pace of launching. The key benefit is that the organization will be better able to adopt full software product line practices if it gets an opportunity to.

5.3.2 Future Work

The slow start pattern was not been applied at ME so it currently is perspective, but not tested. It could be applied to an organization to measure its effectiveness. Slow start is applicable to exploring all 29 practice areas. A possible variant could be a targeted slow start pattern, where several important practice areas are identified and focused on.

5.4 Practice Area Maturity Survey

After the findings of the study were presented to the staff they were asked to redo an updated practice area survey like the one from January 19, 2004. A version of this self-assessment survey is shown in

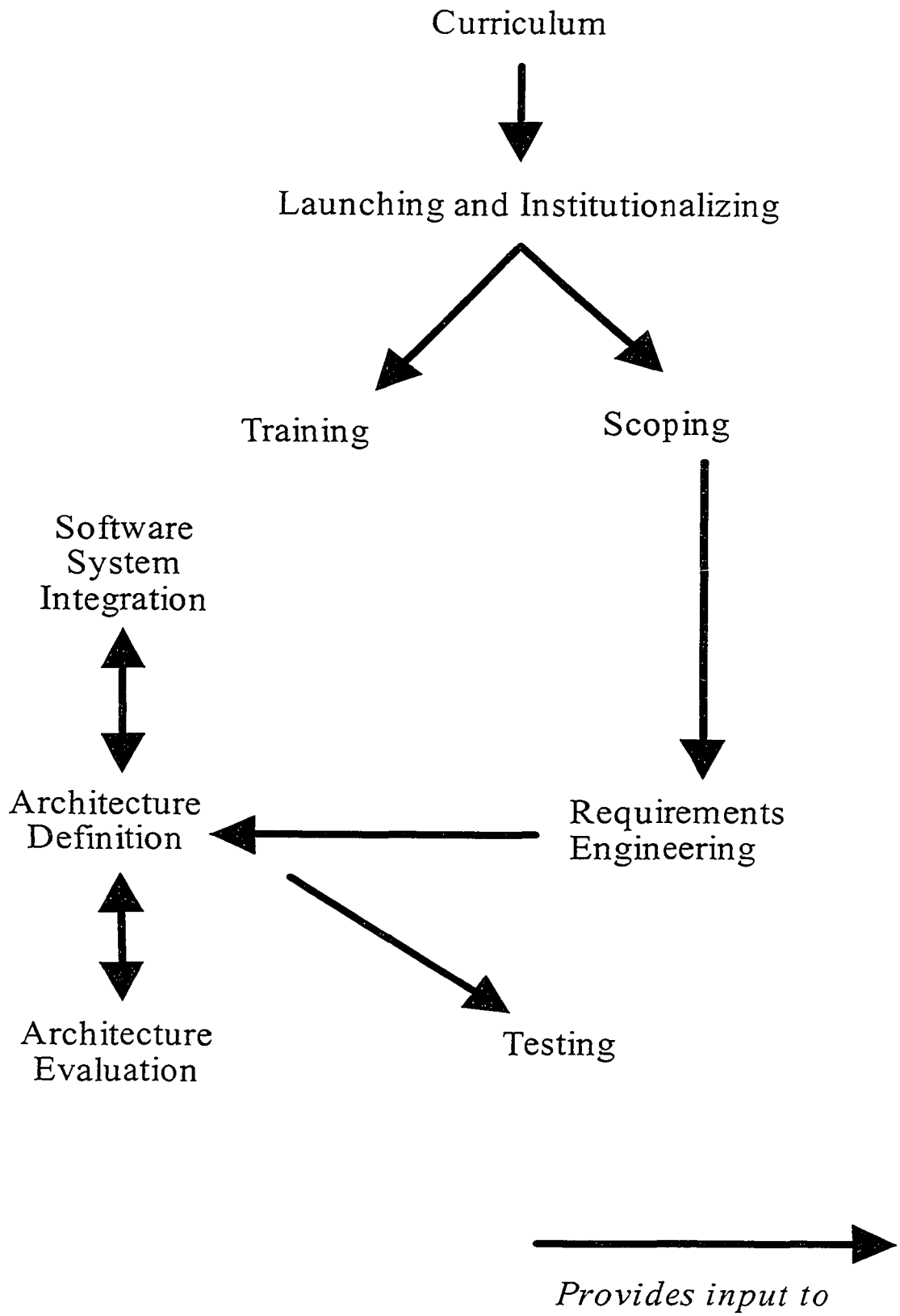


Figure 5.1: *Dynamic Structure of the Slow Start Pattern*

Figure 5.2. (Note this version has one very minor change from the actual in order to hide the identity of ME.) The results of the 13 participants answering the survey are in Table 5.3 and Table 5.4.

The survey results has also been compared to the author's assessment from Table 5.1. Figure 5.3 shows the author's current levels with those of the survey respondents. Figure 5.4 is the improvement opportunity comparison. Finally Figure 5.5 shows a comparison of the author's and respondents' gaps. Gaps were determined by subtracting the current level from the improvement opportunity level. The practice areas that were the most similar (within 1 level in all three categories) are

- 1. Architecture Definition
- 2. Architecture Evaluation
- 4. Commercial Off-The-Shelf Utilization
- 6. Requirements Engineering
- 7. Software System Integration
- 8. Testing
- 9. Understanding Relevant Domains
- 10. Configuration Management
- 11. Data Collection, Metrics, and Tracking
- 12. Make/Buy/Mine/Commission Analysis
- 13. Process Definition
- 17. Tool Support
- 22. Launching and Institutionalizing
- 24. Operations
- 25. Organizational Planning
- 26. Organizational Risk Management
- 27. Structuring the Organization
- 28. Technology Forecasting
- 29. Training

The remaining practice areas with a category that has a gap of at least one, will be further discussed in the remainder of this section.

5.4.1 3. Component Development

For Component Development 12 ME respondents chose a current level and only eight an improvement opportunity level. The author's current level was 2 and the respondents current level was 3.08. The author's level was lower because it was with respect to product line component development. In terms of product-centric development component development is practiced by the company in a consistent fashion which could explain the higher rating. New components are designed to be modular, however this was not the case in the past. The improvement opportunity level is practically the same. The gap difference is high because of the previously mentioned discrepancy in the current levels.

Practice Area	1	2	3	4	5
Software Engineering Practice Areas					
1. Architecture Definition					
2. Architecture Evaluation					
3. Component Development					
4. Commercial Off-The-Shelf Utilization					
5. Mining Existing Assets					
6. Requirements Engineering					
7. Software System Integration					
8. Testing					
9. *Understanding Relevant Domains*					
Technical Management Practice Areas					
10. Configuration Management					
11. Data Collection, Metrics, and Tracking					
12. Make/Buy/Mine/Commission Analysis					
13. Process Definition					
14. Scoping					
15. Technical Planning					
16. Technical Risk Management					
17. Tool Support					
Organizational Management Practice Areas					
18. Building a Business Case					
19. Customer Interface Management					
20. Developing an Acquisition Strategy					
21. Funding					
22. Launching and Institutionalizing					
23. Market Analysis					
24. Operations					
25. Organizational Planning					
26. Organizational Risk Management					
27. Structuring the Organization					
28. Technology Forecasting					
29. Training					

29 Practice Areas Questionnaire

For Internal Distribution Only

Name:

Job Title:

Please rank the following practice areas by indicating the value that is most appropriate.

For where the company is now, write an "N".
For where you think the company should or could be, place a checkmark in the box. If you have no opinion you may leave the box blank.

Legend

- 1: Not practiced at our company at this time and unlikely to be practiced in the future.
- 2: Is practiced by ad hoc on an as needed basis.
- 3: Is routinely practice by the company but not well understood.
- 4: Is practiced by the company in a consistent fashion but often adapted.
- 5: Most mature level of practice. This area is considered to be critical and important. (for example, there is training in this area.)

If at all possible please send the completed form back by Thursday September 30, 2004.

Figure 5.2: *Exit Practice Area Maturity Survey*

Rank	*Average Actual Importance*		*Average Desired Importance*		*Average Difference*	
	Practice Area	*Value*	*Practice Area*	*Value*	*Practice Area*	*Value*
1	9. Understanding Relevant Domains	3.67	8. Testing	4.86	2. Architecture Evaluation	2.18
2	10. Configuration Management	3.55	23. Market Analysis	4.43	1. Architecture Definition	2.11
3	8. Testing	3.50	10. Configuration Management	4.38	28. Technology Forecasting	1.84
4	11. Data Collection, Metrics, and Tracking	3.20	16. Technical Risk Management	4.38	29. Training	1.78
5	13. Process Definition	3.18	18. Building a Business Case	4.38	26. Organizational Risk Management	1.69
6	15. Technical Planning	3.09	11. Data Collection, Metrics, and Tracking	4.29	16. Technical Risk Management	1.56
7	3. Component Development	3.08	28. Technology Forecasting	4.29	18. Building a Business Case	1.49
8	23. Market Analysis	3.00	1. Architecture Definition	4.27	6. Requirements Engineering	1.43
9	24. Operations	3.00	3. Component Development	4.25	23. Market Analysis	1.43
10	25. Organizational Planning	3.00	6. Requirements Engineering	4.25	8. Testing	1.36
11	7. Software System Integration	2.91	13. Process Definition	4.25	14. Scoping	1.31
12	14. Scoping	2.91	26. Organizational Risk Management	4.25	19. Customer Interface Management	1.22
13	18. Building a Business Case	2.89	9. Understanding Relevant Domains	4.22	7. Software System Integration	1.22
14	27. Structuring the Organization	2.89	14. Scoping	4.22	3. Component Development	1.17
15	5. Mining Existing Assets	2.83	2. Architecture Evaluation	4.18	5. Mining Existing Assets	1.17
16	6. Requirements Engineering	2.82	24. Operations	4.14	17. Tool Support	1.16
17	16. Technical Risk Management	2.82	7. Software System Integration	4.13	21. Funding	1.15
18	19. Customer Interface Management	2.78	5. Mining Existing Assets	4.00	24. Operations	1.14
19	4. Commercial Off-The-Shelf Utilization	2.75	15. Technical Planning	4.00	27. Structuring the Organization	1.11

Table 5.3: Practice Area Importance Rank 1 to 19

Rank	*Average Actual Importance*		*Average Desired Importance*		*Average Difference*	
	Practice Area	*Value*	*Practice Area*	*Value*	*Practice Area*	*Value*
20	17. Tool Support	2.73	19. Customer Interface Management	4.00	11. Data Collection, Metrics, and Tracking	1.09
21	22. Launching and Institutionalizing	2.67	25. Organizational Planning	4.00	22. Launching and Institutionalizing	1.08
22	12. Make/Buy/Mine/ Commission Analysis	2.64	27. Structuring the Organization	4.00	13. Process Definition	1.07
23	26. Organizational Risk Management	2.56	29. Training	4.00	25. Organizational Planning	1.00
24	28. Technology Forecasting	2.44	17. Tool Support	3.89	12. Make/Buy/Mine/ Commission Analysis	0.92
25	20. Developing an Acquisition Strategy	2.43	22. Launching and Institutionalizing	3.75	15. Technical Planning	0.91
26	21. Funding	2.22	12. Make/Buy/Mine/ Commission Analysis	3.56	20. Developing an Acquisition Strategy	0.90
27	29. Training	2.22	4. Commercial Off-The-Shelf Utilization	3.44	10. Configuration Management	0.83
28	1. Architecture Definition	2.17	21. Funding	3.38	4. Commercial Off-The-Shelf Utilization	0.69
29	2. Architecture Evaluation	2.00	20. Developing an Acquisition Strategy	3.33	9. Understanding Relevant Domains	0.56

Table 5.4: Practice Area Importance Rank 20 to 29

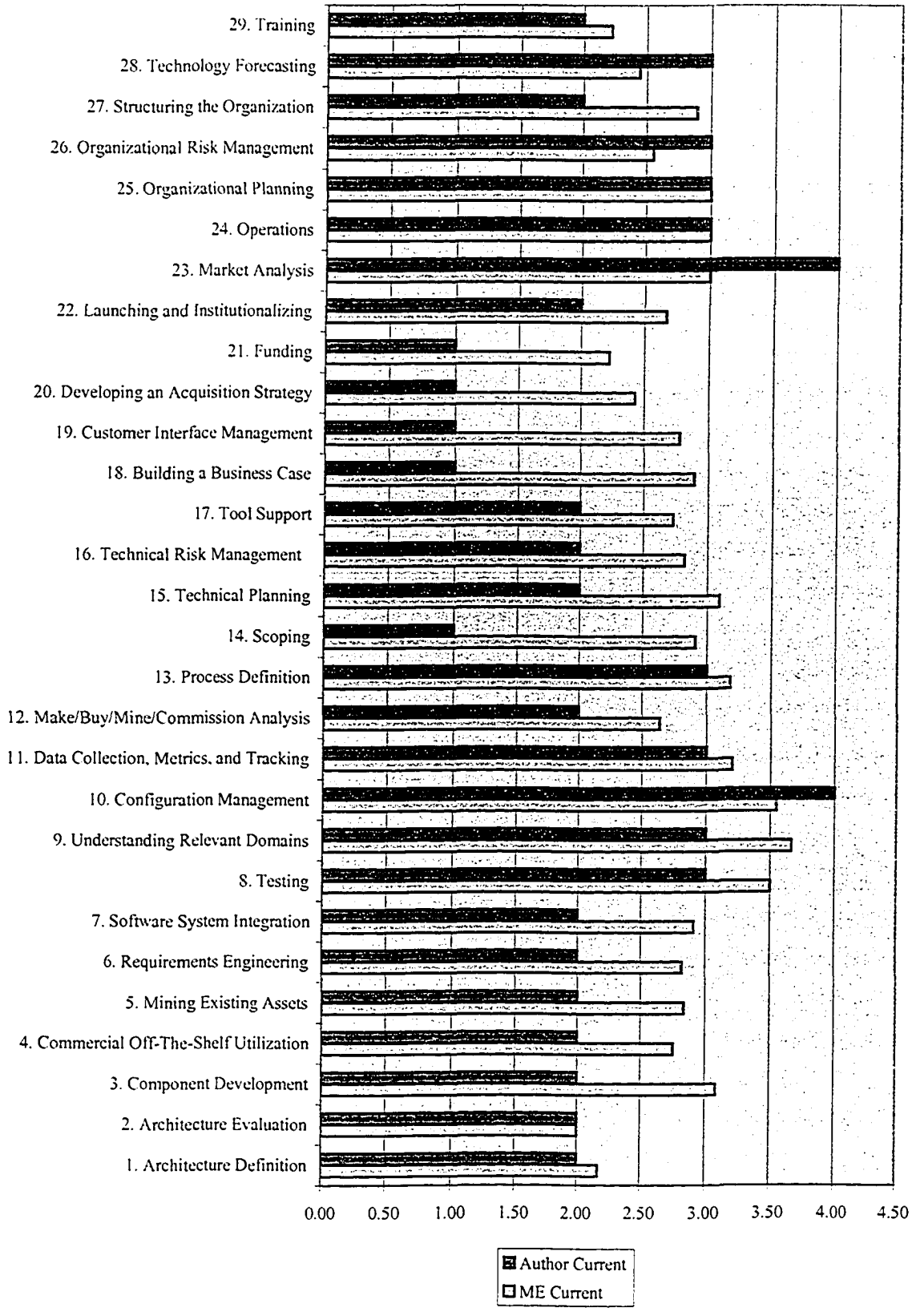


Figure 5.3: *Author and ME Respondents' Current Level Assessment*

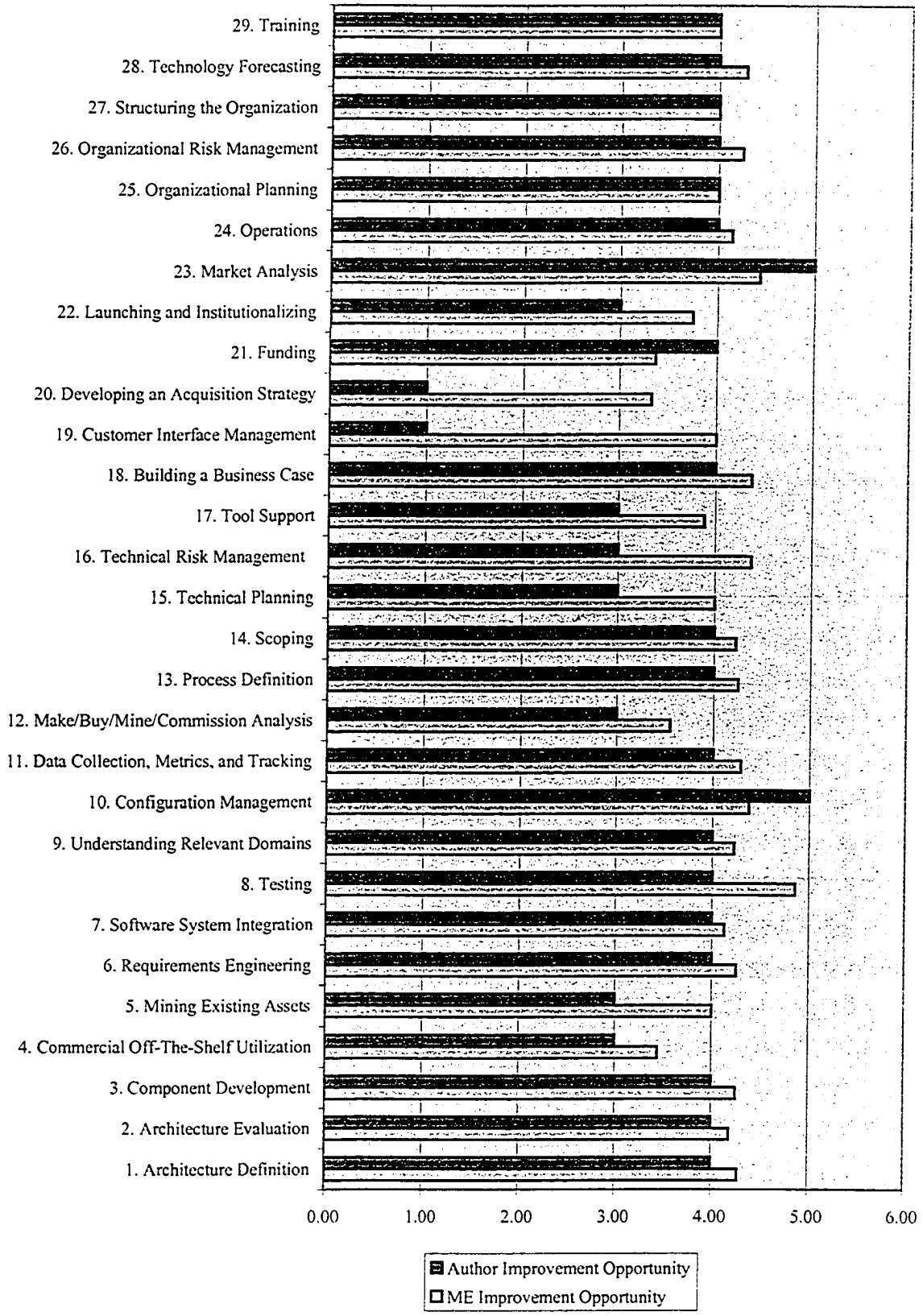


Figure 5.4: *Author and ME Respondents' Improvement Opportunity Level Assessment*

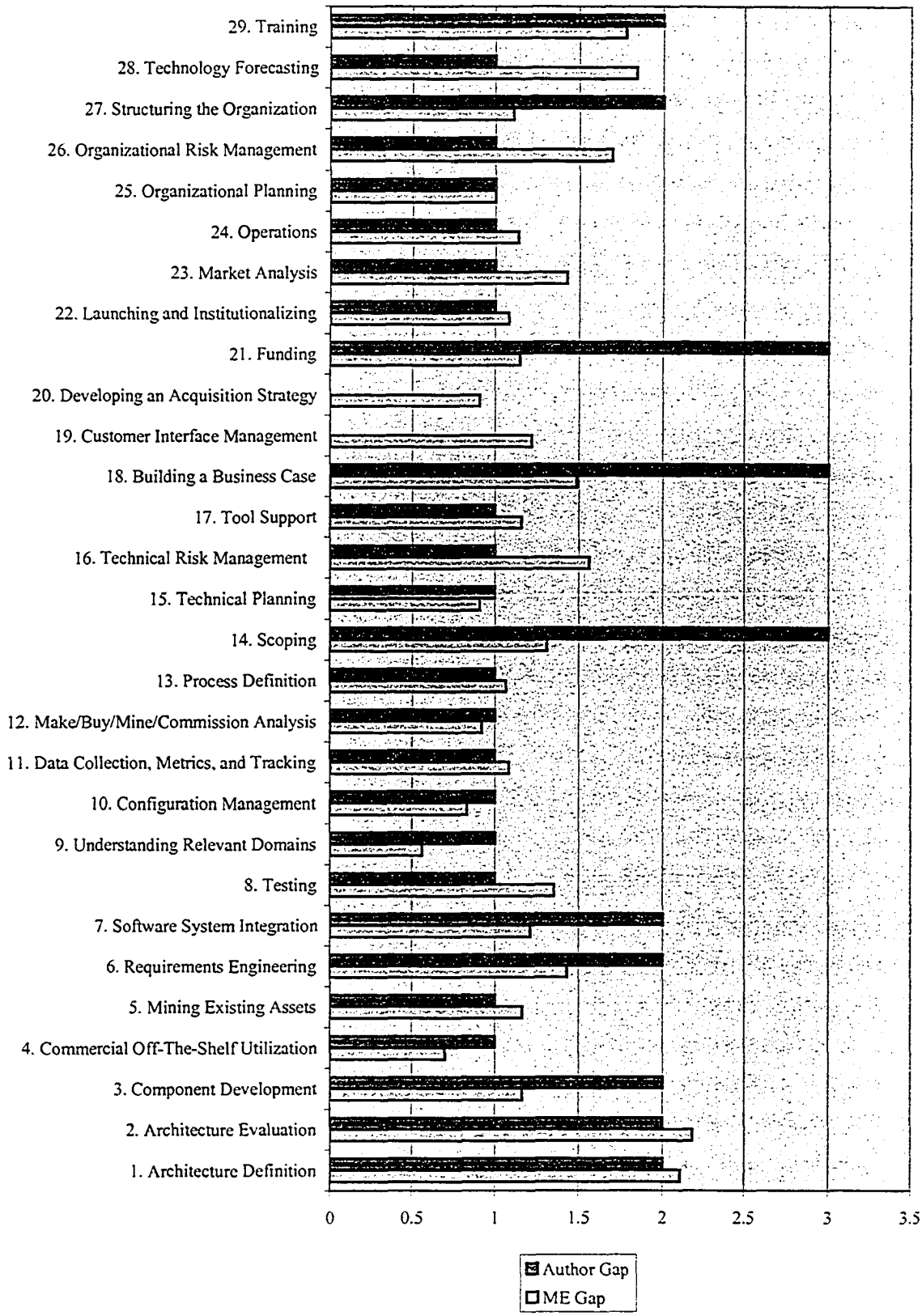


Figure 5.5: *Author and ME Respondents' Improvement Opportunity Gaps*

5.4.2 5. Mining Existing Assets

This area had 12 ME respondents choose a current level and eight, an improvement opportunity level. The author chose 2 for the current level and the respondents average was 2.83. The author's choice was lower because mining had not been done for core assets of a product line. Mining typically was done just for individual products. Also from interviews mining was done on an ad hoc basis and no tools were involved. For example, no clone detection software such as CloneDR [14] is used by ME. The improvement opportunity level was rated by the author as 3 because he did not feel the opportunities recommended were as high as level 4. A higher level would be suggested if ME was committed to pursuing product line development. The improvement opportunity gap value of the author and the respondents, however, is very close.

5.4.3 14. Scoping

Eleven ME respondents rated the current level and nine the improvement opportunity level. The author rated the current scoping level at 1 and the respondent average was 2.91. ME has no documentation regarding its product line scope. High-level scoping definition documentation exists in the marketing literature; however, there is no subsystem level scoping documentation. Current documentation does not describe which subsystems will interact. There is also no single scope definition document. There is a general idea of a product's scope among the interviewees, which could explain the higher current rating given. The improvement opportunity levels are very close and the gap difference is due to the previously mentioned difference, in current level assessment.

5.4.4 15. Technical Planning

There were 11 respondents for the current level and nine for the improvement opportunity level. The author rated the current level at 2 and the respondents' average was 3.09. The difference could be explained in the way this area was rated by the author. In terms of SPLs, there are no reuse plans created. Since core asset development is not done in ME they do not have core asset development and maintenance work plans, or production/reuse plans. ME's plans are made per product, not for shared core assets. Development and QA plans are the only ones that have dependencies. The planning performed by ME is not mature for a product line, but it is mature for product-centric development. Again as stated in Section 5.4.2, the differences in the improvement opportunity levels are because the author feels his suggestions will bring the organization to level 3. The improvement opportunity gap however, remains very close.

5.4.5 16. Technical Risk Management

Eleven ME respondents selected a current level and eight, an improvement opportunity level. The author chose 2 for the current level and the respondents' average was 2.82. This author chose a lower level because a product line effort is not underway. Risks are also managed informally. For the improvement opportunity level the author chose 3 and the respondents' average was 4.38. Again, as in the previous section, the author feels his suggestions will bring the organization to level 3. Until ME makes a commitment to software product lines, it does not seem a higher level will provide much benefit in this area. This is because the products do not have many interdependencies

with each other so there is less risk of one affecting the other. The improvement opportunity gap values are close.

5.4.6 18. Building a Business Case

This area had nine respondents select a current level and eight, an improvement opportunity level. The author assigned 1 for the current level and the respondents' average was 2.89. ME has never made a business case for product line adoption or to adopt any of the 29 SEI practice areas so this is why the author assessed the current level as 1. The higher respondent assessment could be due to the business cases already made on a per product basis. There are processes in place for creation of these. The improvement opportunity levels were very close. The gap differences are a result of the current assessment differences.

5.4.7 19. Customer Interface Management

From interviews conducted some respondents of the first survey shown in Figure 4.5 indicated they thought "Customer Interface Management" meant user-interface design. This area had nine respondents select a current level and eight, an improvement opportunity level. The author chose 1 for the current level and 1 for the improvement opportunity level. The respondents chose 2.78 for the current level and 4.00 for the improvement opportunity level. It is possible ME respondents did not understand this practice area. SEI's Customer Interface Management practices are more geared toward organizations that produce customized systems (low volume, high cost). ME does not do this so this area provided them with no improvement opportunities.

5.4.8 20. Developing an Acquisition Strategy

To at least one respondent, the title of this practice area suggested the practice of buying or merging with another company. This area is actually about dealing with contractors. Seven respondents chose a current level and six, an improvement opportunity level. The low response rate indicates many respondents did not take the time to understand fully this area. ME performs very little contracting so this area does not offer any improvement opportunities. Because of this the author rated its current and improvement opportunity levels 1. ME respondents chose 2.43 for the current level and 3.33 for the desired level. This area could provide guidance if the division does more outsourcing, but right now it does not present any improvement opportunities.

5.4.9 21. Funding

Nine ME respondents chose a current level and eight chose an improvement opportunity level. The author chose a current level of 1 and the ME respondent average was 2.22. The author's level was low because the fiscal infrastructure was product-centric. For example there was no "direct funding" [15] from an ME program or sponsor, or a discretionary fund for product line efforts. The improvement opportunity levels chosen by the author and ME respondents were close. The gap difference was due to the current level assessment difference.

5.4.10 23. Market Analysis

Eight ME respondents selected a current level and seven chose an improvement opportunity level. This is a rare assessment case, in that the author chose a higher current maturity level than the ME respondent average. The author assessed the current maturity at 4 and the average ME respondent level was 3.00. The reason for the difference is that the market analysis maturity may not be known to the engineers. It could also be due to disruptive technologies. ME performs pilot projects where products are released into market to see how it reacts. Not a lot of analysis can be performed on disruptive technologies, so it is felt that a product should be released and then have its market performance analyzed. For example a new product may only be sold in two cities and then analyzed to see how it performs before being released to a larger market. ME may also release products into the market even if there is no or little profit just to increase their market share. Most of the specific practices in the SEI framework are practiced. Information sources have been identified (such as call center reports, newspapers and magazines, focus groups, and surveys), information is gathered from customer contact (such as surveys, direct observation and call center calls), customer segments have been identified, and the competition is examined. One difference is that instead of mapping products to customer segments, it is the segments that drive the development of the product. The customer segments are determined beforehand and they influence what features go into a product. An improvement opportunity level of 5 was given by the author and the respondent average was 4.43. The improvement opportunity gap values were close.

5.5 Anonymous Study Survey Results

An anonymous survey was given to the study participants and 13 responded. The questions and qualitative answers of the survey are given in Appendix C. The results of the survey's quantitative questions are in Table 5.5. "Survey #" is a number assigned to the survey. "Area" is the area the respondent worked in. There options were "Software Engineering", "Management" or "Both". "Presentation" is a value from 1 to 5 of the usefulness of the presentation given by William Luthi on the study's findings. The options were 1) not useful, 2) somewhat useful, 3) useful, 4) very useful and 5) extremely useful. Blank entries mean the respondent did not rate the presentation because they did not attend it. "Report" is a value from 1 to 5 that rates the usefulness of the report. The options for each value for report usefulness were the same as the presentation's. "Interview" is a value from 1 to 5 of the respondent's interview experience with William Luthi. The options were 1) very poor, 2) poor, 3) neutral, 4) very good and 5) excellent. The second to last row in the table contains the average values for the presentation, report and interview ratings. Finally, the last row is a count of the number of respondents that rated the presentation, report and interview.

An analysis was performed on the remaining qualitative questions and answers of the anonymous survey not shown in Table 5.5. Table 5.6 classifies the answers from questions 3 to 6, 8 to 10, 12 to 16 and the responses from the "Additional Comments" section. The classification was

- 2: Very Positive Response
- 1: Positive Response
- 0: Neutral Response
- -1: Critical Response

Survey #	*Area*	*Presentation*	*Report*	*Interview*
1	Software Engineering	3	2	3
2	Software Engineering		3.5	3.5
3	Software Engineering	2	4	4
4	Management	4	4	4
5	Software Engineering	2	2	3
6	Software Engineering	3	4	3
7	Both		3	4
8	Management	4	4	3
9	Software Engineering		2	4
10	Both		3	4
11	Software Engineering	2	3	4
12	Software Engineering		4	4
13	Both	2		3
Average		2.75	3.21	3.58
Count		8	12	13

Table 5.5: Anonymous Survey Results

- -2: Very Critical Response

Question three was about inaccuracies in the presentation. Survey 3 provided a neutral response in that the respondent did not know enough about the subject matter to comment. Survey 4, felt the author assumed F1 engineers used their unit testing software "extensively/effectively" just because they had it. This probably was the impression given in the presentation because there was not a lot of time to go into a lot of depth about each practice area. In the testing chapter of the final report, however; it does list developing a set of unit testing standards as an improvement opportunity. Survey 6 indicated they found no inaccuracies. The overall rating for this question is neutral.

Question four was about things the presentation missed. Survey 3 wanted more background information and perhaps a handout that described SEI's patterns. Survey 6 indicated anything missed was covered in the report. Finally, survey 8 found the presentation long and not interesting. There were two presentations given that day. One on the 29 practice areas and their improvement opportunity recommendations and one on applicable patterns for ME, each one hour. The author does not feel either presentation could be shortened. There is a lot of material each has to cover. Overall respondents indicated the presentation missed something.

The fifth question asked if the respondents had any questions after seeing the presentation. Survey 3 wanted more information on patterns. Somewhat similar, survey 4 found the pattern presentation hard to follow. The author recommends reading the chapter on patterns in the book *Software Product Lines: Practices and Patterns* [14] to gain a better insight. Survey 6 only had questions for his or her supervisors and survey 8 had no questions.

Question six asked what areas of the final report were read. Only one survey respondent, 13, chose not to provide a comment. Reading all or most of the report was considered a very positive response. At least five practice areas was considered a positive response and less than five practice areas or skimming the report was considered a neutral response. Two respondents read most of the report, seven read at least five practice area chapters and three read less than five practice area chapters.

Survey	*Anonymous Survey Question*												
	3	*4*	*5*	*6*	*8*	*9*	*10*	*12*	*13*	*14*	*15*	*16*	*Additional Comments*
1				1		2	0				2	1	
2				0	0	0	0	0	-1	-1	0	0	-1
3	0	-1	0	0	-1	1	1		1	1	1	0	
4	-1		-1	2			1	0		0	1	1	
5				1	-1	-2					1	1	
6	1	0	0	2	0		1	-1	-1	-1	2	1	1
7				1	1	1		1	0	-1	1	1	
8		-1		1									
9				0	0	-1		-1			1	0	
10				1	0	-1	1		0	-1	-2	1	
11				1					2		1	1	
12				1						-1	2	2	
13			0					2			-2	-2	
Average	0.00	-0.67	-0.25	0.67	0.00	0.00	0.67	0.17	0.17	-0.57	0.67	0.58	0.00
Count	3	3	4	12	8	7	6	6	6	7	12	12	2

Table 5.6: Anonymous Survey Qualitative Feedback Classifications

The eighth question asked respondents to describe any inaccuracies in the report. Overall respondents did indicate there were some inaccuracies in the report. The listed ones included the improvement opportunities, the difficulty of improvement opportunities, the interpretations of ME practices from interviews, information about one software program used by ME, spelling, grammar and terminology. However, there were no inaccuracies listed about the comparison of ME's practices to SEI's. Overall though, respondents felt there were very few inaccuracies.

Question nine asked respondents to describe what the report missed. Four respondents felt it did not miss anything, but there were three that did. Survey 5's respondent felt "the study focused on the F1, F2, and F3 products" and paid little attention to F4 and F5 products. He or she felt it was the F4 and F5 products that could lead to a product line. SEI places an emphasis on reuse through core assets. In effect, to have a product line a company must have core assets that can be used in products. The F4 and F5 products could contain product specific code that can be mined into a core asset. However, ME's current priority is improved customer satisfaction for the F1, F2 and F3 products. Those three families currently generate the most revenue for ME. F5's P2 is not produced on a annual basis unlike the products of F1, F2, and F3. There is no future development planned for the F5 code base. F4 was also released for the first time this year; it may too become an annual product, but this was not yet known during the time of the study. F4's product P1B1 was a branch of F1's product P1. Most of the current development effort is spent on the F1, F2 and F3 products so the improvement opportunities were directed toward the development of those products. Product line development will likely be a result of changes to the practices of developing the F1, F2 and F3 products rather than mining core assets from F4 and F5.

Another respondent for question nine, indicated P1P3's architecture was evaluated more than once. In the report the author did indicate the P1P3 team had two weeks to informally evaluate their architecture this year but he did not indicate evaluations occurred "almost every year". Survey 10's respondent wanted an evaluation of the success related to the acquisition of code base 2 and F2. That appeared to be beyond the scope of the report. Also SEI's framework does not provide guidance or any specific practices for buying or merging with other companies. "Merging and Acquiring" could make an interesting candidate for addition to the 29 existing practice areas. There is presently no guidance how to incorporate an acquired company into an existing product line effort. A merge pattern could also be developed as a variant of the In Motion pattern.

Question 10 asked respondents if they had any questions after reading the report. Surveys 1, 2 and 4 had questions directed at ME management. Survey 2 had an additional question about the "applicability and desirability of the various recommendations". The author provided a roadmap of what he felt were the main recommendations. The author feels these main recommendations will allow ME to better position itself for future SPL adoption, so they are the most desirable. Survey 3 was more of a comment, where the respondent indicated an interest in learning more about SEI practices. Surveys 6 and 10 had no questions. Overall responses were considered positive.

The twelfth question asked for comments regarding the respondents' interview experience. The survey 2 respondent referred to his or her interview experience as "mechanical". All interviews required a set of questions, and the author went through the ones he thought were applicable. Doing interviews without question sets could have resulted in the author forgetting to ask something important. The survey 4 respondent felt the author had opportunities to ask "some follow-up/probing questions" but just stuck to the ones on his sheet. For later interviews the author had previous

answers of other practice areas. Because the author had more knowledge, he may have felt "follow-up/probing" questions were not necessary. Survey 6, indicted the flow was hampered by the author having to write down answers and suggested the use of a tape recorder. Use of a tape recorder was discussed early on in the study with Paul Sorenson. It was felt that some interviewees could be more guarded on what they say if they were being recorded on tape, so it was decided to hand record interviews. Survey 7 indicated the author did a good job capturing information. The respondent of survey 13 indicated he or she had a positive interview experience.

Question 13 asked respondents for comments about the interviews they participated in. Survey 2, again expanded on their comments from Question 12, indicating the interviews could have been more "dynamic". Survey 3's comments were positive. The survey 6 respondent wanted to see the questions before the interview. During the interview scheduling, only one person requested to see the questions beforehand. If asked, the author would have provided the questions prior to an interview. Survey 10 indicated there were few interviews for non-technical employees. This statement is true, in that there were 38 software engineering practice area interviews, 18 for technical management and 15 for organizational management. The software engineering and technical management areas on average contain more information (such as specific practices), than the organizational management areas. Survey 11 had a positive comment.

The fourteenth question ask how the study could be improved. Survey 2's respondent indicated the study was too long resulting in loss of interest. The respondent also commented that the report's long length meant it would take a lot of effort to follow-up on. Survey 3 found the study "interesting and useful". Survey 4 suggested having an ME employee partner with the analyst (the author in this case). He or she suggested this would allow for more in-depth and conclusive analysis. Also, an employee would be "left behind to carry the torch". The only possible side effect of the recommendation is the ME employee could bias the findings. Survey 7 suggested a longer executive summary of five to ten pages, "instead of slightly more than one page". The final report [34] was 157 pages. Survey 10 also indicated that the questions should be better adapted given the interviewee's technical background. Survey 12, repeated the survey 6 respondent's question 12 suggestion of using a tape recorder.

From the answers to question 15 it was found eight of the respondents would participated in a similar study conducted at ME in the future. Two respondents indicated their future position would be conditional, and two indicated they would not participate.

Question 16 revealed ten of the respondents were satisfied with the findings of the study. One was "somewhat" satisfied. Survey 13 was unsatisfied because the findings did not add value to his or her role. It is unfortunate, the latter respondent did not find the study added value to their role. However, his or her participation in the study very likely added value to the final report nonetheless.

One respondent provided a positive additional comment and survey 2 provided two critical comments. Survey 2 suggested streamlining the process, which will be discussed later in Section 5.8. Survey 2 also suggests providing a shorter version of the report. This comment is similar to survey 13's recommendation for improvement. Survey 13 suggested having a longer executive summary. Given the amount read by respondents as indicated in the sixth question, a longer executive summary would be written if the study were repeated.

5.6 Hours Spent on the Study

On April 12, 2004 William Luthi began to record the hours he was spending on the study related to producing the final report and presentation for ME. Each entry was later classified as a "One Time" or a "General" activity. A one time activity is one that would not be repeated if the assessment was done again. For example, creation of a template question set, time spent reading about a practice area or a non-steering committee meeting with Paul Sorenson and John Shillington about the direction of the study. General activities include report writing, interviews and steering committee meetings with ME members.

The study hours are presented in Table 5.7 and the time log is given in Appendix D. Statistics are computed for eight different 2004 time periods. Because logging of activities did not begin until April 12, 2004, the hours from January 7 to April 11 had to be estimated. This was done through examination of emails, meeting notes, progress reports, documentation revision history and Onware Groups groupware [40]. The Software Engineering Research Laboratory (SERL) has a website [49] that is run on Onware Groups and this was used by the author. Data was recorded there in "Events", "Discussion Groups" and "Repository" version histories.

In Table 5.7 "Total Hours" is the number of hours logged for the given time period. "Period Length (Days)" is the length of the time period. "Average Hours Per Day" is the average number of total hours spend per day working for the given time period. "One Time Activity (Hours)" are the hours spend on one time activities. "One Time Activity (%)" is a percentage with respect to total hours. "General Activity (Hours)" are the hours spend on general activities and "General Activity (%)" is the percentage of with respect to total hours.

"Research or Preparation" involves activities such as reading and preparing for presentations such as the one on January 19, 2004. "Interview Preparation" consists of creation of interview templates, updating interview templates, typing up interviewee answers, and creation of tables (tools, metrics) and diagrams (marketing variability product diagram) that were shown to interviewees for feedback. "Interviews" are the time taken to do an interview or to email questions. "Interview Scheduling" is scheduling specific to interviews. "Scheduling" is general scheduling for steering committee meetings, meetings with John Shillington and/or Paul Sorenson, and updates to the review's Gantt chart. "Analysis" is time spent analyzing data through discussion, data analysis (spreadsheets), and reading email or notes. "Writing" includes time taken to make the practice area importance survey report, practice area reports and the final report. "Feedback" is the time feedback was given verbally to author by steering committee members. "Rewriting" is acting on verbal or written feedback by updating reports, diagrams or appendices. "Miscellaneous" involves other activities that do not fit within the previous ones. For example,

- updating the time log,
- dealing with accounts, hardware and software problems and issues,
- non-interview meetings,
- creation and updating of surveys,
- typing up of meeting notes and agendas,
- progress Reports,
- requests for documentation,

	2004 Time Periods							
	January 7 to August 4	*January 7 to February 11*	*February 12 to March 11*	*March 12 to April 11*	*April 12 to May 11*	*May 12 to June 11*	*June 12 to July 11*	*July 12 to August 4*
Total Hours	614.45*	61.50*	49.80*	44.90*	207.25	139.25	28.25	83.50
Period Length (Days)	210.00	35.00	29.00	31.00	30.00	31.00	30.00	24.00
Average Hours Per Day	2.93*	1.76*	1.72*	1.45*	6.91	4.49	0.94	3.48
One Time Activity (Hours)	208.27*	37.75*	22.25*	19.50*	84.52	20.50	7.75	16.00
One Time Activity (%)	33.89*	61.38*	44.68*	43.43*	40.78	14.72	27.43	19.16
General Activity (Hours)	406.08*	23.75*	27.55*	25.30*	122.73	118.75	20.50	67.50
General Activity (%)	66.09*	38.62*	55.32*	56.35*	59.22	85.28	72.57	80.84
Research or Preparation (Hours)	54.67*	8.25*	11.00*	4.00*	18.17	0.00	0.00	13.25
Interview Preparation (Hours)	77.02*	12.00*	11.00*	4.00*	48.02	2.00	0.00	0.00
Interview Scheduling (Hours)	14.25*	0.50*	1.45*	0.30*	11.50	0.50	0.00	0.00
Interviews (Hours)	56.98*	4.00*	10.50*	3.00*	30.48	9.00	0.00	0.00
Analysis (Hours)	11.00*	3.00*	2.00*	0.00*	1.50	4.50	0.00	0.00
Writing (Hours)	177.00*	11.00*	8.00*	21.00*	45.00	78.50	2.00	11.50
Feedback (Hours)	7.45*	2.75*	0.00*	1.50*	0.50	0.70	1.00	1.00
Rewriting (Hours)	87.50*	5.00*	0.00*	1.00*	22.50	17.50	16.50	25.00
Scheduling (Hours)	4.50*	2.75*	0.25*	0.10*	0.60	0.80	0.00	0.00
Miscellaneous (Hours)	124.08*	12.25*	5.60*	10.00*	28.98	25.75	8.75	32.75

Values with an '*' are estimates or the result of estimated values

Table 5.7: Hours Spent on Study

- creation of presentations (such as PowerPoint files),
- email and
- using the Onware SERL site.

Figure 5.6 shows a percentage breakdown of the activities of the review from January 7 to August 4, 2004. It should be noted that the original categories were only "Research or Preparation", "Interview Activities", "Writing", "Feedback", "Rewriting", and "Miscellaneous". Log entries were reclassified to provide more detail of specific activities. Because of this, some analysis, scheduling, and interview preparation activities may have contributed to the totals of other areas. Analysis time is low because most of it took place during writing and rewriting of reports. This time would have been classified as writing time. Feedback is also low because most of this took place during meetings. Meetings were often classified as miscellaneous activities.

For the general activities only, Figure 5.7 shows the total time breakdown minus the one time activities. There are several noticeable differences between Figures 5.7 and 5.6. Activities that consumed less time in Figure 5.7 had one time activity. Without one time activities interview preparation was much lower (13% including one time activity and one percent without). Interview preparation consisted of creation of question sets, a major time consuming one time activitiy. Miscellaneoius, and research or preparation are significantly lower. Interview scheduling, and analysis are only slightly lower in Figure 5.7. Feedback and scheduling remained fairly constant between the two graphs. Rewriting, writing and interviews were significanly higher in the general time only pie chart so more time would likely be spent on these type of activities if the study was repeated.

The interview scheduling time appears quite high at a total of 14.25 hours. During the first month four interview meetings with five ME employees were scheduled by phone and email, so this was estimated at 30 minutes. From February 20 to March 5, the author set up eleven interview times. One contractor had some concerns about being interviewed. The time discussing those concerns was estimated at 15 minutes. Also the author needed time to adjust to using Outlook's calendar to schedule meetings, so the 1.45 hours of interview scheduling time is reasonable. Scheduling took the most time from April 12 to May 11 because a majority of the interviews were conducted that period. It also became more complex and there were a large number of interviews that had to be rescheduled. Finally, lag occasionally occurred when accessing ME's intranet through VPN on a University of Alberta terminal. Those previous reasons explain why it was 11.50 hours for the April period.

April 12 to May 11 has the most total hours of any time period. This was due to a large number of interviews having been scheduled during this time period. Previously William Luthi had not been able to schedule many interviews because he was working as a teaching assistant from January to April. This work caused many schedule conflicts so a lot of interviews were scheduled during April when his assistant term ended. When this period began 13 interview questions sets still needed to be developed. This one-time task took a significant amount of effort during this period. The general hours for the April 12 period are 122.73, and the ones for the May 12 period are 118.75 which is a small difference. Not a lot of activity occurred during the June 12 period because Paul Sorenson and John Shillington were gone for most of the month of June. By May 21, 2004, 29 preliminary practice area reports had been produced and receiving feedback for these reports from Paul Sorenson and John Shillington took a while. Most of the feedback was not incorporated until the July 12 period. Also William Luthi did some work on this thesis and did some related reading

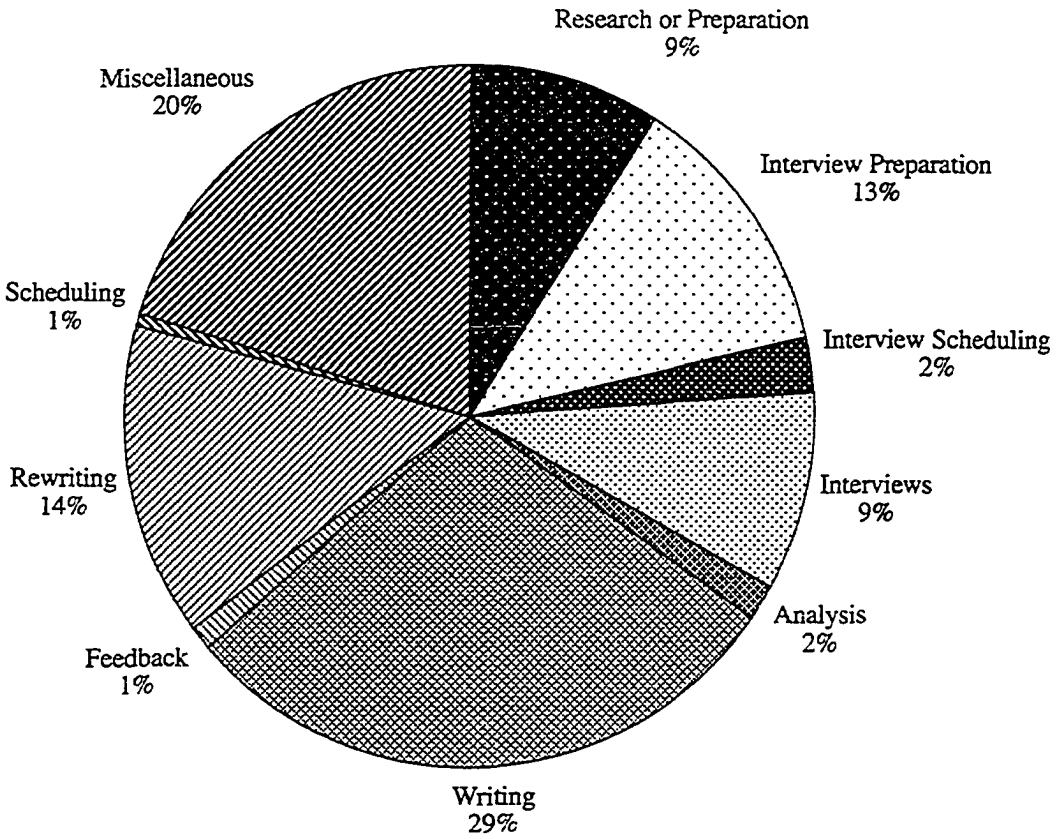


Figure 5.6: *Product Line Technical Review Activity Breakdown*

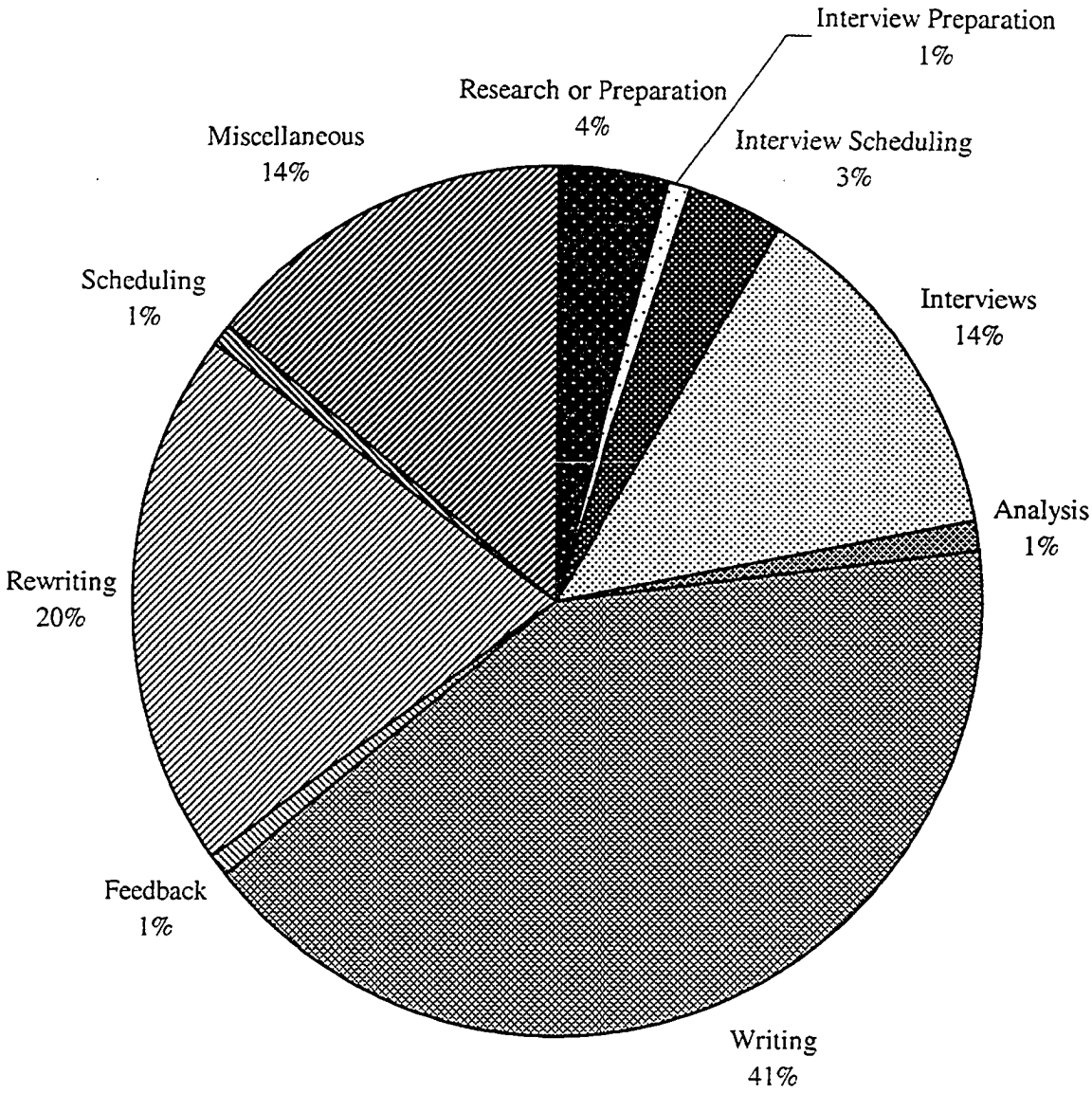


Figure 5.7: *Product Line Technical Review General Activity Breakdown*

during the June 12 period, which was not logged because it was not part of the effort to produce the report for ME.

The time spent on this study during the 97 day period of January 7, 2004 to April 11, 2004 was estimated at a total of 156.2 hours. During this time period William Luthi spent 221.5 hours working as a teaching assistant so he was unable to work on the study full time. 156.2 hours is a reasonable estimate. 3.98 hours per day is the average from the April 12, 2004 to August 4, 2004 time period. If we multiply this by 97 we get 386.52 hours. 386.52 hours minus 221.5 hours of teaching assistant work equals 165.02 hours. That is very close to the 156.2 hours estimate.

Interview activities took 24.13% of the total time, miscellaneous and scheduling, 20.93%, report writing activities, 46.05% and researching and preparation actitives took 8.90% of that time. The total estimated hours spend on this study to produce the final report and presentation at ME is approximately 614 hours. One time activities comprise 208 hours of that total, leaving 406 hours of general time. Picking an arbitrary value of $30/hour and using just the general time, this study would cost $12,183.

Based on some of the feedback from the study participants and the previous effort analysis, this study took too long and would need to be streamlined to become more practical. Even at 329.48 hours, the actual time recorded for April 12 to August 4, at $30/hour this study would cost $9884.50. Part of the reason this study took a long time was because William Luthi had to learn the material as he went. This involved doing research and looking up specific practices during the writing of the reports. Also the report writing took place over a long period of time (May to June 2004) because of delays in receiving feedback from Paul Sorenson and John Shillington. Additionally, making changes and updates to reports based on earlier feedback took additional time and sometimes resulted in more interviews. If this study was repeated, report writing would go faster now that the researcher has experience and better questions sets. For example, if the study were repeated some of the first artifacts created would be a product family variability diagram, a table of tools (software and non-software), a table of metrics, and a glossary.

5.7 BAPO Evaluation Analysis

Based on the interviews conducted and the final report produced [34], a lightweight BAPO Evaluation was conducted based on a four-dimensional evaluation framework [61]. The dimensions of the framework are Business, Architecture, Process and Organization.

5.7.1 Business: Level 1 - Reactive

The low rating is mainly because the company does not practice software product families.

Identity: Implicit

From our analysis, family development is not visible because there is no explicit software product family. A product family is identified for marketing, however, in some cases products in the same family do not share technology or assets. Sharing of assets and technology occurs at a very basic level. High level process assets may be reused such as ones used for market research.

Vision: Short Term

The company has one and three-year plans but these are focused on a per product basis, as opposed to the product family. There are no formal product family plans. The company also does not look too far ahead when developing plans to adopt new processes. For example, a plan to adopt software product lines would require a long term vision along with data to back it up. Plans to adopt new processes are more likely to be justified provided there are short term gains.

Objectives: Partially, and Qualitative

Product family development is not supported by the business units and current organizational objectives of customer satisfaction. There are product families at the marketing level. One code base is used and minor variants are produced for one product.

Strategic Planning: Ad Hoc Process

There is some planning done since some of the products are related. There is some minor sharing of assets like help files but planning with regards to this is ad hoc.

5.7.2 Architecture: Level 1 - Independent Product Development

There is no family architecture, products are developed independently, and there is some limited reuse of code assets in the ME product family.

Software Product Family Architecture: Not Established

Currently architecture is defined on a per-product basis. Core assets currently do not exist.

Product Quality: Ad Hoc

Product quality is not managed explicitly within the architecture. Quality is managed through testing by QA. If the software breaks, a change request is filed and it is up to the software engineers to fix it. There is no standardized infrastructure for the family of products. At a basic level COTS unit testing frameworks (for example JUnit [26]) are available for the programmers to use.

Reuse Level: External Components

The organization uses COTS and open source software both in and for development of their products. There is also reuse of code bases and libraries when new products are created such as P1B1, A1F3, and P2. Segment 7's products also reuse code from P1. However, there is no family architecture to act as a development basis.

Software Variability Management: Limited

There are "limited variation points from the infrastructure components" [61]. A limited infrastructure has been defined for the products developed consisting of operating systems, COTS and open source components, third party database management systems and third party APIs for the graphic user interfaces. Several products are managed by compile-time binding (for example Segments 1, 2,

4, 5 and 6). In general the software life cycle is not taken into account when determining when to introduce or bind variability.

5.7.3 Process: Level 2 - Managed

The organization has few development processes, and little data is collected about development. However, there are defined QA standards and higher level management standards that are tracked and improved.

Predictability: Tolerable

There are high level processes in place for creation of new products however, there are no explicit software engineering processes that guide "the work of development" [61]. There are also some general high level processes that managers can use to aid in decision making as well and processes developed for requirements elicitation. There are some implicit processes the software engineers use but these will vary depending on the person.

Repeatability: "Good practices can be applied, and bad practices can be avoided" [61]

The F1 and Segment 7 teams learn from each other's experiences. However, there was little related learning between them and the F2/F3 team. Higher level management practices are repeatable. Some of the lower level development practices related to build engineering (configuration management) are also repeatable and are documented. Also, informally, some agile practices such as daily stand-up meetings have been applied. More formally, a "coding standards" document has been produced along with configuration management documentation.

Quantifiability: Some Past Project Data Available

There is some data available on past projects. Business and work plans are created, along with software change requests. Not much data is collected about development other than if it is on schedule or not. Data from QA is collected and later analyzed to be more effective on future projects.

5.7.4 Organizational: Level 2 - Business Lines

ME is barely a level 2. There are multiple units and long term products which are the main contributors to the level 2 score. There is a cooperative culture between the Segment 7 team and F1 team. However no code asset sharing occurs between these teams and the F2/F3 team. There is some limited sharing in terms of product documentation between all the units however. Also, during the development cycle, after the study the F2/F3 team will be using the same test scenarios that the Segment 7 and F1 teams use.

Geographic Distribution: Multiple Units

There are three development units: F1 team, Segment 7 team and F2/F3 team. Communication between staff members is easy. Code base 1 which is managed by the F1 team is used in the products of code base 2 (managed by the Segment 7 team). There is no software family however, so no team is responsible for "family assets" [61].

Culture: Internal Focus

The culture is internally focused, individual valued, conservative and product focused. There is cooperation between the Segment 7 and F1 teams since the Segment 7 products require code base 1. However, the F2/F3 team uses its own code base and acts independently of the Segment 7 and F1 teams.

Roles and Responsibilities: Undifferentiated

There are no formal asset roles currently in the organization. An informal role exists between the Segment 7 (code base 2) and F1 (code base 1) teams. The code base 2 products have a component compiled from code base 1.

Product Life Cycle: Long Term

The organization produces products on an annual cycle. After product updates (for example to fix bugs) are complete, a product has hit its end of life. However, the code base remains the same year after year. An individual product's life cycle is short term but the code base's life cycle is long term. For example if an older product only runs on Windows 98, that product will not be updated to run on Windows XP. The code base of the new product that runs on Windows XP may still be the same as the Windows 98's base, however.

5.7.5 BAPO Profile

The BAPO profile for ME is assessed at B1 A1 P2 O2. ME barely achieved its P2 and O2 levels. It should be noted that a high BAPO profile may not be ideal for all organizations, especially SMEs. Some of the higher levels may cause excess overhead for small organizations. Because the framework requires evaluation of ME with respect to software product families its BAPO profile was low. It would have a achieved a higher score if BAPO was applied to individual products.

An increased BAPO profile of B2 A2 P3 O3 would be an improvement over the current level and would be suited to the organization. B2 would mean the business would be aware of software product lines and their benefits. A B4 appears to be a reasonable long term level goal for ME's size. B4 should be flexible enough for ME given its requirement of defined processes and partially quantitative objectives. B5 appears too heavyweight with its requirement of quantitative predictions. There is a desire within ME to be flexible and not hampered by too many processes.

A2 would require ME to adopt a standardized infrastructure. This means specifying external components, more explicit management of quality, institutionalized reuse and "limited variation points from the infrastructure components" [61]. A long term goal of level A4 appears to be a reasonable goal for ME given the stability of its domain.

Level P3 would require more analysis of data from past projects. It may also require the collection of new data. Given ME's size, level P4 appears to be a reasonable goal to strive for. P4 will allow for some measurement so that software processes improve. Continuous tracking of data in P5 may introduce too much overhead which is a current concern of ME.

Level O3 consists of a "domain engineering unit" and "product engineering units" [61]. A domain engineering unit would handle the

"design, development, and evolution of the reusable assets. Product engineering units are responsible for developing and evolving the products built based on the family engineering assets" [61].

For ME, level O3 is the highest level it should strive for given its size. IC (from Figure 4.1) may want to consider going for level O4. Level O5 does not seem appropriate because it is about creating software standards for "industry-wide cooperation" [61]. This is not necessary for ME's industry.

5.8 SEI SPL Assessment versus BAPO SPF Evaluation

Two "comprehensive software product line" yardsticks [9] are the BAPO framework [1] and SEI's Framework for Software Product Line Practice [15]. SEI's Product Line Technical Probe (PLTP) [14] is the means to characterize an organization's product line. From that characterization applicable patterns [14] can be applied. When applied the BAPO four-dimensional evaluation framework (FEF) [61] results in an evaluation profile. Table 5.8 gives an overview of BAPO FEF, SEI's PLTP and the PLTR performed in this thesis. Even though BAPO FEF and PLTP are still young methods with few and no case studies respectively, they are compared in our study to provide knowledge of their properties.

5.8.1 Scope

BAPO FEF is meant to address all dimensions; however, in addition to the main case study cite[61] there has been a case study that just addressed the architecture dimension [31]. The process dimension uses a CMMI assessment which is in common use in industry. Both the PLTP and PLTR can both be targeted to cover just certain practice areas or all of them.

5.8.2 Methodology and Length

All methods require interviews and examination of documentation. The only BAPO FEF case study [61] was based on information gathered from a previous "case study of a large-scale software product family of Magnetic Resonance Imaging (MRI) scanners developed by Philips Medical Systems" [29]. Because of this it was not clear what the exact methodology of a BAPO evaluation would be. The MRI case study took six months to gather information.

PLTP requires a preliminary meeting one month before the probe begins. The actual probe only requires one week of on-site time to conduct interviews. A probe team of four individuals conducts the interviews. This allows one team member at a time to ask questions while the others record the responses.

The PLTR requires steering committee meetings to guide the course of the review. Only one person was present during interviews to ask and record answers to questions. The PLTR took place over seven months. The total hours were estimated at 623, however, 196 of those hours were one-time activities that probably would not need to be repeated. Therefore a PLTR is estimated to currently take between 400 to 450 hours.

Method	BAPO FEF	PLTP	PLTR
Scope	All dimensions but process dimension and architecture dimension evaluation can be done on their own	All or targeted practice areas	All or targeted practice areas
Methodology	CMMI assessment, "observation, interviews, documents and the researcher's impression" [29]	Preliminary meeting, interviews, documentation	Steering committee meetings, interviews, documentation
CMMI Analysis Required	Yes	No	No
Length	6 months [29] and the time to do a CMMI analysis	Preliminary phase takes place 1 month before probe, technical probe: 1 week, report delivered "several weeks later", and follow-on phase 1 1/2 day optional workshop(s) [14]	7 months [34]
Number of Interviewers	3 [29]	4 [14]	1
Deliverables	CMMI analysis and simple BAPO evaluation profile	Presentation, matching patterns, report and optional action plans	29 practice area analysis, improvement opportunities and a report
Estimated Cost	CMMI assessment estimate for ME $37,500, other area assessment: Unknown	Unknown	Around $12,000
Case Studies	1 (indirectly) [61], 3 on the architecture dimension [31] and "87 organizations (some more than once) have performed a CMMI appraisal" [64]	No PLTP case studies are public but several organizations have been profiled in comparison to SEI's framework [8] [14]	1 [34]

Table 5.8: Comparison of Evaluation Methods

5.8.3 CMMI Required in BAPO FEF

BAPO FEF requires CMMI to determine the process (P) dimension. David Rico estimates the cost of an external CMMI level 2 and 3 assessment to be $12,500 for a four person project of

> "5,088 hours to analyze, design, and code 10,000 lines of code... For our one software project with four people, let's estimate 127 hours for the plan and prepare for appraisal stage, 204 hours for the conduct appraisal stage, and 21 hours for the report results stage. That totals 352 hours. Multiply 352 by $100 for an internal labor estimate of $35,200. Add an assessment fee of $12,500 for a total assessment cost of $47,700" [43].

ME has a total of 18 developers and code base 4 has over 50,000 lines of code. Segment 7 and F1's code bases are at least as complex as that of of Code base 4. Based on this let us assume a conservative estimate that a CMMI level 2 and 3 assessment of ME would cost three times $12,500, for a grand total of $37,500. This figure is also within range of several estimates received from CMMI consulting firms (ranges varied from $5000 to $100,000). A very simple anonymous description of ME was given to one firm to obtain a quote for a level 2 CMMI assessment. The firm indicated it would cost $50,000. The PLTP and PLTR both do not require a CMMI analysis.

5.8.4 Deliverables

BAPO FEF has the advantage of providing a fairly simple profile. The profile provides guidance on the next level an organization can aim for to achieve greater maturity. A PLTP is less quantitative. The result of which may be none, one or several patterns the organization falls into. Patterns do have the advantage of recommending actions. The 29 practice areas of SEI's SPLP framework provide more specific guidance on how to improve an area. The SPLP framework lists many specific practices that can be applied. A PLTP also allows for an optional follow-on phase for assisting in the recommendations. A PLTR like a PLTP also recommends patterns an organization can apply. It also provides improvement opportunities for organizations that want to explore incremental SPL adoption.

5.8.5 Estimated Cost

As mentioned previously an estimated the cost of a CMMI assessment for ME would be $37,500. This would contribute to the total cost of a BAPO FEF assessment. No other data has been made available for the cost of a BAPO assessment. Based on PLTP training costs, such as $3,600 (International) a seat for "PLTP team training" [48], it is assumed to be very expensive. A PLTR is at a relatively low cost compared to the other methods at around $12,000. To contrast the PLTR cost with a real consultancy company, Charles Krueger posted on the SoftwareProductLines.com discussion board that BigLever Software, Inc. [5], charges "$2500 per day plus travel expenses" [33] for an assessment.

5.8.6 Case Studies

There have been few public BAPO FEF case studies [31]. BAPO FEF is still evolving. It currently is not clear what level of maturity is suited for SMEs. CMMI assessments however are fairly mature

and have been undergone at many organizations [64]. No public case studies have been presented on the PLTP. However, there have been many case studies [14] relating the SEI framework to large organizations but few on SMEs. Of those done on SMEs none were that similar to ME's case. The closest was a case study of Market Maker Software. In that case study, Market Maker started out in the early 90's with a DOS based product. A key difference between code base 1 and Market Maker's flagship product is that back in the early 90's it was designed to be modular. Code base 1 is not modular. Today Market Maker has adopted product line practices, which was not hard given its modular architecture.

5.8.7 Summary

BAPO FEF is still unproven and requires a CMMI analysis. Assuming the business, process and organization assessments are relatively inexpensive then the high cost of a CMMI assessment will contribute the most to its price. It has the advantage providing an easy to understand evaluation profile. With the profile it would be relatively straightforward to know what direction an organization should move. The PLTP has the advantage of a short length and being performed with the experience of four experts. The impact on staff is minimal at only a week of interviews. Also a report is produced, and the PLTP has an optional follow-on phase to provide assistance carrying out the recommendations. The SEI SPLP framework practice areas and patterns also provide guidance on how to proceed. However based on PLTP training costs, it assumed to be very expensive. Also the PLTP does not allow for an organization to be given a simple profile the way a BAPO evaluation does. A PLTR is at a relatively low cost compared to the other methods. It however took a long time to perform and like a PLTP does not provide an evaluation profile. It does however provide improvement opportunities that allow for companies to incrementally explore SPL practices.

5.9 Lessons Learned

There are several lessons that can be learned from this experience. A general question set was created to get an initial feel for an organization. Unlike the PLTP preliminary phase question set [14] published, it is more general and assumes the organization is very immature with respect to product lines. The question set is provided in Appendix B. All of the interviews conducted were practice area specific, however some general questions were incorporated into question sets. Another lesson learned is to create tables of information first. If the author were to repeat the study he would create tables for tools (software and non-software), COTS components, metrics, products and potential core assets. It was also key to have organizational support from the sponsors, the three ME members of the steering committee. Their support allowed the author access easy access to the employees of ME and for the study to go beyond the original planned deadline. Finally, ME acquired a company that produced F2 and code base 4. If the study was repeated again with a company that went through a merger, some questions would be developed to see what lessons could be learned.

Chapter 6

Summary and Conclusions

This thesis provides a case study profiling the practices of a medium-sized enterprise, referred to as ME, with respect to the SEI Framework for SPLP. ME had approximately 40 employees when the study was completed. A total of 41 products existed under the brands of ME of which it was responsible for the development of 40 of those products. The research found that ME develops software in a product centric way. Specifically, ME is organized so specific teams handle specific products. It does not do planned core asset development, but it does have the potential to do so.

The conclusions of this thesis will be summarized in the context of the four research questions posed in the introduction. The final section of this chapter will provide opportunities for future work.

6.1 How do two current SPL assessment techniques compare?

An SEI framework evaluation and a lightweight BAPO (Business, Architecture, Process, Organizational) SPF evaluation were compared. Prior to this study, ME never had an assessment of its product lines or process capabilities. Table 6.1 shows the main improvement opportunities along with their related practice area(s), uncovered in the case study. Several relevant SEI patterns for ME were also identified: Curriculum, Essentials Coverage, Each Asset, Evolve Each Asset, Product Parts, Plowed Field and Cold Start.

The SEI framework evaluation was mapped to a lightweight BAPO SPF evaluation. The eval-

Improvement Opportunity	*Related Practice Area(s)*
Reinforce importance of modular development	Architecture Definition Component Development
Investigate and adopt unit testing frameworks	Testing
Architecture evaluations	Architecture Evaluation
Documenting component interfaces at a high level	Software System Integration
Training on product line practices and concepts	Training
Documenting commonality and variability	Architecture Definition Requirements Engineering Scoping
Encouraging other product groups to consider product line approaches	Launching and Institutionalizing

Table 6.1: Main Improvement Opportunities with Related Practice Areas

uation profile for the organization was found to be B1 A1 P2 O2. The business level 1 is reactive, architecture level 1 is independent product development, process level 2 is managed, and organization level 2 is business lines. Because the framework requires evaluation of ME with respect to software product families its BAPO profile was low. An increased BAPO profile of B2 A2 P3 O3 was recommended and argued to be an improvement over the current level and well suited to the organization.

The study found that the SEI SPL assessment was not as clear as a BAPO FEF evaluation profile. With a BAPO evaluation profile it would be relatively straightforward to know what general directions an organization should move to reach the next maturity level. Even though a full CMMI assessment was not conducted, a lightweight assessment finds ME is a just barely at P2. A disadvantage is that the BAPO FEF does not give any suggestions on what specific practices to adopt. The advantage of the SEI SPLP framework practice areas and patterns is the guidance it provides on how to improve practices in a specific area. The SPLP framework is a more mature corpus so it provides many practice suggestions to achieve greater maturity in a practice area. Also some of the practices suggested do not require a mature product line. The assessment did find two practice areas that were not applicable for ME: customer interface management and developing an acquisition strategy. Both areas did not provide any improvement opportunities. In the end, there was consistency in the findings of the BAPO FEF and the SEI SPL assessment. Both assessments indicated ME's product line practices are immature.

6.2 What are some obstacles a medium-sized enterprise faces when adopting SPLs?

ME is primarily focused on customer satisfaction of current products. A change in process or structure would only be supported by upper management if there is a direct correlation with customer satisfaction or a return on investment analysis with real cost savings. Finding this correlation is a major obstacle. Choosing to adopt a product line approach for ME is not an obvious decision, as it was in the CelsiusTech [8] case study. Another major obstacle is that SPL research is new and not mature for medium-sized enterprises. SPLs are currently not standardized or common so ME's business management is hesitant to take the risk. Finally, ME is a company that cannot skip its yearly production cycle, so it does not have time to pause and adjust itself for full scale SPL adoption.

6.3 What can a medium-sized organization do if it cannot adopt a full product line strategy, but wants to be in a better position to adopt such a strategy?

From this study a new pattern, Slow Start is presented. The Slow Start pattern consists of the Curriculum pattern and practices focused on organizations that want to transition to product lines. The organization will be producing products on an annual cycle and would like to determine if it should develop core assets for its products. This pattern assumes an organization can gradually transition to software product lines. The payoffs will not be immediate because of the slow pace of launching. The key benefit is that the organization will be better able to adopt SPL practices business case based on greater opportunities to share or reuse software assets across products. Slow

start is not a pattern for product line adoption, and therefore is useful for cases where it is not clear a product line approach is necessary.

6.4 How can a medium-sized enterprise assess its current product line practice state?

This thesis also documents how the study was conducted on ME. The process of this Product Line Technical Review (PLTR) is presented and analyzed. The PLTR provides guidance on how an individual can undertake an assessment of an organization's product line practices. It began with the creation of a steering committee (three ME members and the three University of Alberta members) to guide the review. The review consisted of a series of interviews, surveys, and requests for documentation, which formed the basis for a review report for ME. It was found that one of the first activities performed should be the creation of tables identifying the characteristics of the organization with respect to how software products are developed. These tables include tools, non-software tools (for example processes), potential core assets and metrics. The PLTR is distinct from the PLTP because it can be conducted with one external or internal individual. For this PLTR, interviews were conducted one-on-one except for the interview about tool support. It is also takes place over a longer period of time compared to a PLTP. Unlike a BAPO evaluation profile, the PLTR highlights improvement opportunities for all 29 SEI SPLP framework practice areas.

An estimated 614 hours were spent on this study to produce the final report and presentation at ME. Interview activities took 24.13% of the time, miscellaneous and scheduling, 20.93%, report writing activities, 46.05%, and researching and preparation actitives took 8.90% of that time. One-time activities comprise 208 hours of the previously mentioned total, leaving 406 hours of general time activity that would likely be repeated for another evaluation. Picking a fee for service rate of $30/hour and using just the general time, this study would cost $12,183. The overall effort of implementing a PLTR was documented in Section 5.6. In this section, we showed that a major cost of a BAPO FEF evaluation was the CMMI assessment, which can range from $5,000 to $100,000 depending on the size of the organization. Also, a PLTP is believed to be expensive based on the cost of SEI PLTP courses. BigLever Software, a company that performs software product line assessments currently charges $2,500 per day plus travel expenses. The costs of a PLTR would appear to be reasonable when compared to the costs of a BAPO FEF evaluation, a PLTP and what BigLever charges.

Two surveys were given to interviewees at the end of the review. The first was a self-assessment of the current maturity of ME with respect to the 29 practice areas and the second was an anonymous survey to evaluate the usefulness of the review. The respondents had the opportunity to attend a presentation of the review's findings, by the author and/or read his product line practices report [34]. The respondents' self-assessment for most of the practice areas were similar to the one done by the author. The areas that differed are worth noting, however. The author rated the current levels for component development, scoping, building a business case and funding lower than respondents but the improvement opportunity levels were approximately the same. For mining existing assets, technical planning, and technical risk management the author rated both the current and improvement opportunities lower than respondents. The author gave lower improvement opportunity levels because he felt his recommendations would not result in the respondents desired maturity level. For

customer interface management and developing an acquisition strategy the author rated both current and improvement opportunities the same at level 1 (not practiced). The respondents' current levels and the improvement opportunities both rated as higher. Finally, the author rated the market analysis current and improvement opportunity levels higher than respondents. He felt their practices for that area were close to those described in SEI's SPLP framework.

Respondents that filled out the anonymous feedback surveys generally rated the final presentation of findings "somewhat useful". The report [34] was rated "useful". Finally, the respondents interview experience was rated between "neutral" and "very good".

There are several lessons that can be learned from the development and implementation of this PLTR. One of the first documents that should be obtained from the company undergoing a PLTR is the organizational chart. This provided guidance on who to interview along with verbal suggestions from ME employees. A general question set was created to acquire a feel for ME and any other organization. Another lesson learned was to create important information tables first. If the author were to repeat the study he would create tables for tools (software and non-software), COTS components, metrics, products and potential core assets. It was also key to have organizational support from the sponsors; in this case the three ME members of the steering committee. Their support allowed the author easy access to the employees of ME and for the study to go beyond the original planned deadline.

6.5 Future Work

There are several opportunities for future work. In terms of SEI's SPLP framework, it could be enhanced to provide a practice area related to mergers and acquisitions. A practice describing how to incorporate a company purchased or acquired into a current product line effort should be investigated. Alternatively, a merger pattern could be created, perhaps as a variant of the In Motion pattern.

A future objective would be to improve the efficiency of this PLTR assessment. A repeat of this review would provide data to streamline the process, such as an effort log from start to finish. It would help assess the repeatability of the process and re-usability of the question sets.

Additionally, there are no studies that directly link adopting a software product line to customer satisfaction for an organization with existing, mature products. An opportunity for future work would be establishing a positive correlation between these factors.

Finally the Slow Start pattern proposed could be applied to an organization to measure its effectiveness. A snapshot of ME's current practices was taken. The Curriculum pattern and similar baselining techniques described as specific practices in the launching and institutionalizing practice area were applied. However, the remaining practice areas of the Slow Start pattern that need to be observed are training, scoping, requirements engineering, architecture definition, software system integration, architecture evaluation and testing. Variants of the Slow Start pattern may also be explored by targeting specific practice areas in the review.

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Appendix A

Architecture Evaluation Questions

The questions provided in this chapter have been modified from the original. They have been edited for spelling, grammar and conciseness. Also modifications have been made to ensure ME remains anonymous.

A.1 Questions in Architecture Evaluation Interview Review Template

When: (What time in the life cycle do the review(s) take place or what set of preconditions need to be in place?)

Time Spent: (Are people available and is there enough time for this PA. What is the estimated effort? Who's involved and for how long?):

Questions:

1. Describe the system(s)? (long-lived or short-lived products)
2. What are the business goals of the system?
3. How do you make sure architecture is aligned with business goals?
   (a) Are there periodic mini-evaluations to discover whether the architecture and goals are still well matched?
4. How you evaluate your architecture? (informally, or technical committees)
5. What do you evaluate the product line architecture for? (robustness, generality)
6. What do you evaluate the instance architectures for? (behavioral, quality requirements)
7. Why do you evaluate your architecture?
8. How do you address the results of an evaluation?
9. What are the goals of the Architecture Evaluation?
   (a) Behavioral goals:
   (b) Quality-attribute goals (modifiability with respect to OS or GUI):
      i. With respect to what is modifiability (e.g., OS, GUI, etc) a goal?
10. What are the variation mechanisms to achieve instances of products from the product line?
    (a) What does the evaluation of the variation points focus on?

i. Appropriateness

ii. Flexibility to cover the SPL's intended scope

iii. How quickly products can be built

iv. Runtime performance costs

11. Do you establish bounds on the performance the architecture? If so, how does the evaluation establish bounds on the performance the architecture is able to achieve? (Assuming bounds on hardware and other variables)
12. What are the evaluation artifacts (scenarios, checklists, and so on)?
13. What architecture evaluation techniques are used? (Check those that apply):
    (a) ATAM^{SM}: The Architecture Tradeoff Analysis Method^{SM}
    (b) SAAM: The Software Architecture Analysis Method
    (c) SPE: Software performance engineering
    (d) ARID: Active Reviews for Intermediate Designs
    (e) Active design reviews
14. How do you ensure the right people are involved in the evaluation?
15. How do you plan to ensure there is time for an architecture evaluation? If the architecture evaluations are not done, then ask how could the company ensure there is time for an architecture evaluation?
16. How do you reevaluate the architecture as it evolves?
    (a) Do you use a lightweight version of the original evaluation?
    (b) If there is a lightweight version how is it different?

Artifacts: (inputs in to the evaluation, scenarios, checklists, core assets that contain the articulated, prioritized quality-attribute goals and so on)

Risks Identified: (follow ups to make sure action items get carried out)

Additional Comments:

Questions from interviewees:

Additional Questions:

- Who else would you recommend I talk to about Architecture Definition and Architecture Evaluation?
- I'm looking at other areas to do interviews in. What other areas do you feel it would be worthwhile for me to talk to you about?

Follow-up Questions:

- Removed because they were specific to ME and to hide ME's identity.

Appendix B

General Questions

A general question set was developed near the end of the interview phase of the review. This chapter presents most of the questions from that set. The questions provided in this chapter have been modified from the original. They have been edited for spelling, grammar and conciseness. Also modifications have been made to ensure ME remains anonymous.

B.1 Questions from General Question Interview Review Template

Background: Please tell me what you do?

Questions:

1. What is the annual budget for the company? For example, how much do you spend on development?
2. How many lines of code are the products you work on?
   (a) How many lines of code are added every year?
   (b) How many lines of code are changed per year?
3. What are the business goals of the company?
4. What is the company's perspective of success?
5. Where is the organization headed? Is it headed to the simplification of its processes and offerings?
6. What are the main risks in your unit?
   (a) Making the market release date?
   (b) Keeping on schedule?
7. Do you feel risks need to analyzed more formally? Are the current processes adequate? Were they any big risks that failed to be identified? What is your unit's track record with respect to identifying and mitigating risks?
8. What kind of tools do you use?
9. What tools do you use to support automation of your unit's processes?
   (a) Scripts to test the software

(b) Software to construct daily statistics (for example, it creates a metric of the number of days required for task completion)

(c) Software to automate build process

(d) Unit testing frameworks

10. What libraries or engines in existing products do you feel could make potential core assets in a future product line?

Artifacts made by your Unit: (documentation, analysis, reports, performance tests, unit tests)

Risks Identified: (in your unit)

Additional Comments:

Questions from interviewees:

PRIORITY Follow-up Questions: These are questions that need to be asked now, because of upcoming deadlines and/or because people will be away, (for example, on vacation). *Questions were removed because they were ME specific.*

Additional Questions:

- I'm looking at other practice areas to do interviews in. What areas do you feel it would be worthwhile for me to talk to you about?

Appendix C

Anonymous Survey Questions and Written Responses

This chapter provides the questions from the anonymous survey along with the respondents' responses. After each question responses will be listed except for answers provided in Table 5.5. Each response will begin with the survey number it belongs to. Answers from respondents have been modified to keep ME anonymous and to correct any spelling mistakes. This chapter consists of five sections. Each section corresponds to the survey section.

C.1 Questions

C.1.1 1. Optional: Do you work in software engineering or management or both?

Answers: Please refer to Table 5.5.

C.2 Presentation Questions

If you did not attend the presentation please go to Question Set 3: Report Questions.

C.2.1 2. How useful was the presentation on a scale from 1 to 5?

- 1. not useful
- 2. somewhat useful
- 3. useful
- 4. very useful
- 5. extremely useful

Multiple Choice Answers: Please refer to Table 5.5.
Written Comments:

- 2: See Section 3 →.
- 7: Did not attend.
- 10: did not participate

C.2.2 3. Please elaborate on any inaccuracies you found in the presentation?

Answers:

- 3: I don't know enough about the subject matter to know how accurate it was.
- 4: It appeared that an assumption was made that since F1 engineers had unit testing software they were using it extensively/effectively. As far as I know they aren't.
- 6: No inaccuracies as far as I'm concerned. Covered a lot of ground in a small amount of time.

C.2.3 4. Please elaborate if there was something missed in the presentation?

- 3: Not enough information about the background material. It would have been useful to have a handout or reference before the meeting describing the types of patterns. It was easier to understand the product line practices area.
- 6: Nothing that isn't covered by the report.
- 8: The report was interesting, but I found the presentation to be a bit long and it didn't hold my interest.

C.2.4 5. What questions do you have after seeing the presentation?

- 3: I would like to know more about the types of patterns and product line practices. I was planning to look in books and on the Internet.
- 4: The patterns are going to require some thinking. I found that part of the presentation difficult to follow. I think it would have been better if you had focused on just those patterns that we are most likely to use and perhaps elaborated on how we might use them. The discussion at the end on Each Asset helped.
- 6: The questions I have are for my supervisors - what are we going to do about it?
- 13: none

C.3 Report Questions

If you read at least one practice area report, part or all of the final report please answer the following section.

C.3.1 6. What areas of the final report did you read? (Please list all practice areas and other chapters such as Pattern Analysis for example.)

Answers:

- 1: Architecture Definition, Evaluation, Component Development, Requirements Engineering, Software Integration
- 2: I'd like to read the whole report; instead, I skimmed over each section.
- 3: I skimmed the entire final report and focused on my contribution area.

- 4: I think I've read every practice area as well as the improvement opportunities roadmap. I didn't read the Pattern Analysis. The audit of ME practices is of great value. I don't think there were a lot of surprises, but there was a lot of confirmation of things we already knew. Getting us thinking about doing something about them, or giving them enough air time to raise the visibility of issues is extremely important. I think the improvement opportunities at the end of each PA chapter are great. With respect to product line adoption, there are people who are giving real consideration as to how we might do this. An incremental/evolutionary approach is most likely to be initiated as a result of this study. Whether it actually leads us to a product line organization/methodology isn't know, but it's had an impact.
- 5: Chapters 3 - 13. Then I scanned.
- 6: All of 'em.
- 7: Read through Section 1 through 9. Read conclusion potion of Sections 10 through 16.
- 8: Management chapters and some of the technical chapters of the final report.
- 9:
  - 3. Software Engineering: Architecture Definition
  - 4. Software Engineering: Architecture Evaluation
- 10: Browsed through all. Mainly interested in the organizational management section.
- 11: Chapters 3 through 11 (Engineering), Chapter 13 (Data Collection, Metrics and Tracking), Chapter 19 (Tools); Chapter 25 (Market Analysis), Chapter 28 (Organizational Risk Management), Ch. 29 (Structuring Org.); Chapter 31 (Training)
- 12: READ SECTIONS 1-14, AND SKIMMED THE REST. I WILL READ THE REST, WHEN TIME PERMITS (LIKELY AFTER PRODUCT RELEASE)

C.3.2 7. How useful was the report on a scale from 1 to 5?

- 1. not useful
- 2. somewhat useful
- 3. useful
- 4. very useful
- 5. extremely useful

Multiple Choice Answers: Please refer to Table 5.5.
Written Comments:

- 2: Somewhere between 3 & 4, depending on what we do with it. (I suppose if nothing gets done, then it wasn't all that useful, except as an academic exercise.)
- 3: I found the report useful for giving me an overview of our develop areas I don't normally work with, and it was interesting to read the recommendations for each area.
- 5: To be useful I'd have to spend a long time studying the report. I don't have time. I need a greater knowledge of product lines to understand the report.

C.3.3 8. Please elaborate on any inaccuracies you found in the report?

Answers:

- 2: The collected data and comparisons to SEI seemed quite accurate. Some of the interpretations & recommendations are open for debate, though. e.g., the relative difficulty of some of the recommendations may/may not be true for this organization. Technical Training, for example, is not a common occurrence at the company.
- 3:
  - Section 12.3.2.1 - *Omitted because comment discusses software used by ME*
  - various spelling and grammar errors throughout the document - not many, but it should be reviewed before publication.
- 5: Generalizations were made based on interviews with one person on an area. The generalizations are not always true. People's names are mis-spelled. There are a fair number of inaccuracies, but the gist of it is true.
- 6: Only slight errors regarding terminology, nothing major.
- 7: Did not come across anything material.
- 9: Very little
- 10: none

C.3.4 9. Please elaborate if there was something missed in the report?

Answers:

- 1: Very thorough.
- 2: Given the scope of the report, I think that it was quite thorough and well done. But it is *very* large. That may prove to be a barrier to having all of the results widely read and understood.
- 3: Not that I noticed.
- 5: The study focused on the F1, F2, and F3 products. F4 and F5 did not get much attention. But it is those products that could lead us to a product line.
- 7: Did not come across anything material.
- 9: P1P3's architecture is evaluated more than once. Almost every year.
- 10: I would have liked an evaluation of the success related to the acquisition of code base 2 and F2 (what went well, what could have been improved)

C.3.5 10. What questions do you have after reading the report?

Answers:

- 1: Why hasn't S1 worked more with the recommendations listed here?
- 2:
  1. Applicability and desirability of the various recommendations to our business.
  2. What are our follow-up plans to the report?

- 3: Nothing about ME's practices as such. The report has interested me in reading more about the SEI practices and other background material.
- 4: No questions with respect to the findings or recommendations, just questions that need to be answered internally. Some navel gazing is required to determine our next steps.
- 6: None.
- 10: none

C.4 Questions about the Study's Process

If you participated in the study as an interviewee please answer this section.

C.4.1 11. What was your interview experience like on a scale from 1 to 5?

- 1. very poor
- 2. poor
- 3. neutral
- 4. very good
- 5. excellent

Answers: Please refer to Table 5.5.

C.4.2 12. Please list any additional comments on your interview experience:

Answers:

- 2: The interviews were fairly 'mechanical' because they followed a strict set of questions derived from SEI's work in this area. Perhaps the follow-up interviews were more customized to our company, I don't know.
- 3: see below
- 4: Bill was pretty set on asking only those questions that he had on his sheet. I thought there might have been opportunities to ask some follow-up/probing questions based on answers he got from me, but he motored through his agenda. I felt he was letting me get away with some pretty superficial answers. But there's not doubt he was under time pressures and I could tell he was trying to hurry through the interviews to minimize impact on me. (I appreciate that.)
- 6: I thought that the "conversational" flow was hampered by Bill's need to furiously write notes. Recording it or having a separate person take notes would've been better.
- 7: I thought Bill did a very good job capturing information in detail and capturing a lot of detail in a short amount of time.
- 9: Sometimes, the questions weren't clear and I needed to ask questions to Bill to know more about what he was looking for.
- 13: Bill was friendly and thorough during our interviews - he asked many questions and clearly answered mine.

C.4.3 13. Do you have any comments on the interviews you participated in?

- If so could you please list them?

Answers:

- 2: The interviews could have been more 'dynamic', in the sense of adding/dropping certain questions based on interview information. e.g., if it appears that we don't have a process or a team for handling a task, then any further questions on that topic are not really needed. This may have also helped make the interviews shorter and/or less exhausting.
- 3: The interview went well. Bill asked a wide variety of questions about various areas. His followup questions about my documents helped highlight areas where I could improve the descriptions. The chosen length of time was suitable.
- 6: I'd have liked a preview of the questions before the interviews.
- 7: No
- 10: Went smoothly but was not always conducted for those who are not highly technical.
- 11:
  - Bill was an effective interviewer
  - Amazed at his ability to take comprehensive notes and listen at the same time.

C.4.4 14. How do you feel this study could be improved?

Answers:

- 2: The duration was too long. By the time it was finished, people had either lost interest, were too tired to continue, or couldn't afford to put more time into it. (On the other hand, the results were quite thorough, so I suppose there's a trade-off.) The final report is also *very* long and will take a fair bit of effort to review and followup on.
- 3: I don't have any suggestions for improvement, I found it interesting and useful.
- 4: If the company involved could have someone partner with analyst (Bill) the analysis may be 'deeper' and more conclusive. And, there would be an employee left behind to carry the torch.
- 6: See previous comments
- 7: Considering the length of the report (long, but very detailed) I thought the Executive Summary should have been 5-10 pages instead of slightly more than 1 page. Although, I probably should have attended the presentation.
- 10: Better adapt questions (level of technicality for example) to the interviewee.
- 12: A TAPE RECORDER MAY HELP WITH THE FLOW OF THE INTERVIEWS.

C.4.5 15. If a similar study was to be conducted in the future at the company, would you participate in it? Why or why not?

Answers:

- 1: It presents an excellent outside review of our processes. As we well know, the closer you are to the subject, the more difficult it is to step back and be objective. Bill's survey is a very objective to evaluate our practices.
- 2: Only if I thought that we were going to benefit from it in some tangible way. e.g., improve our process, team structure, tools, etc.
- 3: Yes, my experience with it went well and I found the results interesting.
- 4: Yes. It's educational for me. It's of value to the company to look at itself critically, or have someone else do it. As I said above, I think this study will influence future actions/initiatives at ME. I'm not sure it will result in a product line model, but it will have an impact.
- 5: Yes.
- 6: Yes - it was a great learning experience for me.
- 7: Yes, it provides a good opportunity to reflect on our practices and explore ways to improve.
- 9: Yes, if it doesn't take up too much of my time.
- 10: No, I'm not sure my input was really valuable. Answers needed to be very technical.
- 11: Yes.
- 12: YES, AN OUTSIDE (THIRD PARTY) POINT OF VIEW OF IDEAS AND PROCESSES IS EXTREMELY VALUABLE FOR IMPROVEMENT AND/OR VALIDATION.
- 13: No. I didn't find it added value for my role.

C.4.6 16. Are you satisfied with the findings of the study?

Answers:

- 1: Yes.
- 2: I still need more time to read the report, but I'm satisfied with what I've seen so far.
- 3: Yes, though more background information on the patterns would have been helpful before the presentation.
- 4: Yes. I think it was pretty low cost to ME for the value received.
- 5: Yes
- 6: Yes.
- 7: Overall, yes.
- 9: Somewhat
- 10: Yes, it seems to reflect what is really happening here at ME.
- 11: Yes
- 12: IT'S THE FIRST TIME I'VE BEEN INVOLVED IN A STUDY OF THIS NATURE. I HAVE NOTHING TO COMPARE IT WITH, BUT HAVE FOUND THE INFORMATION PRESENTED TO BE INTERESTING AND VALUABLE.
- 13: No, see Q15.

C.5 Additional Comments

If you have any additional comments about anything related to the study please write them in this section. Thank you for your time.

Answers:

- 2:
  1. If there was a way to streamline the whole process and make the "interview → results analysis → report writing and publication" go faster, without sacrificing too much of the valued content, that would be good. Perhaps more dynamic interviews would help.
  2. Perhaps a shorter version of the final report would also be useful, both for the people who don't have enough time to read the full report, and as a primer for the full report.
- 6: Good luck on your thesis, Bill!

Appendix D

Time Log

This chapter provides both the estimated time log (from January 7 to April 11, 2004), and the actual recorded time log (from April 12 to August 4). Table D.2 lists tasks the author undertook during the study. Values with an '*' are estimates.

"Research or Preparation" involves activities such as reading and preparing for presentations such as the one on January 19, 2004. "Interview Preparation" consists of creation of interview templates, updating interview templates, typing up interviewee answers, and creation of tables (tools, metrics) and diagrams (marketing variability product diagram) that were shown to interviewees for feedback. "Interviews" are the time taken to do an interview or to email questions. "Interview Scheduling" is scheduling specific to interviews. "Scheduling" is general scheduling for steering committee meetings, meetings with John Shillington and/or Paul Sorenson, and updates to the review's Gantt chart. "Analysis" is time spent analyzing data through discussion, data analysis (spreadsheets), and reading email or notes. "Writing" includes time taken to make the practice area importance survey report, practice area reports and the final report. "Feedback" is the time feedback was verbally given to author by steering committee members. "Rewriting" is acting on verbal or written feedback by updating reports, diagrams or appendices. "Miscellaneous" involves involves other activities that do not fit within the previous ones. For example,

- updating the time log,
- dealing with accounts, hardware and software problems and issues,
- non-interview meetings,
- creation and updating of surveys,
- typing up of meeting notes and agendas,
- progress Reports,
- requests for documentation,
- creation of presentations (such as PowerPoint files),
- email and
- using the Onware SERL site.

"One Time ?" is a boolean value that classifies a task. A '1' means the task is classified as a "one time activity". A '0' means the task is a "general activity". A one time activity is one that would not be repeated if the assessment was done again. For example, creation of a template question set,

time spent reading about a practice area or a non-steering committee meeting with Paul Sorenson and John Shillington about the direction of the study. General activities include report writing, interviews and steering committee meetings with ME members.

Some acronyms are used in the Tasks cells of Table D.2. These acronyms are explained in Table D.1.

Acronym	*Meaning*
AD	Architecture Definition
AE	Architecture Evaluation
BABC	Building a Business Case
BAPO	Business, Architecture, Process, Organization
BE	Build Engineer
BL	Bill Luthi
BU	Business Unit
BUM	Business Unit Manager
CD	Component Development
CIM	Customer Interface Management
CM	Configuration Management
COTSU	Common Off-The-Shelf Utilization
CSC	University of Alberta Computing Science Center
CTO	Chief Technology Officer
CVS	Concurrent Versions System
DAAS	Developing an Acquisition Strategy
DCMT	Data Collection, Metrics, and Tracking
DCSE	Distributed Collaborative Software Engineering
ES	Executive Summary
F1	Family 1
F1E	Family 1 Engineer
F1PM	Family 1 Project Manager
F2	Family 2
F2/F3E	Family 2/Family 3 Engineer
F2/F3PM	Family 2/Family 3 Project Manager
F3	Family 3
F4	Family 4
F5	Family 5
FR	Final Report
IO	Improvement Opportunity
GPM	Group Product Manager
JB	Jan Bosch
JS	John Shillington
L and I	Launching and Institutionalizing
LINC	Learning and Innovation in New Company creation
MA	Market Analysis
MBMCA	Make/Buy/Mine/Commission Analysis
ME	Medium-sized Enterprise
MEA	Mining Existing Assets
MESPM	Medium-sized Enterprise Senior Product Manager
MM	Market Maker
MPP	Microsoft Project file extension
MS	Microsoft
OM	Organizational Management

Continued on next page

Table D.1 – continued from previous page

Acronym	*Meaning*
OP	Organizational Planning
Ops	Operations
ORM	Organizational Risk Management
PA	Practice Area
PD	Process Definition
PL	Product Line
PLSC	Product Line Steering Committee
PM	Project Manager
PS	Paul Sorenson
RE	Requirements Engineering
QA	Quality Assurance
QAS	Quality Assurance Supervisor
S7	Segment 7
S7E	Segment 7 Engineer
S7/MEAM	Segment 7/Medium-sized Enterprise Analyst Manager
SA	System Architect
SC	Steering Committee
SCM	Steering Committee Meeting
SE	Software Engineering
SEI	Software Engineering Institute
SERL	Software Engineering Research Lab
SPLAM	Software Product Lines/Agile Methods. Originally the author was also going to look at agile practices of ME but it was decided to limit the scope of the study to just SPLs. SPLAM meetings are just meetings between William Luthi and Paul Sorenson and/or John Shillington.
SPM	Senior Product Manager
SSG	University of Alberta Department of Computing Science Software Systems Group
SSI	Software System Integration
STO	Structuring the Organization
TF	Technology Forecasting
TM	Technical Management
TP	Technical Planning
TRM	Technical Risk Management
TS	Tool Support
URD	Understanding Relevant Domains
WL	William Luthi
VPN	Virtual Private Network

Table D.1: Table of Several Task Acronyms

Date	*Duration in Hours (D)*	*Task*	*Research or Preparation in Hours (RoP)*	*Interview Preparation in Hours (IP)*	*Interviews in Hours (I)*	*Interview Scheduling in Hours (IS)*	*Scheduling in Hours (S)*	*Analysis in Hours (A)*	*Writing in Hours (W)*	*Feedback in Hours (F)*	*Rewriting in Hours (R)*	*Miscellaneous in Hours (M)*	*One Time? (OT)*
7-Jan	1.00*	BL and JS develop a schedule in MS Project					1.00*						0
8-Jan	0.50*	Scheduling through Email					0.50*						0
9-Jan	0.25*	Created an Onware Groupware Discussion group and sent out emails about it										0.25*	0
	1.00*	Steering Committee Kickoff meeting										1.00*	0
10-Jan	0.25*	Scheduling emails					0.25*						0
	0.25*	Received Organizational Chart and looked it over	0.25*										0
13-Jan	1.00*	SPLAM Meeting with JS and PS										1.00*	1
	1.00*	Typing up of SPLAM meeting notes										1.00*	1
15-Jan	0.50*	Scheduling interviews and entering them into Groupware				0.50*							0
16-Jan	0.25*	Email scheduling					0.25*						0
	0.50*	Printer problems, file a problem report										0.50*	0
	2.00*	Updated 1st version of 29 PA survey										2.00*	1

Continued on next page

Table D.2 – continued from previous page

Date	*D*	*Task*	*RoP*	*IP*	*I*	*IS*	*S*	*A*	*W*	*F*	*R*	*M*	*OT*
17-Jan	0.25*	Printer problems continue, discuss with SSG										0.25*	0
18-Jan	2.00*	Making PowerPoint Slide Presentation	2.00*										1
	6.00*	General Readings and Research about SEI's framework	6.00*										1
19-Jan	1.00*	Kickoff Presentation at ME at 1100										1.00*	0
20-Jan	1.00*	SPLAM Meeting with JS and PS										1.00*	1
	1.00*	Typing up of SPLAM meeting notes										1.00*	1
	2.00*	Creating Technology Forecasting Interview Template		2.00*									1
	1.00*	1600 Interview with CTO on Technology Forecasting (TF)			1.00*								0
21-Jan	1.00*	Typing out answers from CTO TF interview		1.00*									1
22-Jan	2.00*	Creation of Technical Planning (TP) Interview Template		2.00*									1
	1.00*	Creation of Architecture Definition (AD) Interview Template		1.00*									1
	2.00*	Creation of Tool Support (TS) Interview Template		2.00*									1
23-Jan	1.00*	TP interview at 0900 with Segment 7 Engineer (S7E)			1.00*								0
	0.50*	AD Interview at 1000 with F1 Engineer (F1E)			0.50*								0
	0.50*	Architecture Evaluation (AE) Interview at 1030 with F1E			0.50*								0
	1.00*	Tool Support (TS) Interview at 1100 with F1E and S7E			1.00*								0
24-Jan	1.00*	Typing up of TP interview answers		1.00*									1

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Table D.2 – continued from previous page

Date	*D*	*Task*	*RoP*	*IP*	*I*	*IS*	*S*	*A*	*W*	*F*	*R*	*M*	*OT*
26-Jan	1.00*	Typing up of AD interview answers		1.00*									1
	1.00*	Typing up of AE interview answers		1.00*									1
	1.00*	Typing up of TS interview answers		1.00*									1
27-Jan	1.00*	SPLAM Meeting with JS and PS								0.75*		0.25*	1
	1.00*	Typing up of SPLAM meeting notes										1.00*	1
29-Jan	3.00*	Data entry and analysis of survey results						3.00*					0
	3.00*	Writing of 29 Practice Areas Survey Summary Report							3.00*				1
2-Feb	0.50*	Scheduling Steering Committee Meeting (SCM) 2 with PS and JS schedules					0.50*						1
	1.00*	Setting up Computer Account at ME										1.00*	0
	4.00*	Writing AD report							4.00*				0
	4.00*	Writing TF report							4.00*				0
3-Feb	0.25*	Scheduling Steering Committee Meeting (SCM) 2					0.25*						1
	0.50*	SPLAM Meeting with PS feedback on 29 PA survey report								0.50*			1
	0.50*	SPLAM Meeting with PS feedback on AD report								0.50*			1
4-Feb	3.00*	Rewriting of 29 Practice Areas Survey Summary Report with PS feedback									3.00*		1
	2.00*	Rewriting of AD Report with PS's feedback									2.00*		1
5-Feb	1.00*	Steering Committee Meeting (SCM) 2 at 0900 about Survey Report								1.00*			0
	1.00*	Typing up of SCM2 notes										1.00*	0
18-Feb	2.00*	ME VPN Software set up in CSC lab										2.00*	0
	0.50*	Scheduling of interviews and meetings				0.50*							0
19-Feb	0.50*	Wrote a Progress Report										0.50*	0

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Table D.2 – continued from previous page

Date	*D*	*Task*	*RoP*	*IP*	*I*	*IS*	*S*	*A*	*W*	*F*	*R*	*M*	*OT*
20-Feb	1.00*	Configuration Management (CM) Interview with Build Engineer			1.00*								0
	0.25*	Scheduling CM interview over the phone and email with contractor				0.25*							0
23-Feb	2.00*	Began writing CM report							2.00*				0
	6.00*	Read Patterns Chapter	6.00*										1
	2.00*	Attempted to see if any patterns matched ME so far						2.00*					1
24-Feb	0.25*	Meeting with Group Product Manager (GPM) for Organizational Management Interview suggestions										0.25*	0
	0.25*	Emailed Jan Bosch requesting BAPO question sets										0.25*	1
	1.00*	Interview with System Architect about TF			1.00*								0
	3.00*	Received and read documentation about load balancing, builds, and coding standards	3.00*										0
	0.50*	Scheduling interviews				0.50*							0
25-Feb	0.50*	Wrote a Progress Report										0.50*	0
26-Feb	0.50*	AD interview with F1 Engineer (F1E)			0.50*								0
	0.50*	AE interview with F1E			0.50*								0
	0.10*	ME interview scheduling with Marketing Manager				0.10*							0
	0.10*	Scoping interview scheduling with ME Senior Product Manager				0.10*							0
27-Feb	2.00*	Wrote TRM interview template		2.00*									1
27-Feb	2.00*	Wrote Funding interview template		2.00*									1
27-Feb	1.00*	TP interview with F1 Engineer 5			1.00*								0

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Table D.2 – continued from previous page

Date	*D*	*Task*	*RoP*	*IP*	*I*	*IS*	*S*	*A*	*W*	*F*	*R*	*M*	*OT*
1-Mar	1.00*	First SPLAM meeting since Feb 3 with PS and JS										1.00*	1
	1.00*	0900 TRM interview with F2/F3 Project Manager (F2/F3PM)			1.00*								0
	1.00*	1000 began Funding report.							1.00*				0
	1.00*	1100 Funding interview with ME Director			1.00*								0
	2.00*	Wrote Building a Business Case (BABC) Interview template		2.00*									1
	1.00*	Write-up of SPLAM Meeting notes		1.00*									1
	2.00*	Created Market Analysis Question Set		2.00*									1
	2.00*	Wrote Scoping Question Set		2.00*									1
2-Mar	1.00*	BABC interview with BU Manager S7/F5			1.00*								0
	1.00*	MA interview with Marketing Manager			1.00*								0
	1.00*	Scoping interview with ME Senior Product Manager			1.00*								0
3-Mar	0.25*	Updated MPP (Microsoft Project) schedule					0.25*						0
	0.10*	Created SCM 3 Agenda										0.10*	0
	2.00*	Wrote URD Interview template	2.00*										1
	1.00*	Began URD Report							1.00*				0
4-Mar	1.00*	SCM 3 at 1000										1.00*	0
	1.00*	URD Interview with S7/ME Analyst Manager (S7/MEAM)			1.00*								0
5-Mar	0.50*	URD Follow-up with S7/MEAM			0.50*								0
	4.00*	Finished First Draft of URD Report							4.00*				0
14-Mar	3.00*	Preparation for meeting with Jan Bosch	3.00*										1

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Table D.2 – continued from previous page

Date	*D*	*Task*	*RoP*	*IP*	*I*	*IS*	*S*	*A*	*W*	*F*	*R*	*M*	*OT*
15-Mar	1.00*	Meeting with Jan Bosch (JB), and JS in DCSE teleconference lab										1.00*	1
	1.00*	Typing up notes into a BAPO question set from JB meeting	1.00*										1
16-Mar	0.50*	SPLAM Meeting with PS and JS										0.50*	1
	0.50*	SPLAM Meeting with PS and JS. JS gave feedback on URD report								0.50*			1
	1.00*	Write up of SPLAM meeting notes										1.00*	1
18-Mar	0.50*	Updated BAPO question set with JB's suggestions										0.50*	1
20-Mar	1.00*	Incorporated feedback from Mar 16 SPLAM Meeting into URD report									1.00*		1
22-Mar	5.00*	Completed First Draft of Funding report							5.00*				0
23-Mar	1.00*	SPLAM Meeting with JS and PS about BAPO questions										1.00*	1
	1.00*	Write up of SPLAM Meeting notes										1.00*	1
24-Mar	1.00*	SCM 4 at 1500 for feedback of preliminary reports on AD, URD, Funding and TF								1.00*			0
27-Mar	5.00*	First Rough Draft of AE Report							5.00*				0
30-Mar	2.00*	Created Testing Question set		2.00*									1
	1.00*	Began Testing Report							1.00*				0
	1.00*	SPLAM Meeting with PS and JS										1.00*	1
	1.00*	Write up SPLAM meeting notes										1.00*	1
	1.00*	Set up Microsoft Passport Account for Free/Busy Service										1.00*	1
	0.10*	Scheduling of SCM 5					0.10*						0
1-Apr	0.20*	Scheduling of Testing Interview with QA supervisor				0.20*							0

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Table D.2 – continued from previous page

Date	*D*	*Task*	*RoP*	*IP*	*I*	*IS*	*S*	*A*	*W*	*F*	*R*	*M*	*OT*
2-Apr	0.10*	Scheduling of DCMT Interview with F1 Project Manager				0.10*							0
4-Apr	1.00*	Began DCMT Report							1.00*				0
	2.00*	Created DCMT Question Set		2.00*									1
5-Apr	1.00*	Testing Interview with QA Supervisor			1.00*								0
	1.00*	SPLAM Meeting with PS and JS										1.00*	1
	1.00*	Write up of SPLAM meeting notes										1.00*	1
	1.00*	DCMT Interview with F1 Project Manager (F1PM)			1.00*								0
7-Apr	4.00*	Completed First Draft of DCMT Report							4.00*				0
8-Apr	5.00*	Complete First Draft of Testing Report							5.00*				0
	0.50*	AD Interview with F2/F3 Engineer at 1300			0.50*								0
	0.50*	AE Interview with F2/F3 Engineer at 1330			0.50*								0
12-Apr	6.00	TM CM Report Writing							6.00				0
13-Apr	5.00	TM Tool Support Report Writing							5.00				0
	4.00	OM MA report writing							4.00				0
	1.00	SPLAM meeting								0.50		0.50	1
	1.00	Admin tasks, this sheet, writing up SPLAM meeting notes, photocopying etc										1.00	0
14-Apr	0.50	Scheduling interviews				0.50							0
	1.00	SCM 5										1.00	0
	2.00	Writing up SCM 5 meeting notes										2.00	1
15-Apr	2.00	Writing up SCM 5 meeting notes										2.00	1
	0.17	Preparing MEA Interview		0.17									1
	1.00	Putting my files into CVS										1.00	1

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Table D.2 – continued from previous page

Date	*D*	*Task*	*RoP*	*IP*	*I*	*IS*	*S*	*A*	*W*	*F*	*R*	*M*	*OT*
	2.00	Installing and setting up WinCVS, Python, plink, pagent, putty, puttygen										2.00	1
	2.33	Writing MEA interview		2.33									1
	1.00	Typing up QA Supervisor's Testing answers verbatim		1.00									1
	0.50	Started Table of Tools							0.50				0
16-Apr	1.00	Mining Existing Assets/Testing Interview with F1E1			1.00								0
	0.75	Setting up WinCVS on ME workstation										0.75	1
	2.00	Scheduling interviews				2.00							0
18-Apr	2.50	writing CD interview template (began 20:40)		2.50									1
	0.75	Uploading papers and updated files to SERL										0.75	1
	0.50	Scheduling meetings (F1PM)					0.50						0
20-Apr	1.00	CD Interview with F1E1			1.00								0
	0.50	SPLAM meeting and scheduling of SCM 6 and 7					0.10					0.40	1
	0.50	Typing up SPLAM meeting notes and updating this Excel file										0.50	1
	3.00	Writing RE interview questions for interview with MESPM		3.00									1
	0.08	Reported blotchy printout problem with cs259 to SSG										0.08	1
	2.42	Preparing Follow-up questions for F1E2 about Architecture		2.42									1
21-Apr	1.00	Testing and Arch follow-up interview with F1E2			1.00								0
	1.00	RE interview with MESPM			1.00								0

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Table D.2 – continued from previous page

Date	*D*	*Task*	*RoP*	*IP*	*I*	*IS*	*S*	*A*	*W*	*F*	*R*	*M*	*OT*
	0.50	Scheduling interviews				0.50							0
22-Apr	3.00	Scheduling interviews				3.00							0
	3.00	Writing L and I Interview Template		3.00									1
	1.00	Began ORM Interview Template		1.00									1
23-Apr	1.00	AE and AD Interview with F2/F1E1			1.00								0
	0.50	Scheduling interviews				0.50							0
	1.00	MEA, Testing and CD interview with F1E3			1.00								0
	1.00	L and I Interview with GPM			1.00								0
	1.50	Scheduling interviews				1.50							0
24-Apr	2.00	Finishing Organizational Risk Management Interview Questions		2.00									1
	3.00	Wrote COTS Utilization Interview questions		3.00									1
	0.50	Updated Tool Table List							0.50				0
25-Apr	3.50	Writing SSI PA interview questions		3.50									1
	1.00	Uploading and updating other files (This one, Terminology, Big Picture)										1.00	1
	0.50	Scheduling interviews			0.50								0
26-Apr	0.50	Waiting for Interviewee to show up			0.50								1
	0.50	Updating Architecture Definition Report									0.50		0
	1.50	Scheduling				1.50							0
	1.00	ORM, TRM, and Funding Interview with GPM			1.00								0
	1.00	CD and COTSU Interview with F1E2			1.00								0
27-Apr	1.00	AD and AE Interview with S7E1			1.00								0
	0.75	Scheduling and Rescheduling				0.75							0

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Table D.2 – continued from previous page

Date	*D*	*Task*	*RoP*	*IP*	*I*	*IS*	*S*	*A*	*W*	*F*	*R*	*M*	*OT*
	1.25	Writing up SPLAM meeting notes for 27-Apr-2004										1.25	1
28-Apr	1.00	MEA and Testing Interview with F1E4			1.00								0
	0.50	Scheduling, updating time log				0.25						0.25	0
	1.00	Began RE Report							1.00				0
	1.00	RE interview with F1PM			1.00								0
29-Apr	1.00	F1E5 interview about Architecture Definition and Evaluation			1.00								0
	1.00	F2/F3E1 interview about SSI and Testing			1.00								0
	0.75	Miscellaneous: emailing questions, Scheduling, updating time table etc			0.25	0.25						0.25	0
30-Apr	4.00	Reading about the Market Marker Product Line Case Study	4.00										1
	0.50	Updated AD Interview template			0.50								1
	0.50	Updated AE Interview template			0.50								1
	0.25	Emailed out Requests for Documentation										0.25	0
	1.00	Wrote up similarities and differences between F1 and MM PL						1.00					1
1-May	3.00	Working on AD report and looking at MM PL for incremental PL tips							3.00				0
	1.50	Updated CIM interview template	1.50										1
	2.00	Went over Salion case study for incremental PL methods	2.00										1
2-May	2.50	Updating Tool, Asset, Product List Appendix tables							2.50				0
	1.00	Scheduling			1.00								0

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Table D.2 – continued from previous page

Date	*D*	*Task*	*RoP*	*IP*	*I*	*IS*	*S*	*A*	*W*	*F*	*R*	*M*	*OT*
	3.00	Going over Transitioning Legacy Assets to a PL Arch paper	3.00										1
	0.50	Working on AD report							0.50				0
	0.50	Updating Windows on LINC office computer with Windows Update										0.50	1
	3.00	Writing BABC Report							3.00				1
3-May	2.00	Writing BABC Report							2.00				0
	1.00	Updates to MEA, Testing and DCMT interview templates		1.00									1
	0.50	Admin: Sorting files, Printing 5 interview templates and emailing BABC			0.50								1
	1.00	Testing interview with SA			1.00								0
	0.50	Going over S7 Arch documentation provided	0.50										0
	1.00	AD interview with S7E2			1.00								0
	1.08	DCMT interview with QAS			1.08								0
	0.92	Admin: scheduling, updating timetable, sorting files				0.25						0.67	0
	0.50	Thinking of answers to JS's comments about BABC report						0.50					1
	4.00	Writing TRM Report first draft							4.00				0
4-May	4.00	Writing ORM Report first draft							4.00				0
	0.50	Last minute editing of ORM report							0.50				0
	0.50	Last minute editing of TRM report							0.50				0
	1.00	Began COTSU report							1.00				0
	0.50	COTSU interview with F1E1			0.50								0
	0.50	TRM interview with F1E1			0.50								0
	0.50	Preparation for SPLAM meeting										0.50	1
	2.00	Writing Operations Interview template		2.00									1

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Table D.2 – continued from previous page

Date	*D*	*Task*	*RoP*	*IP*	*I*	*IS*	*S*	*A*	*W*	*F*	*R*	*M*	*OT*
5-May	1.00	Writing Operations Interview template		1.00									1
	1.00	Updates to Appendices, schedule, Time Log, email				0.25			0.25			0.50	0
	1.00	SCM 6 Preparation (Agenda, Pre-meeting notes, entering event in SERL groupware)										1.00	0
	1.00	Updating Tools and COTS Component tables							1.00				0
	1.50	Updating Architecture Definition Report and related Appendix files									1.50		0
	0.50	Interview Preparation	0.50										0
	1.00	Operations Interview with GPM			1.00								0
	0.50	SSI Interview with S7E1			0.50								0
	0.50	Testing interview with S7E1			0.50								0
	0.50	Reading S7 Architecture Document							0.50				0
	0.50	URD interview with F2/F3PM			0.50								0
	0.50	DCMT interview with F2/F3PM			0.50								0
	0.50	AE interview with S7E2			0.50								0
	1.00	Admin: time table, email, scheduling				0.25						0.75	0
6-May	4.00	Wrote MBMCA interview template		4.00									1
	2.00	Updated AD report									2.00		0
	1.00	MBMCA interview			1.00								0
	0.25	Interview Preparation for DCMT		0.25									0
	0.25	Interview Preparation for MBMCA		0.25									0
	0.50	SSI Interview with F1E3			0.50								0
	0.50	CD Interview with F1E3			0.50								0
	1.00	Admin: Updates to non-PA specific docs (time log, tools, etc)							0.75			0.25	0

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Table D.2 – continued from previous page

Date	*D*	*Task*	*RoP*	*IP*	*I*	*IS*	*S*	*A*	*W*	*F*	*R*	*M*	*OT*
	3.00	Writing up Training Interview Questions		3.00									1
	1.50	Updated CIM interview template		1.50									1
7-May	4.00	Updating AE report									4.00		0
	3.00	Updating Testing Report									3.00		0
	0.75	Interview about CIM with MESPM			0.75								0
	1.50	Updating Testing Report									1.50		0
	0.83	SCM6										0.83	0
	1.67	Talked to JS about Product Core Asset/Variability diagram/tables	1.67										1
	0.50	Setting up accounts for GPM and CTO in SERL										0.50	1
8-May	0.75	Admin: SCM 6 Meeting Notes, Updating time log										0.75	0
	0.25	Created Metrics Table							0.25				0
	0.25	Updated Tool Table List							0.25				0
	4.00	Updated Testing Report									4.00		0
	0.10	Uploading files to SERL site										0.10	1
	0.15	Updates to Time Log										0.15	0
	3.00	Updating Testing Report									3.00		0
	1.50	Writing up SCM 6 meeting notes										1.50	0
	2.00	Making Variability Diagram (Word Crashed a lot)							2.00				1
9-May	2.00	Making Variability Diagram (Word Crashed a lot)							2.00				1
	3.00	Updating Testing Report									3.00		0
	3.00	Writing up SCM 6 meeting notes										3.00	0
10-May	4.00	Writing up PS definition questions		4.00									1

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Table D.2 – continued from previous page

Date	*D*	*Task*	*RoP*	*IP*	*I*	*IS*	*S*	*A*	*W*	*F*	*R*	*M*	*OT*
	1.00	Admin: Variability Diagram, Tool, Metrics tables		1.00									0
	2.50	Writing up STO interview questions		2.50									1
	0.50	Printing/Scheduling/filing/updating SERL site										0.50	1
	0.90	PD interview with GPM			0.90								0
	1.00	BABC interview with BUM F1/F2/F3/F4			1.00								0
	0.50	STO with ME Director			0.50								0
	0.60	Admin, updating table files		0.60									0
11-May	2.00	Reading about P1F10 and installing a Code Base 3 product demo	2.00										0
	3.00	9:20 finished and printed OP interview		3.00									1
	1.00	emails										1.00	1
	3.00	Reading documentation on Intranet Site	3.00										0
	1.50	Compiling Progress Info for SPLAM meeting										1.50	0
12-May	0.67	GPM interview about OP			0.67								0
	0.50	GPM interview about DCMT			0.50								0
	0.75	email follow-ups			0.75								0
	2.33	More email follow-ups (Testing, CM, Variability)			2.33								0
	0.50	reading email follow-ups						0.50					0
13-May	2.00	Writing DAAS Draft Report							2.00				0
	0.50	Wrote up the DAAS interview template		0.50									1
	5.00	Began Technical Planning report. Still not done.							5.00				0
	1.00	MA interview with ME SPM			1.00								0

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Table D.2 – continued from previous page

Date	*D*	*Task*	*RoP*	*IP*	*I*	*IS*	*S*	*A*	*W*	*F*	*R*	*M*	*OT*
	1.50	emailing follow-up questions, and scheduling interviews			1.00	0.50							0
14-May	2.50	Updating Variability Diagram. Word kept crashing							2.50				0
	6.00	Writing TP report							6.00				0
15-May	2.00	Writing TP report							2.00				0
	0.50	Changing files to SPLAM group in SPLAM repository on SERL										0.50	1
	2.00	Writing OP report							2.00				0
16-May	2.50	Writing OP report							2.50				0
	3.50	Writing PD report							3.50				0
	4.00	Writing PD report							4.00				0
	3.00	Writing Ops report							3.00				0
17-May	4.00	Writing STO report							4.00				0
	1.50	Writing Training report							1.50				0
	0.50	TP interview with S7/MEA Manager			0.50								0
	0.50	TP interview prep		0.50									1
	0.50	TP interview with F2/F3PM			0.50								0
	1.00	Admin Follow-up emails GPM, F1E2			1.00								0
	0.50	Updated Appendices							0.50				0
	2.50	Writing L and I report							2.50				0
18-May	3.00	Writing L and I report							3.00				0
	3.50	Writing CIM report							3.50				0
	1.00	Updating MA report									1.00		0
	1.00	Prep for May 18 SPLAM meeting										1.00	1
	1.20	May 18 SPLAM meeting with PS								0.70		0.50	0
	0.80	Writing email about Friday presentation					0.80						0
	2.00	Updating various reports and filling PLSC repository									1.00	1.00	0

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Table D.2 – continued from previous page

Date	*D*	*Task*	*RoP*	*IP*	*I*	*IS*	*S*	*A*	*W*	*F*	*R*	*M*	*OT*
	5.00	Writing Scoping report							5.00				0
19-May	4.50	Writing RE report							4.50				0
	1.00	URD interview prep		1.00									0
	0.75	URD interview			0.75								0
	2.25	Updating appendices: Tool List							2.25				0
20-May	10.00	Writing CD report							10.00				0
	3.50	MBMCA report writing							3.50				0
21-May	2.00	Writing COTS report							2.00				0
	2.00	MEA report writing							2.00				0
	1.75	Writing SSI report							1.75				0
	1.50	Making slides										1.50	0
	2.75	SPLAM meeting										2.75	0
	1.50	IO Presentation/SCM 7										1.50	0
	1.00	Admin: Photocopying time table										1.00	0
22-May	2.00	Writing up SCM 7 meeting notes						1.00				1.00	0
	3.00	Writing up SPLAM meeting notes for 21-May-2004						2.00				1.00	1
	2.00	Writing up SPLAM meeting notes for 21-May-2004						1.00				1.00	1
24-May	1.00	Writing up SPLAM meeting notes for 21-May-2004										1.00	1
25-May	0.50	Writing up SPLAM meeting notes for 21-May-2004										0.50	1
	1.00	Added PS changes to OP report									1.00		0
	1.00	Writing Summary of Friday's presentation for JS										1.00	1
26-May	3.00	Updating CM report. This took a long time because of the large # of changes.									3.00		0

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Table D.2 – continued from previous page

Date	*D*	*Task*	*RoP*	*IP*	*I*	*IS*	*S*	*A*	*W*	*F*	*R*	*M*	*OT*
30-May	2.50	Updating CM report. This took a long time because of the large # of changes.									2.50		0
31-May	2.50	Updating TS report									2.50		0
	2.50	Updating PD report									2.50		0
4-Jun	8.00	Backing up data, sys admin stuff										8.00	1
7-Jun	4.00	Working on BABC report									4.00		0
8-Jun	1.00	SPLAM Meeting										1.00	1
	1.50	Writing up SPLAM Meeting notes/updating thesis outline notes										1.50	1
14-Jun	2.00	Updating URD report									2.00		0
15-Jun	3.00	Updating URD report									3.00		0
	2.00	DCMT Updating									2.00		0
	2.00	Writing Patterns Report							2.00				0
18-Jun	1.00	SPLAM meeting								1.00			1
20-Jun	2.00	On Sunday went to my cubicle to try to log on										2.00	1
	1.00	Tried to log on to VPN with no success										1.00	1
22-Jun	0.75	SPLAM Meeting (last one until next month)										0.75	1
	1.50	Updates to training report									1.50		0
	2.00	Admin tasks, updating time remaining, uploading to SERL etc										2.00	0
24-Jun	2.00	Updating STO report									2.00		0
9-Jul	1.00	Unable to log into VPN at LINC office										1.00	1
6-Jul	1.00	Returning key to GPM's mailbox										1.00	1
10-Jul	1.00	Setting up CVS on MacOS X										1.00	1
	0.50	Updating Operations report									0.50		0
	1.00	Updating TF report									1.00		0
	1.00	Updating OP report									1.00		0

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Table D.2 – continued from previous page

Date	*D*	*Task*	*RoP*	*IP*	*I*	*IS*	*S*	*A*	*W*	*F*	*R*	*M*	*OT*
	1.00	Updating CIM report									1.00		0
	1.00	Updating L and I report									1.00		0
	1.00	Updating TP report									1.00		0
	0.50	Updating DAAS report									0.50		0
12-Jul	6.00	Updating various reports and filling PLSC repository									6.00		0
13-Jul	2.50	Roadmap writing							2.50				0
	1.50	SPLAM meeting preparations										1.50	1
	1.00	SPLAM meeting								1.00			1
	1.00	Rewriting roadmap									1.00		0
	5.00	URD, TP, and CM updates									5.00		0
14-Jul	5.00	Updating the glossary									5.00		0
15-Jul	4.00	Creating the final report file									4.00		0
	1.00	Writing the Exec summary							1.00				0
	1.00	Writing intro and Study chapter							1.00				0
16-Jul	1.00	Updating final report, updated ES							1.00				0
	3.00	Creating survey							3.00				0
	1.00	Updated Scoping and RE reports							1.00				0
	0.50	Updating this time log										0.50	0
17-Jul	2.00	Updating final report (word crashed and corrupted file several times)										2.00	0
	3.00	Writing up SPLAM meeting notes										3.00	1
19-Jul	0.25	Reading CMM paper JS sent me	0.25										1
	1.50	Printing and photocopying for 20-Jul SPLAM meeting										1.50	1
20-Jul	2.00	Updating References chapter in Final Report (FR)							2.00				0
	0.75	SPLAM meeting										0.75	1

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Table D.2 – continued from previous page

Date	*D*	*Task*	*RoP*	*IP*	*I*	*IS*	*S*	*A*	*W*	*F*	*R*	*M*	*OT*
	0.50	Printing and photocopying for 20-Jul SPLAM meeting										0.50	1
	1.00	Writing up notes from SPLAM meeting										1.00	1
	1.00	Updating files from SPLAM feedback: Surveys, SCM8 agenda										1.00	0
	0.50	Updating time log										0.50	0
23-Jul	2.00	Cutting and Pasting report into one and mailing off to PLSC										2.00	0
26-Jul	4.00	Preparing for the SC meeting, photocopying, making pre-meeting notes										4.00	0
27-Jul	3.00	Preparing for the SC meeting, photocopying, making pre-meeting notes										3.00	0
	1.00	SCM8										1.00	0
	1.50	SCM8 post meeting at Tim Hortons										1.50	1
28-Jul	2.00	Writing up Paul's changes to ES and Intro									2.00		0
	2.00	Writing up SCM8 meeting notes										2.00	0
29-Jul	1.00	Admin: Emailing to set up SCM9/Final Presentation										1.00	0
30-Jul	2.00	Updating Report with PS's Case Study Chapter Changes									2.00		0
	1.00	Updating this time log										1.00	0
1-Aug	8.00	Preparing Final Patterns Presentation	8.00										0
2-Aug	2.00	Updating PA Presentation										2.00	0
3-Aug	5.00	Rehearsing and reading up to prepare for Aug 4 presentation	5.00										1
4-Aug	3.00	Aug 4 Findings presentation										3.00	0

Values with an '*' are estimates.

Table D.2: Time Log