Lessons Learned Collaborating on a Process for SPI at Xerox

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Abstract

During 1995-1998, Xerox Corporation's West Coast Production Systems Group (PSG West) worked with the Software Engineering Institute (SEI) to apply the prototype Process Change Model (PCM) to aid in their efforts to reach Level 2 of the Software Capability Maturity Model (CMM), and to develop the generic processes required for Level 3. The Process Change Model, along with a companion guidebook, was designed to provide the basis for a systematic approach to technology-specific change based in part on "whole product" principles, with a focus on one key process area (KPA) at a time. This report describes a collaborative effort to develop a more systematic and detailed approach to software process improvement (SPI) through use and evaluation of prototype versions of the PCM and guidebook. In particular, the work of the PSG West software engineering process group (SEPG) to apply the PCM and guidebook in working with improvement action teams focused on the KPAs of the Software CMM is described. Lessons learned about the "live" evaluation and maturation of a new process and guidebook such as this are presented. These lessons should be of interest to those engaged in work on technology maturation and the adoption of technological or process innovations as well as to those engaged in SPI and process development.

Capability Maturity Model and CMM are registered in the U.S. Patent and Trademark Office.

1 Introduction and Background

Xerox Corporation's West Coast Production Systems Group (PSG West), an organization that includes about 450 software developers, initiated a Software Capability Maturity Model (CMM)-based software process improvement effort beginning with a CMM-based appraisal for internal process improvement (CBA IPI) in late 1994 [Paulk 91].[1] From 1995 to mid-1998 PSG West created a software process improvement (SPI) strategy and executed related tasks for its dozen or so software projects. Four improvement action teams (IATs) were initiated over a three-month period, with the goal of achieving Software CMM Maturity Level 2 and of creating the process solutions that would be required for Level 3.

PSG West established a collaboration with the Software Engineering Institute (SEI) to use the SEI prototype Process Change Model (PCM) and related guidebook.[2] The goal of the collaboration was to provide structure to the work of PSG West improvement action teams. The SEI would receive the feedback necessary for the PCM's further development. Because of Xerox's quality-based culture (divisions of Xerox Corporation won the Malcolm Baldrige award in 1989 and again in 1997)[Caudron 91], PSG West approached the SPI effort systematically, documenting effort expended, minutes of meetings, and lessons learned in a disciplined manner, and making available a good record of the collaboration.

This report describes the process and results of the collaboration during Xerox's 1995-1998 SPI work (their work continues). The strategy inherent in the PCM reflected an approach to software process improvement that is common in the software community—that is, a key process area (KPA)-based approach. The emphasis in this approach is on the development of "generic" process descriptions, by IATs, which can then be adapted by project organizations.[3] This report describes the pros and cons of that strategy as applied at PSG West, in the context of a detailed look at the collaboration.

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[1] We reference the original technical report on the Software CMM, not the current and more widely known book on the Software CMM, because the original is what was used at PSG West. The current version is [Paulk 95].

[2] We refer to both the model and guidebook from this point forward as the "PCM" or the "prototype PCM," as was the case in PSG West's usage of the terms. Throughout this report, we emphasize that the prototype versions of the PCM itself and the related guidebook were used. Since the work described here was completed, the model has been reengineered both for SPI use [Kasunic 98] and for application to more general technology adoption. The latter version was renamed the "technology transition model," and is presented in the SEI course, Introducing New Software Technology. In addition, aspects of the PCM have been incorporated into the IDEAL-Based New Technology Rollout (INTRo) process, now being evaluated [Levine 99].

[3] This is a typical approach to Software CMM-based software process improvement; see for example, any of the proceedings of the Software Engineering Process Group conference, 1996-1999.

This report is organized as follows: In the remainder of this chapter we describe how SPI began at PSG West and give background on the SPI infrastructure and the decision to use a model-based approach to SPI. Brief descriptions of the PCM and another SEI model related to SPI, the IDEAL[SM] model [McFeeley 96], are provided. Chapters Two through Nine each describe one of the eight major activity areas from the PCM. For each area, we describe the purpose of the activity and the tasks it included, and the highlights of what PSG West actually did (the PCM was offered, not mandated, for use). Then, also for each activity, we discuss issues at both the IAT and SEPG level and lessons learned. In our discussion of Activity 8, Wrap Up (in Chapter 9), we focus on overall lessons learned in the use of the PCM. In the final chapter, we present our perception of the value of the collaboration. The experiences described here should be of interest to those engaged in work on technology maturation or the adoption of technological or process innovations, as well as to those engaged in SPI and process development.

1.1 How SPI Began at PSG West

In 1986, a number of quality improvement teams and benchmarking projects began to document the limitations of existing development and maintenance practices in PSG West software projects. While pockets of improvement existed, these activities did not spread to PSG West as a whole. PSG West's approach to software development was similar to other typical organizations assessed at Software CMM Level 1. Management at PSG West believed that there must be better approaches to software development, despite the business necessity of giving priority to schedule.

Malcolm Baldrige Award winners are required to "adopt" a university and teach people at that university quality principles. In 1993 Xerox as a corporation adopted Carnegie Mellon University (CMU) and initiated a quality education effort.[4] In this joint program, personnel from the Software Engineering Institute at CMU and Xerox participated in technical interchange: quality principles and methods were provided by Xerox to CMU, and assistance with Software CMM-based software process improvement was given by the SEI to Xerox. In 1993, Xerox Corporation embraced the Software CMM as the basis for diagnosis and improvement of software process throughout the company, and began a working relationship with the SEI, which provided consultants to assist in a number of SPI efforts.

1.2 Establishing a Permanent SPI Organizational Infrastructure

In SPI orientation activities conducted by SEI consultants, management at PSG West agreed that any software process improvement effort must be continuous and long-term. Thus management at PSG West determined that for SPI to succeed, PSG West needed to establish a permanent organizational infrastructure that could build and deploy effective process im-

[SM] IDEAL is a service mark of Carnegie Mellon University.
[4] Paul Allaire, then president of Xerox, is a CMU alumnus.

provements through direct and cohesive participation at all levels of management. Based on the recommendations of the SEI, PSG West established the following groups to be directly responsible for software process improvement at PSG West:

- Executive council
- Management steering team (MST)
- Software engineering process group
- Improvement action teams

In making these suggestions, the SEI consultants followed guidance based on the lessons learned by the software community and the SEI; these lessons were later described in *IDEAL: A User's Guide for Software Process Improvement* [McFeeley 96]. These early SPI efforts pre-dated the PCM collaboration.

1.3 How PSG West Began Using PCM

Details of the PCM were taught in an SEI course, *Introducing New Software Technology*, attended by the PSG West SEPG. At that point in initial SPI activities, the SEPG was investigating approaches to IAT work. A collaboration with the SEI, to apply the PCM in the work of one or two IATs at PSG West, was subsequently negotiated. The risk of using the new model and guidebook was to be mitigated by having the SEI author work with the PSG West SEPG as a coach.[5]

1.4 Using Models for Guidance in SPI at PSG West

The PSG West SEPG chose several models to provide a basis for their SPI strategy and plans. SEPG members selected the Software CMM as the reference model for improved software engineering practice. PSG West used the SEI's IDEAL model because it provided the basis for an overall strategy and its guidebook [McFeeley 96] offered high-level guidance for SPI. The PCM was used as the basis for the plans made by the IATs, and for support to them from the SEPG. PSG West wanted to use existing models and adapt the models to suit their needs rather than invent approaches and strategies from scratch. The approach to using these models is described in the following sections.

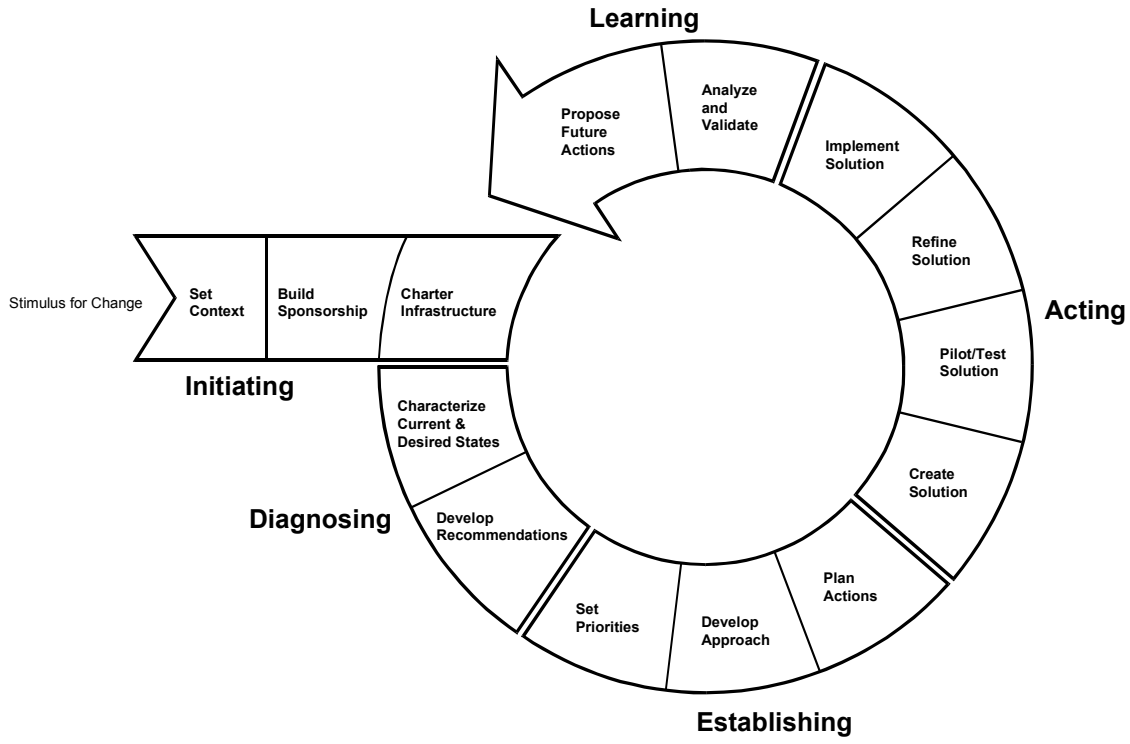
1.4.1 The IDEAL Model

The IDEAL model consists of five phases of improvement in an organization: Initiating, Diagnosing, Establishing, Acting, and Learning (see Figure 1) [Gremba 97, McFeeley 96]. In

[5] In 1994, early in the relationship between Xerox and the SEI, an initial collaboration led to the development of a software inspections adoption process for Xerox based on one SEI consultant's prior experiences [Ackerman 83, Fagan 76]. Later, an adaptation of the inspections adoption process for application to software technology more generally was developed [Fowler 96a, Fowler 96b], in the form of an early draft of the Process Change Model and guidebook. The model combined aspects of the Xerox Leadership Through Quality problem-solving process with the generalized adoption process, and the guidebook was prepared containing guidance on the application of the model.

the Initiating phase, an organization determines the need for change due to business conditions, quality issues, or other fundamental stresses. In the Diagnosing phase, the organization takes stock of its situation, comparing it to a more desirable state. This phase is often performed as an audit, perhaps by a consulting firm, or as an assessment, such as those performed for the International Standards Organization or using the Software CMM. In the Establishing phase, plans are laid for addressing the issues identified in the Diagnosing phase; this may include setting up teams or task forces to take action on the issues. In the Acting phase, the teams execute tasks to further understand issues and resolve them if possible. Finally, in the Learning phase, the organization looks back at the experiences of the entire IDEAL cycle, and notes lessons that have been learned and steps to take to improve their performance in the future.

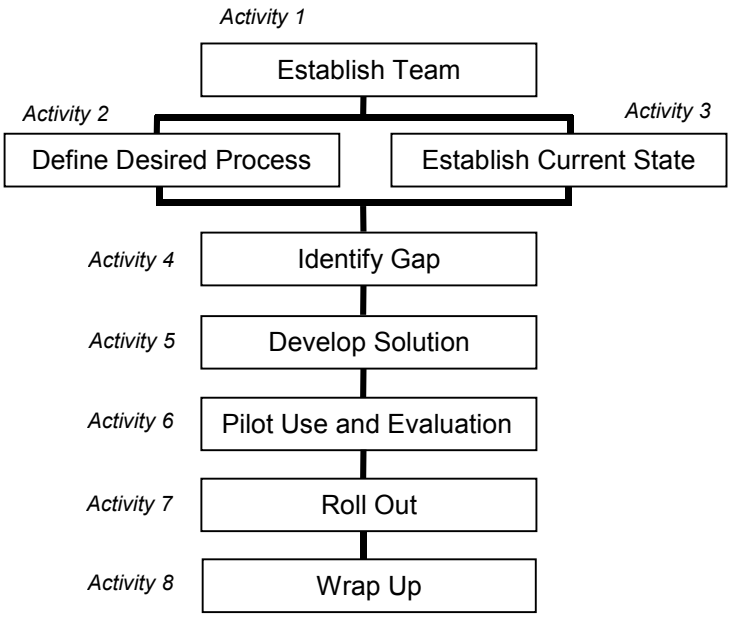
Figure 1: The IDEAL model



1.4.2 The Process Change Model: Elaboration on IDEAL

The PCM (see Figure 2) overlaps and expands upon the Establishing, Acting, and Learning phases of the IDEAL model, and is focused on the work of a team that is responsible for introducing a specific software-related change (such as an IAT). One or more teams, depending on the size of the organization and the breadth of improvement-related change that is desired, follows the PCM independently, with the SEPG performing overall coordination.

Figure 2: The Process Change Model



There are eight major activities in the PCM, represented at their most abstract level in Figure 2. In Activity 1, the team—an IAT, in the case of PSG West—is established, with a charter written to provide scope, establish boundaries, and describe team member roles. During Activity 2 through Activity 4, the IAT gathers and evaluates the requirements for the particular area it will focus on; in PSG West's case the requirements were derived from a comparison between the KPA being introduced and the baselined current state of KPA-related work in the PSG West software projects. In Activity 5, the IAT develops a prototype solution based on those requirements, possibly in conjunction with an interested project. In Activity 6 the IAT performs pilot testing of the prototype solution, preferably on more than one project; this also allows the IAT to evaluate the process of adaptation and introduction in the context of a specific project. Steps in Activity 7 address "rolling the solution out"—that is, adapting and deploying a solution, project by project, to participants in the particular improvement effort. In Activity 8, the IAT wraps up and hands off materials for ongoing support to a central group—the SEPG, in the case of PSG West—and to other functional organizations such as training, and then disbands.

1.4.3 Using the Models

The essence of the use of the PCM and IDEAL models was that the PSG West SPI effort was managed like a project, with the SEPG acting as project manager. The SEPG created a schedule for SPI as a whole, based on the elements in the IDEAL model. The PCM activities provided the basis for IAT-level plans. These elements were tracked and reported on a regular basis during the SEPG meetings and during the meetings with the MST. The SEPG used a combination of the two models to provide a high level status of PSG West's SPI effort (see Figure 3).

Figure 3: An IDEAL and PCM-Based Status Report Format

IDEAL:	*Initiate*	*Diagnose*	*Establish*	*Act*					*Learn*
		PCM:	*Establish Team*	*Define Desired Process/ Establish Current State*	*Identify Gap*	*Develop Solution*	*Pilot Use and Evaluation*	*Roll Out*	*Wrap Up (and repeat PCM cycle)*
IAT Schedule	Reqts. Mgt.	Plan: Actual:							
	Plg. & Trkg.	Plan: Actual:							
	SQA	Plan: Actual:							
	SCM	Plan: Actual:							
	SSM	Plan: Actual:							

The SEPG took the lead in learning about Software CMM, SPI, and the PCM. Each IAT was assigned a member of the SEPG as a resource—a consultant—in these areas. This allowed the members of the IAT to focus on the specific technical or process work related to their KPA.

The Requirements Management improvement action team (RM IAT) and the combined action teams for Software Project Planning and Software Project Tracking and Oversight (SPP/SPTO IAT) used the PCM directly, with lessons passed along to other IATs whose work was scheduled to take place later. (For these latter teams, the PCM was optional.) Thus the experiences described below come predominantly from those two IATs.

2 Activity 1: Establish Team

Each section in this and the following chapters describes one PCM activity and its purpose, lists the tasks in the activity, provides highlights of work done by one or more IATs, notes what worked well and what problems were encountered, and ends by summarizing lessons learned. Some issues crossed IAT boundaries and affected all the teams; these are described here as SEPG-level problems. The lessons learned that are listed are based on in-process as well as post-process feedback from the IATs using the PCM, and from the SEPG.

2.1 Purpose

The purpose of Activity 1 was to set up an IAT and develop a plan for improving a software development project's process in the area of a specific KPA. Important work in this Activity included confirming sponsorship by a specific manager for the IAT. The sponsoring manager—"sponsor" for short—was to provide administrative and strategic guidance to the IAT and to articulate IAT progress or issues to other managers. In most cases, the sponsor was also a member of the MST and a project manager whose project would, eventually, participate in a pilot implementation of an IAT solution. Aligning the sponsor's perspective with that of the SEPG consultant supporting the particular IAT, as well as with the IAT leader once he or she was appointed, was thus particularly important in the early life of an IAT. Other important tasks in Activity 1 included developing an IAT charter, appointing IAT members, holding an IAT kickoff session, and developing an IAT plan. Selecting a domain expert—someone who had experience and background in the area that the IAT was to work in—was also included in Activity 1.

2.2 Tasks

1. Assign SEPG consultant and sponsor.
2. Draft a tactical plan.
3. Align the understanding of the sponsor and the SEPG consultant.
4. Select the IAT leaders and members.
5. Conduct a management awareness workshop.
6. Finalize the tactical plan and align sponsor, SEPG consultant, and IAT leader.
7. Conduct a "go/no go" meeting for IAT.
8. Conduct the IAT initial training.

9. Conduct the IAT kickoff.
10. Develop an improvement activity plan.
11. Select a domain expert.
12. Record and analyze lessons learned.

2.3 Highlights of What Was Done

Most of the work specified in Activity 1 was already underway when PSG West decided to work with the PCM. Activity 1 PCM tasks were revised to reflect this during a pre-collaboration revision process which customized the PCM for PSG West use. PSG West kept to its plan, developed prior to the collaboration, to initiate one IAT about every six weeks. This approach to IAT start-up was consistent with the goal to make the RM IAT the first user of the PCM, and to pass along lessons from its early use to the SPP/SPTO IAT and other IATs interested in following the PCM.

2.3.1 Establishing the Management Focus Teams

Early in the SPI start up activities, three management focus teams (MFTs) were established by the MST to address the four Software CMM common features, which include common elements that support the activities performed by a KPA, such as policy statements, sponsorship, allocation of resources and funds, and training. The size of the MFTs ranged from three to five members. The PCM did not address establishing the MFTs explicitly, although its "whole product" approach [Moore 91] implied preparing materials and taking actions regarding common features and other support for implementing KPA activities.

2.3.2 Establishing the Improvement Action Teams

The MST chartered five IATs to create solutions to the problems identified in the CBA IPI. Software engineering professionals drawn from PSG West projects staffed each IAT; one of the members was appointed to be the team leader. Each IAT was tasked to improve and/or implement software practices in a specific KPA.

IATs met weekly for two to four hours, and worked outside the meetings for about another six hours, with an occasional full-day meeting off site. The size of the IATs ranged from 6 to 10 members. The teams followed the activities in the PCM, coached by the SEPG member assigned to their team as consultant. Their goal was to prepare KPA-specific process descriptions and related materials that would help software projects adopt, maintain, and evolve the processes, and plan their deployment.

2.3.3 Training Members of the Improvement Action Team in SPI-Related Concepts

The SEPG was responsible for facilitating the development and progress of the IATs, including Software CMM- and SPI-related training. Xerox did not have internal training courses related to SPI at that time, so the SEPG provided some training itself, developing the materials based upon

its own training. Other training, in KPA-specific topics, was acquired as needed by the IATs. Internally available courses related to team and quality methods were also used. Training subjects, audiences, and sources of material and/or instructions are listed in Table 1. (For completeness, we list all courses here, even though several were not used until later PCM activities.)

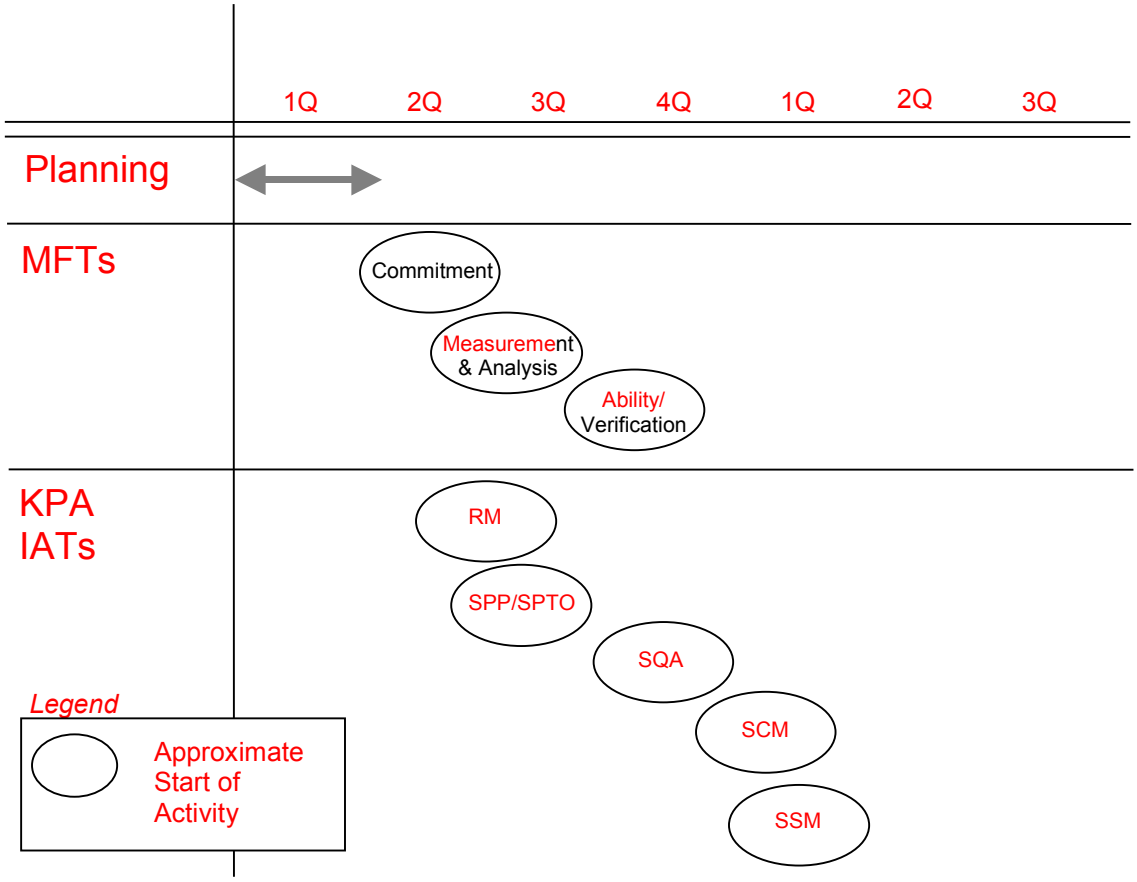
Table 1: Training Received by Improvement Action Teams

IAT Training Topic	Audience	Source of Material/Instruction
Software CMM overview	All IAT and MFT members, MST members, first-line managers, and project leaders	Software CMM [Paulk 91] and PSG West SEPG training
Overview of PSG West SPI strategic plan and SPI infrastructure	All IAT and MFT members, MST members, first-line managers, and project leaders	PSG West SPI strategic plan/PSG West SEPG
Overviews of specific KPAs	All IAT and MFT members	Software CMM [Paulk 91] and PSG West SEPG
Requirements, and a software tool for RM	RM IAT members	Vendor
Team methods	RM IAT members	Xerox internal training
Root cause analysis	Software configuration management (SCM) IAT members	Xerox internal training
Goal/question/metric technique	Measurement and analysis MFT members	Vendor
Software project planning and management	SPP/SPTO IAT members; SEPG and MST members; managers involved in the pilot use of the SPP/PTO solution	Vendor
Software quality assurance	SQA and SEPG members	Vendor

2.3.4 The Lead Goose Strategy for Launching Improvement Action Teams

The PSG West SEPG decided to stagger the initiation of IATs (and MFTs), based on the experiences with SPI in other Xerox organizations. (See Figure 4.) This "lead goose" strategy meant that the earlier teams might take longer to get going, and might have to do more work to develop the first instances of materials and tactics, but the net effort of all the teams would be reduced. In effect, the first IAT would break the trail for the other IATs, reducing their risk by passing lessons back to them as they started, and by developing materials such as templates that could be reused. The SEPG members who were waiting for their IATs to begin work would help the lead IATs to prepare these materials.

Figure 4: The SPI Activity Start-Up Time Line: IAT and MFT Start-Up Schedule Showing the RM IAT as "Lead Goose"



2.4 What Worked Well

2.4.1 Membership

Overall, Activity 1 was a positive experience for the IATs. Most IATs felt that strong members had been selected: they had the needed experience, skills, and expertise; worked well together; and supported the work they were assigned to do. Attrition was occasionally a problem: one team even lost a member before team kickoff. The consensus was that IATs needed to be staffed in anticipation of losing members due to relocation, promotion, resignation, etc. Some team members observed that the IAT served as a "good networking forum."

2.4.2 Support from SEPG

The PCM suggested using examples, checklists and templates, but provided only a few of these. And in fact, the creation of document templates was well underway at PSG West prior to the start of the SEI/Xerox collaboration, and was one of the most useful activities in the direct support of IATs by the SEPG. The SEPG created templates to help IATs facilitate rapid development of materials and to provide a standardized approach. Then once one IAT had used a template, an example plan was also available. For example, a template for the piloting plan was developed, used by the RM IAT to create a piloting plan, and then reused by other IATs subsequently, with each sharing an example of its plan.

2.5 IAT-Level Issues

2.5.1 PCM Training

The IATs felt that training on the PCM was too limited, as the SEPG consultant for each IAT had provided only a brief overview at the kickoff of each team, with the assumption that detailed guidance would come through the consulting relationship. As IATs began to follow the guidance in the PCM in detail, it was not clear to them how the individual tasks supported the overall objective of the PCM process—to create usable solutions and pilot them. IATs stated that they needed more of a "big-picture" perspective from the SEPG and the SEI coach.

2.5.2 PCM Value

The IATs were unclear about the value of the PCM. Also, one team expressed specific concerns about the PCM style and format; the consistency of its terminology with that of other SEI sources; an uneven level of detail; and inconsistencies between sections.

2.5.3 Level of IAT Effort

Regarding level of effort estimated for IAT work, some teams reflected that 10 hours per week might not be enough time to do the job they were given and that it was difficult to coordinate all of the team members' schedules.

2.6 SEPG-Level Issues

2.6.1 Extent of IAT Training

A general concern was how much training IAT members should receive, and whether training from the SEPG was enough. Some IATs wanted training directly from the SEI or from vendors. There was consensus that the SEPG needed to better understand what members of an IAT knew prior to training. Conveying the "big picture" of the PCM was particularly challenging, because the SEPG itself had had training on the PCM but did not have experience using it.

2.6.2 Managing the Collaboration Day to Day

The relationship between the PSG West SEPG and the SEI was designed to filter the interaction between the SEI coach and the IATs. This had the positive effect of channeling concerns through the SEPG and allowing for organizational learning—if all SEPG members knew of lessons and issues, then all IAT members could be assured of access to these. It also had a negative effect by delaying the SEI coach's awareness of concerns as well as her ability to provide clarification to both the SEPG and the IAT.

2.7 Lessons Learned

- *Anticipate attrition when staffing IATs.*

It is inevitable that IAT members will be lost. The team needs to be large enough so that when there is turnover in membership, a core group that can maintain momentum still remains. Focusing on IAT leader selection is necessary but not sufficient in the early life of an IAT.

- *Identify back-up sponsors.*

There may also be attrition in the group of sponsoring managers. Some managers may be more interested in SPI than others or may have more time available. Early identification of additional sponsor candidates allows for including them in SPI-related activities from the start. A group of managers educated about and interested in SPI is then available to draw from as needed.

- *Overprepare SEPG members for critical presentations.*

If SEPG members are using a common process (such as the PCM) for IAT work, rehearse any process overview presentation given by SEPG members with the process coach (in this case the SEI coach) and/or each other. This allows consolidation of SEPG knowledge of the process and a smoother presentation to IATs. As experience is gained, SEPG consultants working with IATs kicking off later will then be able to get better support from those working with earlier IATs.

- *Complete document templates prior to starting IATs.*

The PCM focused on creation of templates by the IATs for the eventual users of the solutions created by the IATs. It is equally important to prepare templates for the IATs to use, and these need to be ready prior to the IATs' beginning to use the PCM or other common process model.

- *Minimize the adjustment required of teams when a process is new or rough.*

When using a prototype document such as the PCM, make sure it looks as much as possible like a finished product. Provide formatting and terminology that is consistent with documents that IAT members are accustomed to working with.[6]

[6] This lesson was applied by the IATs as they prepared their process solutions, and expedited solution acceptance by both the MST and the adopting projects.

3 Activity 2: Define Desired Process

3.1 Purpose

The purpose of Activity 2 was to create a requirements specification for the process a project would follow to be consistent with a particular KPA. The IAT's task was to determine what was needed for that KPA process for projects at PSG West. The simplest approach to this was to use the Software CMM itself; another approach was to use the Software Process Framework (SPF) [Olson 94], which restates the Software CMM in a process format and can serve as a starting point for process definition.

The essence of this step in the PCM was interpreting the Software CMM so that its applicability to PSG West projects was clear. This meant determining what outputs and states would result from a project's use of a Level 2 KPA process; who received those outputs or was affected by the state change; how the Software CMM statements might be translated into a process format that PSG West projects would understand; how current policy might need to be revised to support the envisioned new process and its outcomes; and how the process would be delivered (what training, documentation, and behavior changes would allow a project to execute that process).

3.2 Tasks

1. Identify the KPA process output.
2. Identify the customer (for the output).
3. Identify the KPA process requirements.
4. Translate the KPA process requirements into specification.
5. Review the draft policy (for the KPA process).
6. Identify the initial whole product "wheel" (what things besides the process would be needed to help users use the process).
7. Record and analyze lessons learned.

3.3 Highlights of What Was Done

3.3.1 Educating the Team

The RM IAT located and viewed a tape from the SEI Software Engineering Series on requirements management [Zelesnik 92]. The RM IAT also looked at the Software Process Framework for an example of how requirements management looked when specified as a process. Later, the team brought in a vendor to obtain training on requirements engineering as

well as on a related software tool, acknowledging that the RM IAT would have to select a subset of material from what they learned in order to address RM as a KPA. The SPP/SPTO IAT brought in training on project planning from another vendor; this proved very valuable, particularly in the area of estimation. Other IATs brought in courses on software measurement and quality assurance. Again, these were not tailored to implementation of particular KPAs.

3.3.2 Gathering Process Requirements

The RM IAT knew that it could not create processes without adapting them to suit local conditions. Thus the RM IAT organized a "roundtable" meeting, inviting marketing, planning, and software development representatives from each project participating in the SPI effort. The purpose of the meeting was to solicit input on how best to manage requirements from the perspective of people in various roles. Participants were sent the draft requirements management policy, the draft requirements specification for the requirements management KPA, and questions to stimulate thinking. The SPP/SPTO IAT built on the RM IAT's lessons learned, using the same approach but with changes. Its roundtable was made a two-stage process, where the first meeting was orientation and the second meeting focused on gathering data.

3.4 What Worked Well

The roundtable format first used by the RM IAT was successful, and was also used by other IATs. In gathering process requirements, members of the RM IAT needed to discuss and concur on a common interpretation of the Software CMM practices for requirements management. They clarified who the "customer" was for the RM process, with a list of specific customers to refer back to, and built a common understanding of RM for PSG West. They used the SPF to understand how RM looked as a process.

3.5 IAT-Level Issues

3.5.1 IAT Level of Effort

Based on records kept by the SEPG, it appears that people were not able to devote as much time to the IATs as originally planned. Based on a basis of 10 hours per week per IAT member, 240 hours of IAT work were planned in the first month of RM IAT operation, and 200 hours in the second month. Actual hours were 79 and 80, respectively. Project work commitments conflicted with members'getting to IAT meetings. The PCM did not suggest a particular approach to IAT effort or frequency of meetings; at Xerox, teams were set up to work on quality and other corporate issues, and these typically met every week, so the IATs were structured in the same way.

3.5.2 The PCM and IATs as Change Agents

As the collaboration between PSG West and the SEI continued, it became clear that the already steep learning curve for the Software CMM and software process improvement was

made steeper for the IATs as they also tried to learn both about their KPA-related change and about being change agents according to the PCM.

3.5.3 Software CMM-Specific Training for IATs

Very little training and education specific to requirements management or other KPAs was available in 1995. While the Level 2 KPAs were well known areas within software engineering generally, their specific presentation and definition in the Software CMM was not yet widely addressed by Xerox internal training, commercial training, or consulting organizations. For example, it was fairly easy to find a course on requirements engineering or systems engineering, or software project management, but it was difficult to find courses that addressed requirements management or project management as defined in the Software CMM. And while IAT members had had experience in the particular areas where they were working, they had not had experience framing those areas according to the Software CMM; much education, both from outside and from their own personal and group efforts, was needed. This had not been clearly spelled out in the PCM, in part because the PCM was not Software CMM-specific.

3.5.4 KPA Process Requirements: The Roundtable and the SPF

Attendees at the first roundtable meeting held by the RM IAT did not immediately distinguish between the "requirements" referred to by requirements management, and the requirements for a *process* to do work in a KPA — in this case the requirements management process. Nonetheless, after this was clarified, the team felt that the roundtable was a success and received good information from it.

The RM team's rewrite of the requirements management process of the SPF to adapt it for PSG West took longer than desired; the detail in the SPF was a distraction for the team members, who were new to developing process descriptions. In addition, the team discovered that requirements terms obtained from the roundtable discussion and other investigations were not used consistently across PSG West projects and that the current approach to requirements biased the terminology that they wanted to use for the revised PSG West process.

As the RM and SPP/SPTO IATs gained experience, useful lessons were passed to the IATs that had started later. For example, in the case of defining the desired state in Activity 2, one member said, "Don't get trapped defining what your project does now—describe what the new process will do."[7] Another member said, "Draft a process—not the procedures or how to do it, but what to do."

[7] Much later in the collaboration, PSG West IATs indicated that they felt they were required to start with a "clean slate" in developing process solutions. This perception caused them to assume that they could not use current good practices from PSG West projects, and definitely slowed down both the solution development and solution adoption efforts.

The PCM focused on getting the requirements and then developing, in conjunction with stakeholders, a vision of how those requirements might be transformed into a process for RM or one of the other KPAs. Guidance on how to elicit the requirements was not provided, based on the assumption that software project members would have experience with requirements. In addition, the PCM did not make clear what level of detail was required, or how the current process in a software project might feed into the requirements-gathering process.

3.6 SEPG-Level Issues

3.6.1 Providing KPA-Specific Knowledge to IATs: Training

Once Activity 2 was underway, IAT members immediately saw the need for more detailed knowledge as they worked to create a specific vision for how each KPA process would work at PSG West. This problem was handled at the IAT level, but it might have been handled more effectively at the SEPG level, had it been recognized earlier in the SPI planning process. The SEPG and IATs acknowledged, during Activity 2 and later in Activity 5, that more detailed training and/or education in their respective KPAs should have occurred during Activity 1, in addition to the more general courses that were provided.

3.6.2 Providing KPA-Specific Knowledge to IATs: Domain Expert

The PCM suggested that, in addition to KPA-specific training for the IATs in Activity 1, a domain expert be selected to serve as an adjunct member of the IAT. A domain expert, as described in the PCM, would have experience eliciting requirements from stakeholders and adapting existing approaches to a KPA, to develop the "desired process" that is the objective of Activity 2. Some issues in Activity 2 came about as a result of not having domain experts in place for the IATs.

3.7 Lessons Learned

- *Be sure the IAT has content expertise.*

Even if team members believe that they share a common understanding of a KPA, viewing a video or taking a one- or two-day class as a group early in the life of the team ensures that all members have been exposed to the same terminology. The IAT should get expert help as soon as possible, especially for learning about how other organizations have approached KPA solution development. Having access to a domain expert can compensate for incomplete knowledge early in the life of an IAT.

- *Hold a roundtable meeting to get customer input. Provide Software CMM and SPI orientation.*

Use a two-stage approach to gathering process requirements from projects, with the first stage being orientation to the Software CMM and SPI (or other frameworks) and the second being data gathering. A major lesson learned was that many attendees didn't know about SPI

or the Software CMM, so the roundtable took longer than expected, and a second meeting had to be scheduled to finish the work.

- *Use packaged processes with caution.*

Packaged processes such as those in the SPF or purchased from vendors can save time, but only if not followed literally. Examining several packaged processes might clarify what can be safely simplified or left out. It is best to look at processes that have been used in the same application areas as those in which your organization works.

- *Strike a balance between drawing out the best of what is and the best of what can be with the desired process.*

Build on the best of your current process while remaining open to new approaches. No single project may have all the answers, but together good practices from a number of projects may provide an excellent solution. Use external materials to enhance this composite solution, remembering that the solution in hand is already one with which project personnel are familiar.

4 Activity 3: Establish Current State

4.1 Purpose

The purpose of Activity 3 was to gather enough data to characterize the current state of practice in the KPA being improved within PSG West projects. This activity required meetings of the SEPG and IAT leaders with the MST to determine which projects would be baselined, and then a review and analysis of existing processes in those projects. One objective was to note where good practices and policies were already in place so that these could be built upon in developing solutions. The other objective was a compilation of a baseline of practices common across the projects. (While a CBA-IPI produces similar information, under the ground rules for an assessment, this information must be kept confidential.) Having a detailed baseline allowed the IATs to determine the difference between what worked well and what needed to be changed, and to use that as the basis for defining KPA-based processes at PSG West.

4.2 Tasks

1. Identify the projects to be baselined.
2. Review and analyze existing processes.
3. Baseline common practices across all the projects participating in SPI or other improvement efforts.
4. Record and analyze lessons learned.

4.3 Highlights of What Was Done

4.3.1 Identifying Projects to Baseline

The SEPG and MST initially identified projects that would participate in the SPI effort. These projects were to be baselined and become pilot sites for the solutions developed by the IATs. (Later, when specific IATs were looking for pilot sites, the appropriateness of a project would be re-examined. If, for example, the project was well past the requirements stage, then it would not be suitable for a pilot of the RM IAT's solution.)

4.3.2 Interviewing Members of Baseline Projects

The RM IAT developed questions based on the Software CMM to use when interviewing members of projects that would be baselined. The idea behind the interviews was to determine the current practice in the projects. Interviewers included one person on the RM IAT who was also a project member and another RM IAT member who was not a member of the

project being interviewed. Interviewing took slightly more than a week of calendar time to complete. The primary person from a project to be interviewed was the program manager.

Baseline metrics were defined so that the RM IAT had a way to characterize what particular projects were doing in requirements management. The process specification for requirements management developed in Activity 2 was used as a checklist during the interviews.

The objective of the "lead goose[cd1]" strategy was that one IAT would try a task and pass along the lessons it learned from the attempt. In this case, the other IATs and the measurement and analysis MFT followed the example of the second IAT performing baselining interviews (the SPP/SPTO IAT), perhaps due to the RM IAT's experience of the time-consuming nature of using the SPF. The SPP/SPTO IAT developed interview questions without reference to the Software CMM or the SPF.

4.4 What Worked Well

In general, the IATs handled Activity 3 well. Most had experience preparing questionnaires and doing interviews, and this paid off. The teams used a variety of strategies. The RM IAT felt that having a checklist helped to structure their baselining interviews and to perform them consistently across a wide range of projects. The SPP/SPTO IAT adjusted the format of the interview questions so that terms were defined in a statement placed immediately beneath the question being considered. This IAT also allowed the interviewees to keep the questions. Having an IAT interviewer with some product knowledge helped in communicating with the interviewees. The SCM IAT sent interview questionnaires to interviewees ahead of time so that they could be completed before the actual interview. People were eager to participate in the interviews. The process was helpful to the SCM IAT; team members met and began to build relationships with their customers for the SCM process that the IAT would develop.

4.5 SEPG-Level Issues

The IATs reported to the SEPG that interviewees from the projects being baselined for SPI expressed the need to know where to focus when multiple initiatives required their attention. This was due in part to another major organizational change effort that was under way at the same time as the SPI effort. The SEPG worked to link and coordinate with the change related to this other effort, and to respond to the suggestion of the IATs that this should be addressed as part of multi-level communications about SPI. (The PCM did not address organizational change unrelated to technology change.)

4.6 Lessons Learned

- *For baselining projects, use a matrix based directly on the Software CMM.*

Use of a Software CMM-based matrix rather than one based on the process specification for requirements management from Activity 2 would have allowed some concurrent execution of tasks in Activity 2 and Activity 3. The statements in the Software CMM are in effect a set of

requirements for complying with a particular KPA, and so can be used as questions to determine if, for example, projects are performing a particular activity or have a certain policy in place. Using the Software CMM and SPF as the basis for developing interview questions saved considerable time. Suggestions for how to develop these questions and provision of examples would help expedite the baselining process.

- *Send questions to interviewees ahead of the interview.*

In the case of PSG West, this gave interviewees a chance to become familiar with the material, and the interviews went more smoothly. Including definitions of terminology was important, and especially helpful when these definitions were next to the question where the terms were used. Interviewees appreciated being able to keep a copy of the questions.

5 Activity 4: Identify Gap

5.1 Purpose

The purpose of Activity 4 was to compare the findings from Activity 3 on the current state in PSG West projects, with the desired state information gathered in Activity 2. The gap between the two served as a basis for estimating how much work was needed to achieve the desired state of successful implementation and the use of process solutions for Software CMM Level 2 KPAs. Issues to be examined included systemic sources of this gap (root causes), effort required to address these, and related risks. After this activity was completed, an IAT would have a strong understanding of the difficulty both of developing its task and of deploying the product solution. This would then serve as the basis for renegotiating its charter and plan with sponsors, and revising either as needed. The techniques for performing this activity were drawn from quality methods [Brassard 94].

5.2 Tasks

1. Analyze organizational risk associated with change by performing "fishbone" analysis of problem symptoms [Ishikawa 82].
2. Identify problem.
3. Analyze problem. (Determine root cause.)
4. List organization risks and mitigation strategies.
5. Estimate time required for change and magnitude of change.
6. Record and analyze lessons learned.

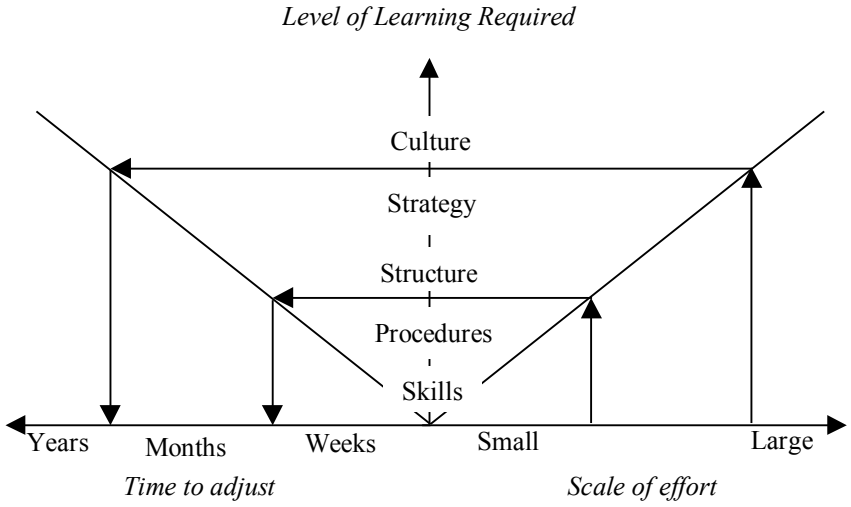
5.3 Highlights of What Was Done

5.3.1 Risk Analysis for Organizational Change

The RM IAT performed the first task in Activity 4, but decided to skip the remaining tasks except for the lessons learned analysis. The team used a hierarchy of organizational change, reprised in the PCM, that ranged from change affecting skills and procedures to change requiring adjustments in structure, strategy, and culture [Adler 90] (see Figure 5). The team identified problems related to implementing requirements management; these fell into each of the categories—each "bone" on the fishbone chart—of the hierarchy.

The RM IAT later did informal root cause analysis which, in turn, led to the development of mitigation strategies for use later in the solution development.

Figure 5: Hierarchy of Types of Organizations from Adler and Shenhar



5.4 What Worked Well

Despite initial difficulties in understanding the steps in Activity 4, most IATs indicated that gap analysis work led to an improved understanding of the risks they were facing in developing and implementing solutions. In the case of the RM IAT, they were able to create more cogent statements of the risks in implementing a requirements management process solution at PSG West.

The SPP/SPTO IAT felt that the results of their root cause analysis work were excellent. The IAT tracked its time and determined that each of the 10 root causes identified took about 1.5 hours to find. In addition, as part of reviewing Activity 4 prior to starting it, this team chose to be selective about PCM tasks, interpreting them as it supported their objectives.

The SCM IAT brought in a root cause analysis trainer from Xerox corporate training, who developed a training session customized to their needs. The IAT also narrowed its scope prior to beginning the root cause analysis. This analysis was considered essential in identifying the core issues by the SCM IAT. This team also acknowledged being able to build on the IATs' work that preceded the SPI work.

5.5 IAT-Level Issues

The RM IAT felt that the PCM wasn't clear in specifying how the tasks in Activity 4 led to later activities in the PCM. Their understanding of root cause analysis from prior experience or training at Xerox was that it was a lengthy, detailed process. When the SEI coach explained that the PCM approach to root cause was an informal process for quickly getting at

the essence of issues, the RM IAT expedited development of risk statements and mitigation strategies.

The SPP/SPTO IAT initially relied heavily on the PCM, and expressed concern when it did not provide enough specific guidance or when it was inconsistent. They also stated that they felt like "guinea pigs" because the PCM was being changed too frequently in response to their problems with it.

5.6 SEPG-Level Issues

The experiences of the RM IAT indicated that the descriptions of tasks in Activity 4 needed clarification and lacked consistency with other PCM activities. In response, the SEPG began working more closely with the SEI coach to revise the PCM as needed. The SEPG reassured the RM IAT and other IATs that problems could be worked out even while using a rough, prototype PCM. The SEPG determined that it needed to bring in the SEI coach early when problems arose.

5.7 Lessons Learned

The lessons listed here are based on in-process as well as post-process feedback from the IATs using the PCM, and from the SEPG.

- *Make arrangements with the coach to be on call.*

The SEPG and the SEI coach agreed that the coach would be available by phone to respond immediately to questions that arose during the RM and SPP/SPTO IAT meetings.

- *Assess IAT skill needs as early as possible.*

It would have been helpful to the RM team, as they obtained root cause analysis training, to have training tailored to the SPI context. Most Xerox personnel had been trained in this and other quality methods, but had not used them for SPI-related problems.

6 Activity 5: Develop Solution

6.1 Purpose

The purpose of Activity 5 was to develop processes, materials, and services that would constitute a solution to the problems identified in Activity 4. Work in this activity was based on "whole product" principles. Stated simply, this meant that the process solution would be delivered to users in projects with accompanying support services such as communication, training and consulting, and with documentation, examples, templates and background material. Development of the solution and collateral materials was to be based on research into best (or good) practice elsewhere and informal benchmarking with partner organizations. Possible suppliers of commercially packaged materials and training were to be tracked down and screened. Then the solution would be prototyped and tried out, if possible, with a project. Based on the results of this early version and its use, implementation plans for a final solution would be written, and the final collateral materials prepared in anticipation of a full-blown pilot evaluation of the solution in Activity 6.

6.2 Tasks

1. Identify best practice, clarify goals.
2. Benchmark solutions that other organizations have used.
3. Screen/select solution component sources.
4. Design a solution.
5. Prepare an implementation plan.
6. Prepare implementation materials.
7. Record and analyze lessons learned.

6.3 Highlights of What Was Done

6.3.1 Special PCM Training

The RM IAT and its SEPG consultant were given a special half-day training session on the steps in Activity 5 by the SEI coach, because Activity 5 was one of the two most complex activities in the PCM. In addition, because the IATs were having difficulty understanding the PCM "big picture," the SEPG arranged to have a Xerox corporate technical training group work with the SEI coach to develop PCM overview training. The RM and the SPP/SPTO IATs received this training.

6.3.2 Identifying Best Practices and Benchmarking

The RM IAT looked at software tools that would support requirements management, and also purchased training from a vendor. The IAT developed a requirements management benchmarking questionnaire and then looked for benchmarking partners both inside and outside PSG West and Xerox, to compare notes on how requirements management was done, and get ideas for their own solution design for requirements management. They ordered a literature search and hired a local university professor to review the search findings and reduce them to the best few items for the RM IAT to examine. They also performed their own searches on the World Wide Web.

6.4 What Worked Well

6.4.1 Data Gathering Activities

The PCM recommended looking both inside and outside one's organization to tap existing practice as input to developing process solutions. Reviewing conference proceedings, doing library and Internet searches, holding training, and tracking down experienced people were all considered beneficial by the RM IAT. Having developed the benchmarking questionnaire proved a helpful experience, and the questionnaire expedited phone interviews and email inquiries for this IAT. The SPP/SPTO IAT, like the RM IAT, arranged for training to be brought in, investigated project management literature and Internet sites, attended seminars, and reviewed best practices on existing projects. This IAT also drew heavily upon IEEE standards for project management. The SCM IAT was able to draw from the Xerox SCM Guide, and this sped up their progress.

6.4.2 Building on Prior Know-how

Because PSG West had more experience with SCM than with the other Level 2 Software CMM KPAs, there was more consistency of understanding of this KPA among the SCM IAT members. Less work was necessary to sort out what was needed in the process solution that they were developing.

6.4.3 Need for Ongoing Communication about SPI

As IATs moved into Activity 5 tasks, SPI-related activity at PSG West intensified, and the need for communication increased. SEPG members worked with PSG West managers, technical leads, and software developers to get them involved with and supportive of the SPI effort. These individuals helped the improvement activities gain momentum. Some were already members of IATs and provided information informally to other members of their projects. Some later became subject matter experts, a formal role set up at PSG West to ensure that SPI-related information and expertise were continuously accessible to software developers and managers.

6.4.4 Emergence of Solution Integration Issues

Another outcome of IAT work converging in Activity 5 was the recognition of the need for understanding the interfaces between solutions—that is, for understanding how the solutions would integrate when put into practice in a project. IAT leaders organized meetings to work toward consistency among the solutions that their teams were developing. The SQA team in particular pushed for this, because it was responsible for auditing projects using the processes defined by the KPA solutions, and thus needed to understand the interfaces between solutions and to explain interdependencies to those being audited.

6.5 IAT-Level Issues

6.5.1 Unevenness of PCM Activities

The RM IAT suggested that a revised PCM have greater consistency among activities in level of effort and duration. For example, completion of the first two tasks in Activity 5 required two calendar months, compare to only a few weeks each for Activities 1 through 4. The SCM IAT said that felt that it could have skipped benchmarking; the process did not go well, in part because they were not able to recruit many benchmarking partners. In addition, they felt they had enough expertise on the team and did not need the external data.

The SCM IAT also said that it wanted more training on the Entry Criteria-Task-Validation-Exit Criteria (ETVX) approach to process description, which the PCM recommended [Radice 88].

6.5.2 Scarcity of Software CMM-Specific Information

The RM IAT reported that it was difficult to get information specific to the RM KPA in Software CMM Level 2 when interviewing benchmarking partners, participating in training courses from vendors, and while searching the literature. For example, the search service was not familiar with the Software CMM, so it was hard to get them to focus their search effectively.

6.6 SEPG-Level Issues

All of the RM IAT's problems with Activity 5 became the SEPG's problems, in that revisions to Activity 5 needed to be made so that other IATs performing Activity 5 tasks would have fewer issues to address. In particular, regarding benchmarking as described in Activity 5, the PCM description of the term was unfamiliar to the PSG West staff. The SEI coach was aware of a relatively quick and qualitative (versus quantitative) approach to benchmarking and had written about this approach in the PCM [Spendolini 92]. However, given the Xerox culture, where benchmarking was an extensive and quantitative activity, the RM IAT assumed that the benchmarking process described in the PCM was similarly extensive.

The biggest set of issues for the SEPG to address came in Activity 5, as the IATs started to develop their process solutions. These issues included the need for a better understanding of

the PCM approach to benchmarking, the need for training on the ETVX process notation, how Activity 5 tasks used the outputs from Activities 1 through 4, and how to do early evaluation of the draft process solutions. (Eventually the IATs agreed to use the ETVX notation as adapted by the RM IAT.)

6.7 Lessons Learned

- *Identify and resolve any conflict in the meaning of widely used terms.*

Terms such as benchmarking are widely known and it is easy to assume a common understanding. The PCM version of benchmarking should have been discussed during the pre-collaboration revision of the PCM, and any conflict between the PCM approach and the Xerox corporate approach should have been noted and resolved at that point.

- *Chunk the introduction of unfamiliar strategies, processes, notations, etc.*

Activity 5 was the first step in the PCM that contained primarily unfamiliar material and in addition, it was lengthy. The IATs needed guidance in smaller and clearer chunks.

- *Perform a training needs analysis prior to initiating any improvement efforts.*

The PCM overview training was not prepared early enough so that SEPG members had materials for use while training the IATs. The assumption was made that the PCM document plus the consulting of the SEPG member with an IAT, would negate the need for formal training. As it was, the PCM document was more helpful as a supplement to the training that was eventually developed than as the main source of guidance for the IATs.

- *Select domain (subject matter) experts early.*

Most IATs saw the need for domain expertise most clearly in Activity 5. At that point, they agreed that selecting a domain expert early, as recommended in the PCM, would have been helpful. Each IAT could have taken advantage of a domain expert's experience in a number of areas: for initial education in a particular KPA, for assistance in baselining and determining the desired process, for guidance in benchmarking, and for solution design and prototyping.

7 Activity 6: Pilot Use and Evaluation

7.1 Purpose

Activity 6 focused on piloting the process solution and the related materials and services that were developed in Activity 5 by an IAT for a particular KPA. The purpose of piloting was to validate a solution prior to deployment in the project community. Piloting was the responsibility of the IATs, but the SEPG provided assistance with this task. Note that while the IATs were staffed by people who were spending at least 80% of their time on project work, the piloting process was their first opportunity, as IAT members, to engage the PSG West projects and determine if the work they had done was on target.

7.2 Tasks

1. Prepare the pilot plan and materials.
2. Initiate the introduction sequence and begin pilot use.
3. Monitor the pilot projects and record issues and problems.
4. Evaluate results of the piloting process and determine next steps.
5. Record and analyze lessons learned.

7.3 Highlights of What Was Done

7.3.1 Planning for Pilots

The SEPG created a plan for the collective IAT piloting process. This plan contained a list of prospective pilot projects with their schedule status; for each pilot, notes indicated where it might be appropriate to intercept the project in order to pilot solutions. The SEPG also created a template pilot plan which the IATs used to plan each of their pilots. The template provided a consistent starting point for each IAT.

There were three important problems to solve in planning the pilots, which the SEPG led the process of addressing:

1. How do we pilot KPA-focused solutions in projects?
2. How do we handle piloting multiple solutions in projects?
3. How do we handle management sponsorship of piloting solutions in projects?

7.3.2 The Initial Piloting Strategy

The initial approach to the piloting strategy was based on implementing an entire IAT solution within a single project. The RM IAT, for example, had planned to work closely with any project that agreed to act as a pilot. This strategy required the IAT to complete its solution before the pilot could begin. (The adoption of the idea of prototyping partial solutions in collaboration with projects during Activity 5 came too late for most IATs to benefit; see discussion below in 9.4). The assumed benefit of this approach was that at the end of the pilot the project would have already implemented the IAT solution, and roll out would then not be necessary for the project involved. Also, the IAT would be able to test its entire solution. As it turned out, most IATs did not pilot in this manner.

7.3.3 Criteria for Selecting Pilot Projects

The material in the pilot plan template provided a basis for selecting projects to participate in piloting. Each IAT created a pilot plan based on this template and adopted the following criteria:

- Project is in the appropriate development life-cycle phase to support the KPA.
- Project schedule can accommodate the introduction and completion of a pilot.
- Project pilot team contains the appropriate skill levels to execute and evaluate the solution.
- Project is representative of PSG West software development projects.
- Project should not be in a recovery mode (that is, not in the process of recovering from a difficult situation).
- Project must be able to implement the solution without much difficulty or risk, and implement it within the pilot schedule.
- Project is of an appropriate size to execute and evaluate the solution.
- Project is appropriate for piloting the specific solution.
- Selection of this project contributes to a good mix of pilot projects from across the division.
- Project personnel want to do the pilot and there are resources to staff a pilot project team to work with the SEPG and the IAT.

Using these criteria as guidelines, the SEPG and the MST reviewed projects at PSG West and determined which were candidates. Projects were then contacted by the SEPG to discuss their interest in participating in a pilot and the resources they had available for participating.

7.3.4 Pilot Sponsorship

The pilot strategy included the concept that MST members would be sponsors of the pilots: many but not all of the managers of PSG West projects were members of the MST. By sponsoring the pilots, MST members were endorsing the efforts of the IATs and the SEPG. In practice, the current business processes were given higher priority than piloting the KPA so-

lutions, so the strategy was not as successful as expected. Also, the selection criteria for pilots provided a strong filter that limited the projects available for pilots.

7.3.5 Dealing with Project Schedules and Deadlines: Piloting a Composite of the Solution

The initial strategy of implementing the complete KPA process solution during piloting proved difficult because projects were asked to absorb the overhead of piloting without any schedule or resource relief. Given that time and some level of resources were essential to implement a solution, the IATs decided to alter their strategy to pilot partial solutions with the projects.

This approach meant that multiple pilots were needed to test the solution completely. This strategy had a smaller impact on each project, and the project managers were more willing to accept the pilots. In retrospect this is not surprising, because all of these new processes were developed externally to the projects and were perceived as a major risk by project personnel. The IATs, on the other hand, had to use more time and effort in engaging and supporting multiple pilots, and this delayed the final release of the solutions.

7.3.6 Piloting Multiple-KPA Solutions

Some IATs determined that they needed to work together to pilot their solutions. For example, the SQA IAT identified the need to work with the SPP/SPTO IAT to validate its own solution, which described the process for helping prepare and review a project's software development plan. The SQA IAT needed to test its process in an environment where the software development plan template created by the SPP/SPTO IAT was being used, and these IATs began working together to engage a project jointly to achieve this goal.

This evolution of the piloting strategy proved extremely difficult to achieve in practice because once again the overhead on the project and project deadlines became an issue. Just one project agreed to pilot multiple KPAs and negotiated with the IATs to pilot only selected pieces of each KPA solution to minimize the resources needed.

7.4 What Worked Well

7.4.1 Project Participation in Piloting

Most projects participating in pilots appointed a team of their own staff (the PCM called them Local Change Teams [LCTs]) as a type of mini-, project-specific IAT—to work with PSG West IATs to customize KPA solutions and apply them. Communication among the MST, IATs, and piloting projects occurred frequently. During monthly status meetings with the MST, the SEPG discussed plans, status against plans, issues and opportunities, and budgets. Each SEPG consultant assigned to an IAT and piloting project communicated informally with them on a weekly basis, addressing plans, progress and roadblocks.

7.4.2 Revising the Solutions

The IATs were extremely thorough in developing their KPA solutions, and this became apparent during the pilots. None of the pilots provided input for significant changes to the KPA solutions. Although the IATs did not pilot their entire solutions, the fact that so few changes resulted from the pieces that were piloted provided a degree of confidence in the remaining pieces of the solutions. In retrospect, one way to look at the solutions that were developed is to view them as the result of an extensive organizational learning process. Even while some projects did not adopt the solutions intact, or adapted them heavily, the expertise accumulated by IAT members, who were drawn from throughout PSG West, was broadly available to serve as the basis for a variety of approaches to solutions.

7.4.3 Solution Hand Off After Piloting

Once the IATs completed piloting their solutions and making adjustments based on the results of the pilots, they were ready to provide the solutions to the SEPG for inclusion in the process asset library. The IATs and the SEPG all agreed that it was appropriate for the IATs to present the final work to the MST for approval before giving it to the SEPG for publishing online. Once again the RM IAT took the lead, and prepared a brief slide presentation as well as a package for handing out to the MST members. The package contained the requirements management process description, templates and job aids. It also included a table with cross references of the Software CMM requirements management practices with the RM process description showing where the process description addressed each of the practices. In accordance with the PCM, the package also contained the lessons learned for the whole RM IAT activity. The other IATs later adopted this format.

7.5 IAT-Level Issues

Complete process solutions could not be piloted on a single project. Coordination across IATs in Activity 6 thus became even more necessary than it was perceived to be in Activity 5. IATs, especially the RM IAT in leading the way, became aware of how important piloting really was for making change work. One RM IAT member noted, in reflecting on the experience of piloting the new requirements management process solution, that there would be a painful period of time while old habits were being replaced with new ones. The RM IAT felt it was helpful to explain to the piloting project that this painful transition was to be expected, and that the IAT members would support project members as they went through it. Another RM IAT member noted, “The RM process is fine. Implementation of the process is the question and depends upon the organization.” The PCM attempted to describe the difference between the process that was *inherent in* the solution, and the process for the *introducing or implementing* of the solution in a project, and the need for repeatability of both. During piloting, the RM IAT discovered first-hand why this was the case.

7.6 SEPG-Level Issues

During the period when IATs were most involved in piloting, the membership of the SEPG was evolving. Newer members were not yet completely familiar with the PCM and how the IATs were using it, and this may have limited the effectiveness of PCM use for piloting.

7.7 Lessons Learned

- *Get sponsorship, as well as funding relief, for projects piloting the IAT solutions.*

Schedule relief is not possible in a market-driven organization. Thus getting senior management to provide projects with resource relief by underwriting the risk out of special funds may give IATs a firmer basis for negotiating pilot participation. This is also difficult, but essential, and needs to be arranged during SPI strategy and plan development as well as again when piloting becomes imminent. Providing an estimate of the nature and amount of resources required from the project may help in the negotiations with both senior managers and project managers.

- *Plan on piloting a series of partial solutions for a given KPA.*

Piloting a complete solution all at once is very likely impossible, so planning to pilot partial solutions is a good idea. Also, anticipate the need to pilot in conjunction with at least one piece of a solution for another KPA; this mirrors the complex situations on projects in the "real" world.

- *Anticipate difficulty during pilot.*

Helping project organizations to make process changes, while projects are underway developing and delivering product, is very difficult. Plan for pilots the same way you would plan for working with an external customer to try out a new product. During the pilot pay careful attention to the steps used in the introduction of the solution; these should be refined as you work with a range of projects until they are highly repeatable. After each significant piloting event, and especially during the first IAT's piloting process, the SEPG and representatives of all the IATs should debrief that IAT, to reduce risk for later IAT piloting work.

- *Draw IAT members from the broadest range of projects that are candidates to act as pilots.*

Drawing IAT members from a broad range of projects pays off during piloting. At PSG West, the broad organizational learning represented by the collectively gained experience of IAT members became the basis not only for successful piloting but also for later roll out (broad deployment) of the solutions. Some IAT members supported early use of parts of solutions in their home projects prior to any "official" use during piloting or roll out.

8 Activity 7: Roll Out

8.1 Purpose

The purpose of Activity 7 was to facilitate the adaptation and adoption, by each PSG West project, of the solutions that were developed in Activity 5 and piloted in Activity 6. As originally envisioned in the PCM, Activity 7 was to be performed by the IATs with ongoing support from the SEPG and from other organizational functions such as training. In addition, the PCM proposed using an LCT on each project, to work with the IATs in performing the adaptation for the solutions. As implemented in PSG West, Activity 7 was solely the responsibility of the SEPG, to whom the IATs had handed off their process solutions and collateral materials at the end of Activity 6 work. And as in Activity 6, the LCTs were sometimes implemented formally, sometimes informally, and with various names.

8.2 Tasks

1. Design and negotiate ongoing support, including monitoring and improving mechanisms that support the solutions.
2. Prepare a roll-out plan.
3. Prepare for introduction to project n.
4. Initiate roll-out plan in project n.
5. Monitor and improve the solutions.
6. Record and analyze lessons learned and wrap up.

8.3 What Worked Well

8.3.1 How the MST Participated in Roll Out Planning

The MST participated in an all-day off-site meeting to give input on which projects should participate in the roll-out process and to assess the goals and objectives of roll out as articulated by the SEPG in the Activity 7 description.

8.3.2 Staggered Approach to Roll Out of Solutions

The SEPG created a plan that outlined rolling out of piloted and revised solutions to software projects in a phased manner. This approach was selected because the SEPG could effectively support only one project at a time. The MST approved the roll-out sequence based on the need and current status of these projects.

8.3.3 Communication about Roll Out of Solutions

Dissemination of the solutions began with a communication memo sent to all members of PSG West software projects, notifying them of the availability of the process solutions. While the KPA process solutions were being developed by the IATs, the SEPG established a directory structure on a file server in the Xerox internal network for storing of the processes and any IAT-related materials such as minutes of meetings. This area was in effect the early process asset library, and eventually evolved into a web site. Its main purpose at the time was to provide a common area for use by the IAT and SEPG while processes were being developed.

8.4 IAT-Level Issues

The transition from piloting in Activity 6 to roll out in Activity 7 was not clear cut. It was difficult to determine criteria for completing pilots, since piloting of solutions occurred across projects, with only partial deployment of solutions in each. As discussed earlier, there were also issues of integration among solutions that needed to be worked out; the SQA IAT's own solution depended on resolving these.

8.5 SEPG-Level Issues

The SEPG understood conceptually and strategically what had to happen in Activity 7. But lacking practical experience, and at the same time working to support the IATs in the problems just described, the SEPG had its own learning curve to climb. The SEPG decided to create a roll-out plan for all of the KPA solutions created by the IATs, which included a schedule of which solutions to introduce to which projects and when. Included in the plan was a set of prerequisites to roll-out tasks: having an SEPG hotline established, having the process asset library ready, and having a subject matter expert network set up. Implicit in all of this was the decision that the SEPG would indeed be responsible for Activity 7; the IATs were to be retired as they handed off their completed solutions.

8.6 Lessons Learned

- *LCTs or their equivalent are essential to successful roll out of solutions.*

As projects came nearer to applying the process solutions in practice, the SEPG saw the need to establish project-based teams to work on project-specific versions of IAT solutions—and began to establish these, if not always labeling the teams as LCTs. These teams were constituted somewhat differently from project to project, but generally included a manager as either a full time or part-time team leader, and part-time project members as representatives of the areas affected by the solutions. The teams worked to translate the general solutions from the IATs to the specific situation in the projects. In some cases, they created their own solutions and did not use those of the IATs.

This meant that the biggest change in SPI infrastructure during roll out was within the projects themselves. The LCT was responsible for planning and implementing SPI within the project, and took on the role of communicating local SPI information to project members.

The SPI activities for the project were defined in the SPI implementation plan that identified and defined the roles of the project-based team and defined a schedule for each of the SPI activities. This plan was the road map for SPI implementation within the project.

- *Plan to evolve the SEPG role during roll out.*

During roll out, the role of the SEPG members also changed, from advisors and facilitators of the IATs, to advisors and facilitators of the projects as they implemented SPI. The SEPG became the keeper of the process solutions and maintained these processes via a documented change process. The MST members continued to meet, although less frequently, and also continued with their role as SPI champions. Within the projects that they managed, they ensured that SPI implementation continued.

9 Activity 8: Wrap Up

9.1 Purpose

The purpose of Activity 8 was to evaluate the work of the first seven activities, determining where the PCM could be adapted and improved for its use in another change effort. The PSG West evaluation, facilitated by the SEPG, included interviewing IAT members for their final feedback and lessons learned, coming to closure on all tasks, publishing results, and recognizing the efforts of IAT members and others.

9.2 Tasks

1. Analyze the lessons learned and wrap up.
2. Conduct the final lessons learned analysis.
3. Conduct a checkpoint review.
4. Publish the results.
5. Recognize the efforts of IAT members.

9.3 Highlights of What Was Done

The SEPG debriefed all of the IATs, obtaining lessons learned from each. The SEPG also reviewed the lessons learned reports that had been provided by each IAT at the end of each PCM step. The SEI coach interviewed representatives of the SPI effort, including MST members, SEPG members, IAT members and LCT or other project team members. The authors of this report represent the SEPG and the SEI, and wrote this report as documentation of the analysis of the PCM collaboration.

9.4 Lessons Learned in Activities 1-7

These lessons reflect on the entire set of PCM activities, including the areas of the "lead goose" strategy, solution integration, piloting, training, IAT size, and IAT duration.

- *Plan on multiple partial pilots of solutions and work with piloting projects opportunistically.*

The process of piloting IAT solutions led to an improved understanding of piloting. The PCM did not address multiple and partial pilots. The original version of the PCM recommended one complete pilot.

As the IATs began to develop solutions and to try to pilot them, they discovered that projects participating in pilots wanted the relationships among the solutions documented and evaluated. These projects, busy trying to complete product development, did not have time to determine the interfaces between the solutions themselves. (At PSG West, the SQA IAT led the effort to work on these solution integration issues because its solution was affected by all of the other IAT solutions: this IAT had to check and facilitate compliance.) What appeared to work best was for piloting projects to adopt a piece of a solution, and then "digest" that prior to taking on the next piece. Integration issues were solved in a just-in-time-manner when projects were ready for the next solution piece. Most IATs partially piloted their solutions on two projects.

This approach might seem inconsistent with the idea of developing complete, KPA-specific solutions. However, the solution development process created a knowledge base that both the IAT and the SEPG drew upon, during piloting and also during roll out.

- *Provide training and job aids.*

It was expected by both the SEI and PSG West that, with the PCM being a prototype, a great deal of direct support to IATs would be needed, and this was routinely provided via the SEPG consultant assigned to each IAT. However, at several points during the collaboration, it was clear that more formal training would also have been helpful. IAT members expressed concern that terminology used in the PCM was not consistent with terminology used in SPI and Software CMM orientation and training. IATs also indicated that they thought the PCM "big picture" was missing. A better overview of the overall flow of the PCM and additional detail at the beginning of each activity would have helped IATs understand the transition from the previous activity. Brief, formal training of IATs as they began use of the PCM, and as they proceeded, would also have been helpful.

The final area where additional PCM training for the IATs was identified was the "EVTX" notation used to describe PCM processes. This notation was not described in enough detail in the PCM for IATs to use themselves without training.

In areas not related to the PCM itself, some IATs drew upon Xerox internal training resources for quality-related courses, and obtained training in team building, benchmarking, and root cause analysis. Most IATs obtained KPA-related training from vendors, to build on the brief orientation given them by the SEPG at kick off.

In addition to training for IATs, training for members of the MST and for sponsors of pilot projects and even for senior management is recommended. The PCM addressed keeping sponsors informed but did not specifically call for training or orientation for sponsors or the MST. In most cases, managers involved in SPI had limited exposure to SPI concepts and experience because of time constraints. Brief training (perhaps 2 hours) of these managers at key points would be helpful to both them and those they manage.

In general, training all those involved to an appropriate level of knowledge and skill should be part of rolling out solutions; IATs should consider working early in solution development with internal training personnel to get assistance with training design and development, and if possible hand off the ongoing training job to internal training organizations.

- *Create IATs that are representative and adequately sized.*

The PCM provided detailed guidance on selecting IAT leaders, but did not offer guidance on selection of members or numbers of members. PSG West's experience indicates that IATs should have members representing most (if not all) projects that will be involved in a major change effort like SPI. This broad representation "seeds" those projects with early expertise in the IAT's area of focus. In addition, having adequate size allows for team attrition while assuring maintenance of a critical mass of members. Some IATs at PSG West with greater numbers of members (8 to 12) seemed to be better able to maintain momentum, as loss of members or intermittent attendance had less impact. Other teams seemed to evolve so that a core group emerged, in effect acting as co-leaders; this was also a successful strategy but more vulnerable to member availability.

- *Set up IATs that require full time membership.*

The PCM did not specify how IATs should do work, in terms of either amount or frequency. But one result of the SEI/PSG West collaboration was to make clear that providing several working models for teams, with pros and cons for each, would have been helpful. Without these as possible alternatives, PSG West chose to organize its teams in a well-respected, quality methodology-based approach.

But SPI was new to PSG West (indeed, new in general) and feedback from the IATs indicated that 10 hours per week was not enough time for them to accomplish their charters. They also indicated that part-time IAT work made it difficult to sustain momentum and make progress. At PSG West, meeting less than weekly was problematic even as early as Activity 1: not everyone could attend each meeting, and efficiency was lost as the IAT needed time to re-establish context and regain momentum at each meeting. IAT members reported performing many tasks outside of normal working hours and in addition to their usual project tasks. One alternative to part-time membership suggested by a PSG West IAT member was to convene an IAT for a period of time of perhaps one month, moving project members to full-time IAT work temporarily. By not having to split their attention, members could focus on IAT work and expedite solution development and piloting. (This approach may not always be feasible.)

10 The Value of the Collaboration

The SEI and PSG West both gained value from the collaboration; both also took risks and had disappointments. Collaboration per se is inherently risky—it implies willingness to work together where neither party has the last word. It also implies that those engaged in the collaboration are approaching it from different perspectives and capabilities, and thus that communication across those perspectives may at times be difficult. This was certainly true for the collaboration described here. In addition, there was the added complexity of the subject of the collaboration being an immature product (the PCM), and the context of the collaboration being a major SPI effort.

The PCM described how IATs could plan and manage change efforts in PSG West software organizations with the assistance of the SEPG. It provided a step-by-step process for introducing software technology, including processes, methods, and tools that support implementing KPAs of the Software CMM. When the SEPG began planning SPI following its assessment, it looked for guidance on how best to approach SPI; they anticipated that the PCM offered the benefit of IATs not having to develop their strategies and plans from scratch, and of savings in time and effort.

The reaction to the PCM was mixed. Some SEPG members liked the structure provided by the PCM. The IAT members disliked the lack of maturity of the PCM. The PCM was useful in providing an overall road map for the IAT members, but it was not as helpful to IATs with the details of developing, piloting, and deploying their solutions. And the SEPG members, serving as consultants to the IATs using the PCM, were not yet expert, as they were also new to the PCM.

One area where the IATs felt that the PCM fell short was in KPA-specific examples of processes and artifacts such as software project plans or SQA plans. It is now common for organizations within the software community to purchase processes, often with example artifacts, and modify them. There were none available at the time PSG West was working on the SPI effort described here, with the exception of the SPF, which had no accompanying artifacts.

If a “lead goose” strategy is used to initiate a group of IATs, then the lead IAT needs adequate time. At PSG West, the RM IAT had the most to learn, being first. Each team that followed RM worked more quickly, and eventually the IATs’ schedules were nearly concurrent. Starting the RM IAT an additional four to six weeks early would have allowed more time for the SEPG to learn from and respond to that IAT’s experience. Revisions not only to the PCM but

also to templates and other materials could have been made available to the other IATs in a more timely way.

The result of the PCM having limited artifacts was that the SEPG and IATs themselves created what was needed. The PSG West SEPG had resources for creating draft templates, for example the Pilot Plan template used by the IATs, and was also able to draw upon a Xerox technical communication group to refine the template and make it easier to use. The template was then used to bootstrap the creation of examples: it required extra effort on the part of the first IAT completing the template, but the resulting plan became an example that all the other IATs could follow. While these templates were proprietary and not available for public use, the strategy of creating a template and bootstrapping an example was a valuable output from the collaboration which could be widely shared by the SEI.

A theme throughout the use of the PCM was that the IATs, understandably, wanted "how" as well as "what." That is, they wanted PSG West-specific guidance as well as KPA-specific guidance. The essence of the PSG West/SEI collaboration was that the SEI would provide the "what" and would work with PSG West to develop a PSG West-specific "how." PSG West people knew their own context, and SEI could help them articulate this and use it as they applied the PCM. But the IATs needed specific "hows" faster than this collaborative process could accommodate. This experience provides a good argument for why it might have been preferable to apply the PCM to one IAT, and to have that IAT precede the others by several months. Doing this would have allowed for revising the PCM to include more PSG West-specific material and approaches prior to the main SPI effort. However, this approach may not viable due to the priority of getting products to market.

Altogether, most SEPG and IAT members agreed that the PCM, offering a common approach to a complex, unfamiliar process of introducing change, was useful despite the limitations in structure, content, granularity, usability, and format identified by the RM and others. In addition, many discussions were held over the course of the collaboration regarding how the PCM might have been more effectively used; the most common problem seemed to be that the IATs, with no experience as change agents, attempted to follow the PCM too carefully. A major benefit of the PCM, given the concurrent activity of the IATs, was a common vocabulary for the work they were doing. This was used in communicating among teams and also provided a common basis to status reporting.

The SEI coach and others from the SEI found the experience of evaluating the prototype PCM in the context of an actual SPI effort invaluable. The feedback just described was received during periodic on-site visits and regular teleconferences as well as at the end of the collaboration and was specific to the PCM. This was extremely useful. In addition, the opportunity to work closely with an organization performing SPI allowed the SEI to observe activities that were not addressed in the PCM. For example, the PSG West SEPG did an excellent job of managing SPI-related communications across groups and levels within the organization. The PCM addressed communication only with regard to specific KPA-related or-

ganization changes. Inventive approaches such as the round table meetings for gathering process requirements should be recommended. And, in a more general area of concern, the SPI effort took place in the context of other, broader corporate change; the PCM did not address how to integrate the change effort it addressed with other technology or organizational changes. Some general guidance in this area might be helpful.

As we look back, we are once again convinced that this type of collaboration is invaluable on a number of levels. During the collaboration, Xerox, specifically PSG West, learned as an organization. This learning is observed and documented by the SEI, which in turn shares this learning to the software engineering community. Other organizations then build on this learning, and many people and groups benefit. However difficult our work was at times, we were always encouraged by keeping this larger goal in mind. We hope the reader has found our story at least as enlightening to read as we found it to write.

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13. ABSTRACT (MAXIMUM 200 WORDS)

During 1995-1998, Xerox Corporation's West Coast Production Systems Group (PSG West) worked with the Software Engineering Institute (SEI) to apply the prototype Process Change Model (PCM) to aid in their efforts to reach Level 2 of the Software Capability Maturity Model® (CMM®), and to develop the generic processes required for Level 3. The Process Change Model, along with a companion guidebook, was designed to provide the basis for a systematic approach to technology-specific change based in part on "whole product" principles, with a focus on one Key Process Area (KPA) at a time. This report describes a collaborative effort to develop a more systematic and detailed approach to software process improvement (SPI) through use and evaluation of prototype versions of the PCM and guidebook. In particular, the work of the PSG West software engineering process group (SEPG) to apply the PCM and guidebook in working with improvement action teams focused on the KPAs of the Software CMM is described. Lessons learned about the "live" evaluation and maturation of a new process and guidebook such as this are presented. These lessons should be of interest to those engaged in work on technology maturation and the adoption of technological or process innovations as well as to those engaged in SPI and process development.

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