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After the Appraisal: A Systematic Survey of Process Improvement, its Benefits, and Factors that Influence Success

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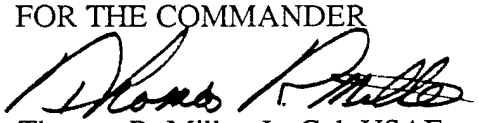

Thomas R. Miller, Lt Col, USAF
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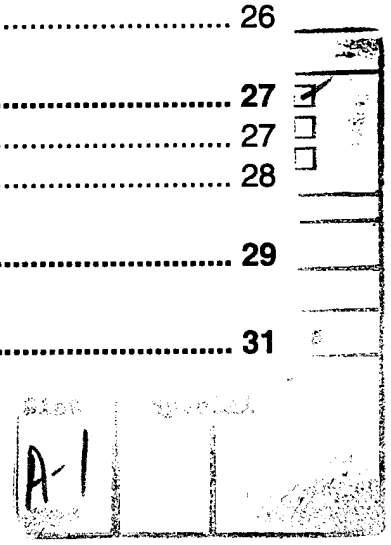

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After the Appraisal: A Systematic Survey of Process Improvement, its Benefits, and Factors that Influence Success

Abstract: Very little published evidence exists about the impact of the Capability Maturity Model[sm] (CMM) or CMM-based appraisals on subsequent software process improvement and organizational performance. A few credible case studies do exist, but it is uncertain how widely their results apply. We present evidence here from a much broader cross section of software organizations. Our results suggest that process maturity does indeed pay off in better product quality, ability to meet schedule commitments, and other indicators of organizational performance. The vast majority of survey respondents also report that their appraisals proved to be highly accurate and useful in guiding their subsequent process improvement efforts. Not all organizations have been equally successful, however, and improvement often takes longer and costs more than expected. We identify several factors, most of them under management control, that distinguish more successful from less successful organizations.

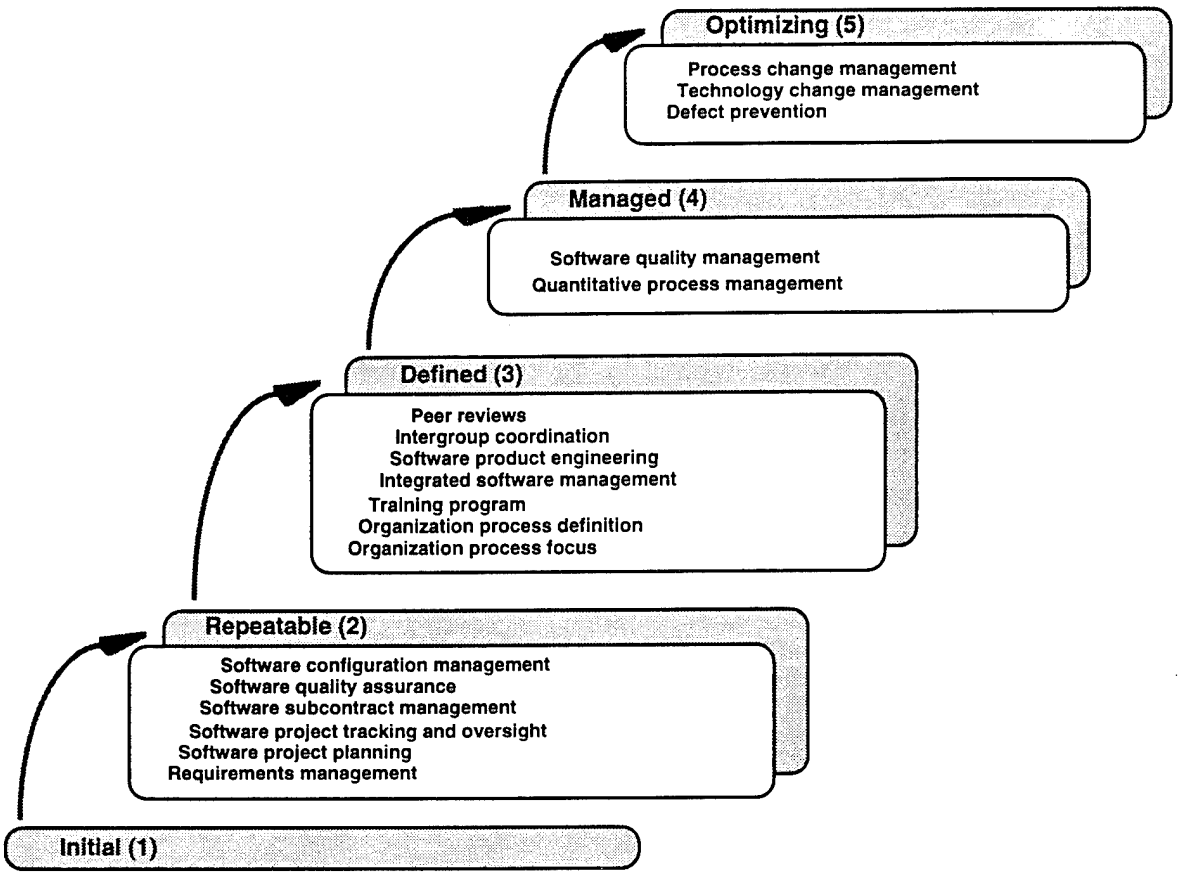
1 Introduction

1.1 About the CMM and Process Maturity

The Capability Maturity Model (CMM) [Paulk 93a, Paulk 93b] has had a major impact on software organizations throughout the world. Building on earlier work at the Software Engineering Institute (SEI) [Humphrey 87], the CMM is used as a reference model to guide software process improvement (SPI) efforts in many hundreds of software organizations. Initially adopted by defense organizations and their contractors, it is now used in organizations both large and small throughout the software industry.

As seen in Figure 1-1, the CMM describes five developmental levels of software process maturity. At the *initial* level, software projects depend on the technical skill and often heroic efforts of specific individuals. They proceed in an *ad hoc* fashion, from one issue to another. At the *repeatable* level, the focus is on establishing effective project management controls meant to enhance product quality, and to improve the project's ability to set and meet reasonable time and budget commitments. At the *defined* level, the improvement effort concentrates on developing tailorable software processes to be used throughout the entire organization. At the *managed* level, the emphasis is on monitoring software processes quantitatively and adjusting them to better meet product quality goals. Finally, at the *optimizing* level, quantitative data are used consistently to improve the organization's processes on an ongoing basis.

[sm] Capability Maturity Model,[sm] CMM,[sm] and IDEAL[sm] are service marks of Carnegie Mellon University.



Source: [Paulk 93a]

Figure 1-1: The Capability Maturity Model

Several appraisal methods exist that are meant to characterize the extent to which a software organization has established processes that meet the criteria established by the CMM, and to guide subsequent process improvement [Paulk 92, CBA Project 94, Whitney 94].[1] Other, sometimes competing, approaches exist, but the influence of the CMM is pervasive throughout the field [Coallier 92, Coallier 94, Craigmyle 93, Kuvaja 94, Dorling 93, Drouin 95].

1.2 The Evidence So Far

Very little published evidence exists about the CMM or CMM-based appraisals that goes beyond individual experience or strongly stated opinion. However, despite doubt from some quarters [Bollinger 91, Bach 94, Bach 95, Jones 95], what little publicly available evidence does exist is quite encouraging to proponents of the CMM. Several case studies document well conceived and implemented process improvement efforts which returned very substantial business value to their organizations.

1. Documentation on the CBA IPI method is available through CBA lead assessor training: Members of the CBA Project. *CMM-Based Appraisal for Internal Process Improvement (CBA IPI) Lead Assessor's Guide v1.0.* Pittsburgh, PA: Software Engineering Institute, Carnegie Mellon University, May 1995.

A recent report [Herbsleb 94] reviews process improvement efforts in 13 organizations, and shows improvements in cycle time, defect density, and productivity. Benefit to cost ratios presented there are quite impressive, ranging from 4:1 to almost 9:1. Other published papers include descriptions of process improvement efforts at Hughes Aircraft [Humphrey 91], Raytheon [Dion 92, Dion 93], Schlumberger [Wohlwend 93], Texas Instruments[Benno 95], and the Air Logistics Center at Tinker Air Force Base [Lipke 92, Butler 95]. Taken together, these case studies present credible evidence about what can happen as a result of CMM-based SPI.

1.3 Limitations

The greatest limitation of the evidence to date is one of representativeness. We do not know how representative the published cases are of the experiences of CMM-adopters in general. Clearly, not every software organization is as successful as those that choose to publicize their experiences widely. Those who have achieved higher maturity may be more anxious to tout their accomplishments than are those who are experiencing difficulty.

We need to proactively seek out organizations that have had a wide variety of experience in implementing software process improvement. We need to learn about the struggling as well as the outstanding if we are to better understand the characteristics that distinguish between them.

We also need to examine the experiences of different types of software organizations. Early adopters of CMM-based software process improvement came largely from defense contractors and military organizations. More and more organizations from elsewhere in the software industry are now embarking on CMM-based process improvement efforts. We need to study organizations from these different business environments in order to understand how broadly applicable the CMM is as a model for SPI. We also need to include smaller organizations in order to objectively evaluate their concerns [Brodman 94].

1.4 The Survey

This survey examines appraisals and process improvement efforts from a broad cross-section of software organizations. The sample includes software process assessments (SPAs) that were conducted in the United States and Canada during calendar years 1992 and 1993 - long enough ago for genuine change to have taken place (at least one year), yet recent enough to expect accurate recall from people familiar with the appraisals and their aftermaths (no more than three years). (See Appendix A for more detail about the sample.) We were able to obtain information allowing us to contact 167 specific individuals, each of whom was in a good position to observe the aftermath of one of 61 appraisals. Using an intensive schedule of reminders and email, we received 138 completed questionnaires, which is 83 percent of the total number sent. They represent 56 of the 61 appraisals (92 percent) from which we sampled.

One often hears that process champions differ substantially from managers and developers in their views about software process improvement. Hence we designed the survey sample to allow comparisons among people whose perspectives might be expected to differ as a result of their differing roles. The data reported here are based on the responses of individuals who filled one of three roles for each appraisal: 1) the project level software manager most knowledgeable about the appraisal; 2) the most knowledgeable and well-respected senior developer or similar technical person available; and 3) an organizational level SEPG manager, or someone with equivalent responsibilities, if such a person existed.

Interestingly enough, it turns out that there are *not* characteristic, systematic differences among the respondents who fill the three different roles. We correlated organizational role with the respondents' answers to all of the other survey questions described in this report, and found only two statistically significant relationships ($p \leq .05$ by chi-square criteria). A third approached significance ($p \leq .10$). With enough comparisons, one can always find a few apparently significant differences, but such a consistent pattern of nonrelationship is highly unlikely to occur by chance. (See Appendix A for more detail.)

The overall agreement among people who fill different organizational roles gives us more confidence in the survey results than we would have had if we relied entirely on process champions. Since there are no characteristic role differences, we have combined all respondents for the analyses presented here. The larger number of individual respondents also gives us more confidence in the overall results than we would have if there was only one respondent per organization.

As with any survey, most of our data rely on the self-reports of our respondents, and we do not know with certainty on what they based their answers. However, all that must be true for the results to be useful is that if we ask 138 people about, e.g., the ability to meet schedules in their organizations, those who say that it is "excellent" or "good" usually *are* better able to meet schedules than are those who say their ability is "fair" or "poor."

Survey data are necessary if we wish to generalize beyond a few selected cases. Furthermore, there is evidence that people in fact try to answer survey questions honestly. For example, self reported and appraised maturity levels are quite consistent in this survey (see Section 3.1). Our respondents also describe substantial differences in process improvement among their organizations, and those descriptions vary among each other in understandable ways.

1.5 The Report

Our goals for the survey are three-fold:

1. to describe what typically happens to process improvement efforts after CMM-based appraisals
2. to understand as much as possible about why some improvement efforts are more successful than others
3. to learn more about the relationship between process maturity and organizational performance

The remainder of this report contains the following sections and appendices. After an overall summary of the survey results (Section 2), we present several sections with more detailed results. First, we discuss new evidence about the impact of process maturity on organizational performance (Section 3). This is followed by descriptions of the appraisals themselves (Section 4), the progress of process improvement since the appraisals (Section 5), and a series of factors that distinguish among more *versus* less successful SPI efforts (Section 6). Finally, we present our conclusions (Section 7).

Appendix A describes the survey sample in more detail. Appendix B provides additional evidence about differences due to organizational size. Appendix C contains a series of figures that are referenced in Section 6, and provides additional detail about factors related to varying success in process improvement. The survey questionnaire is reproduced in Appendix D.

2 A Summary of the Survey Results

2.1 Impact of the CMM

A number of conclusions are apparent based on the results of this survey. First of all, we present new evidence, based on a much broader and more representative sample of software organizations than heretofore available, that process improvement does pay off in terms of better organizational performance. Our respondents from higher maturity organizations are considerably more likely than those from level 1 organizations to report better performance with respect to product quality, staff productivity, ability to meet schedule commitments, and their own staff morale and job satisfaction. In addition they generally report better performance with respect to customer satisfaction and ability to meet budget commitments.

The basic results hold up for organizations from different sectors of the software industry, among those newer to the CMM as well as those from defense contractors and the federal government. The results also appear to be unaffected by the size of the organizations involved. Organizations with relatively few software employees appear to benefit from higher process maturity just as do larger organizations.

2.2 CMM-based Appraisals

On the whole, our survey respondents view their software process assessments (SPAs) as having been both highly accurate and useful in guiding their subsequent process improvement efforts. This is true in light of their actual experience in the one to three years following the appraisals.

The respondents report that the appraisals did a good job in identifying their organizations' strengths as well as their weaknesses. Most report that their organizations' process improvement efforts have been largely determined by the results of their appraisals. Based on their experiences following the appraisals, a large majority (over 80 percent) believe that the CMM has provided useful "road map" direction about what process improvements ought to be tackled first. Only 10 percent now think that their appraisals or the CMM caused them to neglect important process improvement issues.

There are difficulties though. Over a quarter of the respondents say that the findings and recommendations raised by their respective appraisals were too ambitious to achieve in a reasonable time period. Large numbers of the respondents said that they needed more assistance and guidance about *how* to achieve tangible improvement in the areas identified by their appraisals. Knowing what to improve is not enough. They need more guidance about how to go about making the improvements actually happen. There is evidence that those who reported such difficulties in fact made less progress in their subsequent process improvement efforts.

All in all, however, most respondents believe that the money and effort they devoted to their appraisals were well spent, and that the appraisals had a substantial positive impact on their organizations.

2.3 Progress Since the Appraisals

The survey respondents report that a substantial amount of progress has taken place since their appraisals were conducted. Most (56 percent) of the respondents report that their organizations have experienced at least moderate success in addressing the findings and recommendations that were raised by their appraisals; 31 percent report substantial success or marked success throughout their organizations. Only 14 percent say they have had little if any appreciable success thus far.

The vast majority of the respondents report having followed up their appraisals with action plans and process action teams to carry out those plans. Almost three-fourths said that their organizations had implemented process changes in demonstration projects or organization-wide as a result of their appraisals.

There also is evidence that the appraisals have helped establish and maintain buy-in and commitment for software process improvement. Our respondents report that support for process improvement has improved among their organizations' management, technical personnel, and appraisal sponsors, as well as those who participated directly in the appraisals.

Overall, then, the evidence from our survey suggests that a good deal of progress has been made since the appraisals. There is very little evidence indeed that the appraisals have had a negative impact on the progress of process improvement. Very few (4 percent) of our respondents said that their appraisals have been counter-productive. Contrary to some critics, over 80 percent of the respondents said that their organizations' software processes had *not* become more bureaucratic and that technical creativity had not been stifled since their appraisals. Indeed, in the commercial and government sectors, there is evidence that more mature organizations have fewer paperwork requirements than do less mature organizations.

Still, we detect more than a little discouragement about the pace of process improvement. About a quarter of our respondents say that "nothing much has changed" since the appraisal. Almost half say there "has been a lot of disillusionment over the lack of improvement." Over 40 percent say that process improvement has been overcome by events and crises and that other things have taken priority. Almost three-quarters tell us that process "improvement has often suffered due to time and resource limitations"; over three-quarters say that process improvement has taken longer than they expected; over two-thirds say that it has cost more than they expected.

Such difficulties often afflict organizations when they attempt to achieve challenging goals. Clearly, though, there is a need to counter unrealistic expectations about process improvement in some software organizations. Process champions and managers must do a better job of managing those expectations if they are to maintain support for continuous process improvement over the long haul.

2.4 Prospects for Successful Process Improvement

Our respondents' answers to several questions about the characteristics of their organizations are related to the degree of success they attribute to their process improvement efforts. Managers can take a number of actions based on these results.

First of all, managers can actively monitor the progress of process improvements in their software organizations. They can clearly state process improvement goals, and work to ensure that adequate resources are invested in their process improvement efforts. According to our survey respondents, organizations that fare well with visible management and support also are the ones most likely to experience success in addressing the improvements suggested by their appraisals.

Managers can also have at least some control over the ways that their improvement efforts are staffed and compensated. Staff must be compensated for their process improvement efforts as part of their normal work assignments. Process improvement is not something to be accomplished in one's spare time, after the "real" work has been done. People involved in process improvement should be well respected in their organizations. Those who do the technical work should be included in the improvement effort. Process improvement is not something to be left to others. Organizations that do a better job of staffing and funding the improvement effort are also the ones whose post-appraisal SPI efforts have been most successful according to our respondents.

Our data suggest a number of factors that can make process improvement difficult to achieve. Aspects of organizational culture are among those most likely to inhibit such change. When our respondents say that they have seen excessive turf guarding and organizational politics, they also report less success in addressing the findings and recommendations that were raised in their appraisals. Similar results exist when there is cynicism and discouragement left over from previous failures or when the technical staff tend to feel that SPI gets in the way of the "real" work.

Our data also suggest ways in which the research and development community can contribute to the prospects for successful software process improvement. Those survey respondents who say that the recommendations raised by their appraisals were too ambitious are also less likely to report successful improvement efforts following the appraisals. Similar results exist when the respondents are asked about the need for more guidance, mentoring, and assistance in implementing the improvements suggested by the appraisals. We need to learn more about *how* to make change happen, not just *what* needs to be improved.

3 Results of Software Process Improvement

More and more, the process improvement community has been seeking objective evidence about the effect that process maturity has on the performance of software organizations. To that end, we included in our survey a series of questions about organizational performance, and correlated the answers with measures of process maturity.

3.1 Process Maturity

Although we know the appraised maturity levels of our respondents' organizations (see Appendix A), we thought it likely that some of them would achieve higher levels in the one to three years since their appraisals. Thus we asked them to estimate their current maturity levels. The improvements they report (Figure 3-1) are consistent with what one would expect based on their appraised maturity levels [Hayes 95]. Moreover, there is relatively little difference between the appraised and reported maturity levels. For example, 77 percent of those whose organizations were appraised at the initial level say that they still are at level 1; 79 percent of those appraised at the repeatable level say that their organizations still are properly classified at level 2.

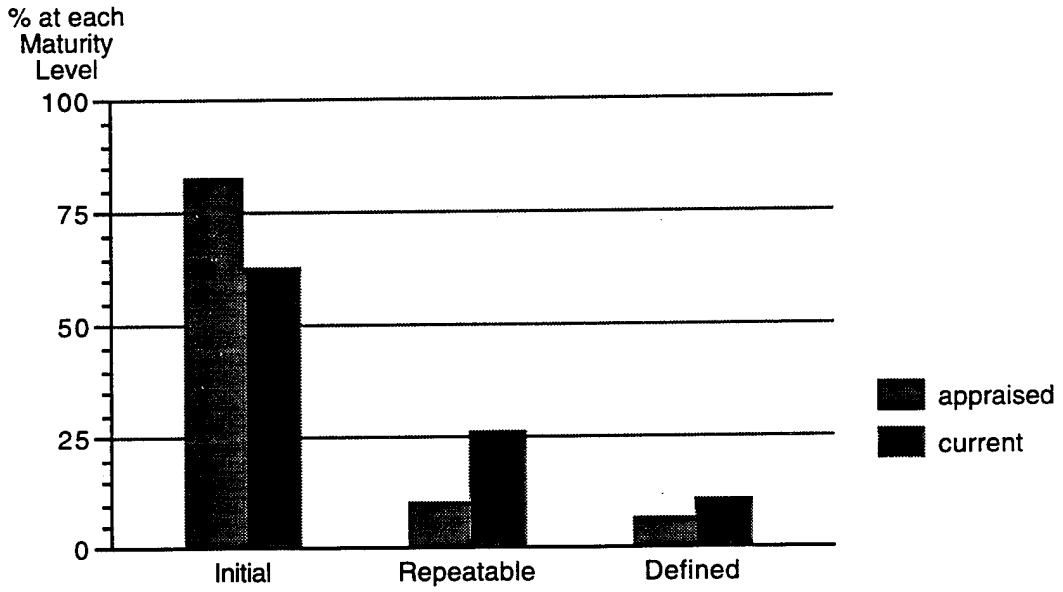


Figure 3-1: Maturity Level

CMM-based and earlier process improvement efforts influenced by the SEI have now existed for quite some time among government contractors [Humphrey 87]. Although there is a growing interest in software process improvement among commercial companies, such efforts are more recent. As would be expected given their shorter exposure, and has been shown

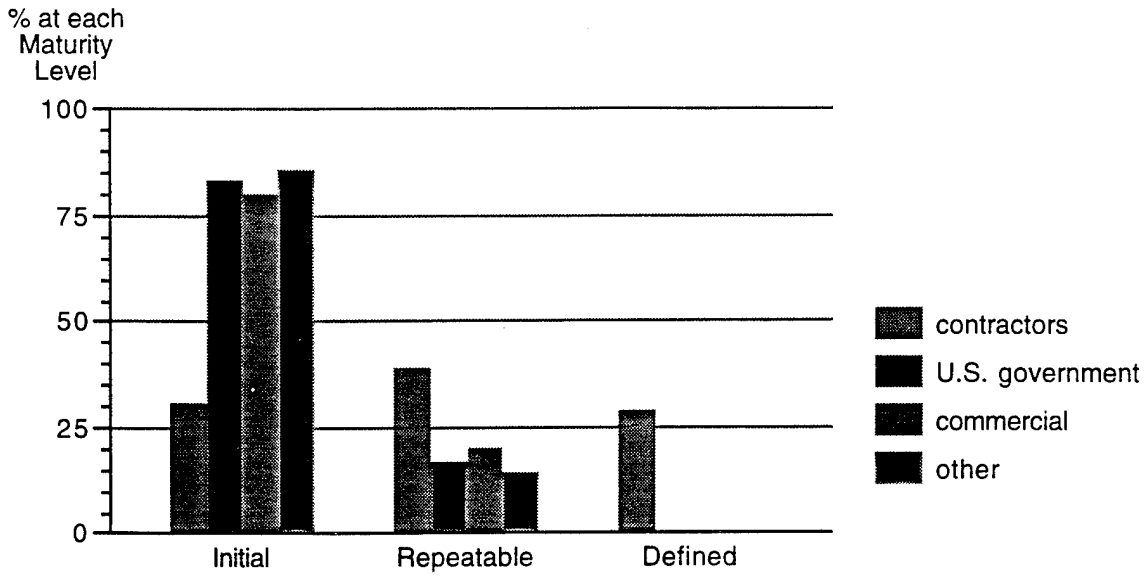


Figure 3-2: Maturity Level by Sector

elsewhere [Zubrow 95], the commercial companies tend to have less mature improvement efforts than the government contractors. Indeed, as seen in Figure 3-2, all of the respondents who say they have achieved level three, the defined level, come from organizations that are government contractors.

As seen in more detail in Appendix B, our sample includes organizations of varying sizes. About one-third of the survey respondents report coming from organizations that employ over 200 software people. Another one-third employ 70 or fewer such individuals. However, there are no statistically significant or consistent differences in maturity level among the different sized software organizations.

3.2 Impact on Organizational Performance

We asked the survey respondents how they would describe their organizations with respect to six performance characteristics. Two of them, ability to meet schedule and budget commitments, address process predictability. The others are product quality, staff productivity, staff morale / job satisfaction, and customer satisfaction. Performance as described by our respondents on all six characteristics does in fact differ by process maturity.

Each line in Figure 3-3 shows the percentage of respondents at each maturity level who characterize performance in their organizations on one of the six characteristics as "good" or "excellent." As seen in the graphs, higher maturity organizations do indeed tend to perform better than do those who remain at the initial level. Five of the six correlations with maturity level are statistically significant (at the .05 level according to chi-square criteria). The sixth, ability to meet budget commitments, approaches statistical significance. There is an

unexplained dip in reported customer satisfaction at the repeatable level. However, the overall patterns are quite clear. Higher process maturity does appear to pay off in better organizational performance.

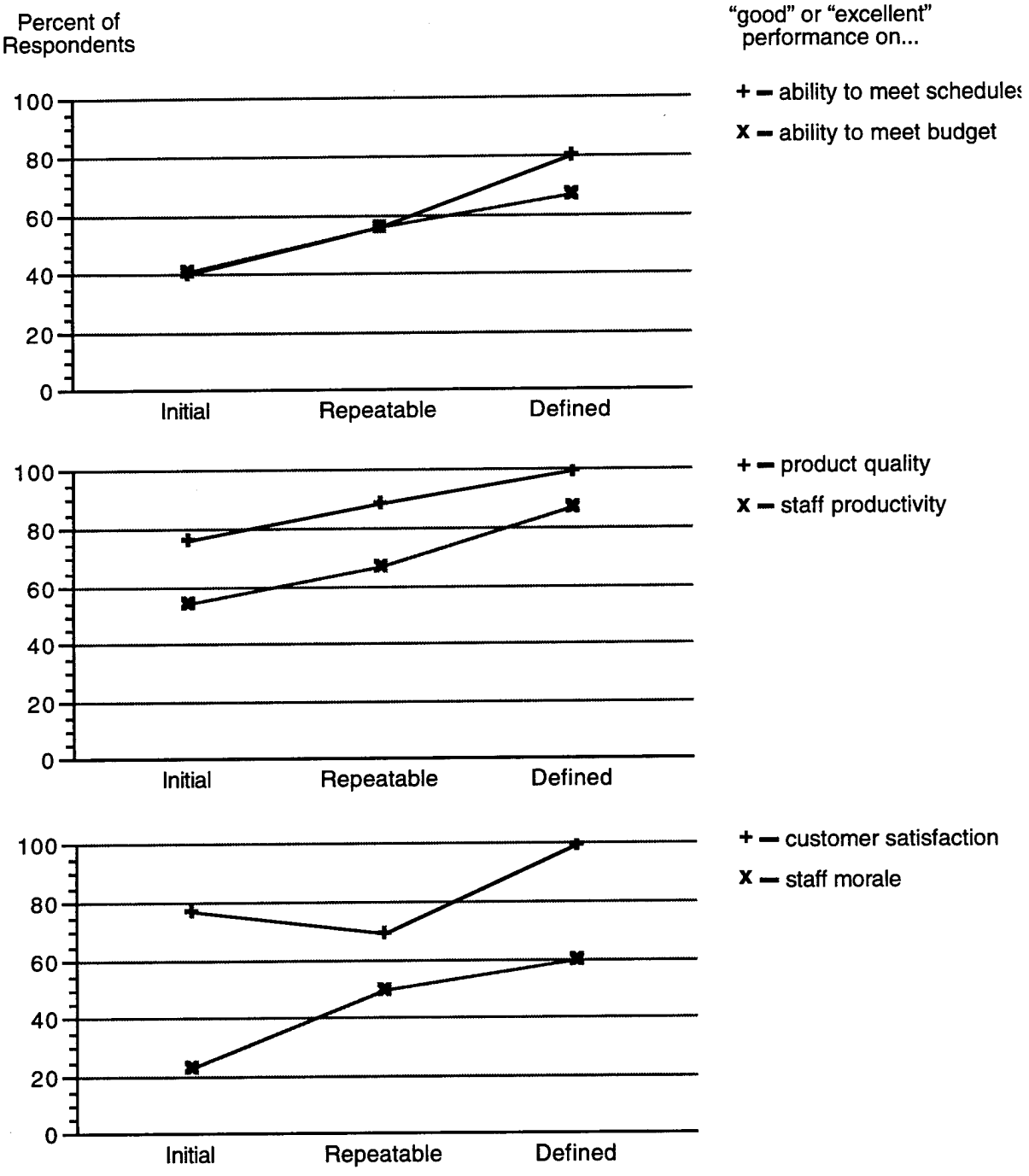


Figure 3-3: Impact of SPI on Organizational Performance

Notice, for example, that 80 percent of those who report that their organizations are at level 3 say that their ability to meet schedule is good or excellent. Only 39 percent of those who remain at the initial level make a comparable claim.

Similarly, notice the pattern of responses about product quality. Almost one-fourth of those at level 1 report that their products are of only "fair" or "poor" quality. On the other hand, *all* of the respondents who report that their organizations have achieved level 3 say that their product quality is good or excellent. Indeed (not shown in Figure 3-3), almost two-thirds of those who claim level 3 status say that their product quality is excellent. Only eight percent of the level 1 respondents make a similar claim.

Those respondents claiming higher maturity level status are also much more likely to report that their staff morale is good or excellent. As seen in Figure 3-3, fewer than a quarter (23 percent) of those at the initial level report that morale is good (only one says it is excellent) in their organizations; indeed, another 23 percent (not shown in the figure) say that their morale level is poor.

3.3 Impact of Industrial Sector and Organization Size

Recall from Figure 3-2 that all of the respondents in our sample who claim level 3 status for their organizations are federal government contractors. However the characteristic relationships between process maturity and organizational performance are *not* entirely due to the level 3 organizations. On the whole, respondents from level 2 organizations tend to report better performance than those from level 1 organizations, regardless of industrial sector.

The relationships between higher maturity level and three of the performance factors (ability to meet schedule, ability to meet budget, and higher staff morale) are statistically significant, even excluding the government contractors from the analysis. The other three approach significance by chi-square criteria. All six relationships are similar to those reported in Figure 3-3. Such consistency is highly unlikely by chance alone.

Similarly, the relationships between maturity level and organizational performance persist among organizations of varying size. Again, as one would expect with small sample sizes and relatively few higher maturity level organizations, the individual statistical relationships are not always significant.[2] However they consistently follow the same pattern: higher maturity level is associated with better organizational performance. See Appendix B for a more detailed analysis of results for small organizations.

2. Actually, all of the relationships controlling for size approach statistical significance (at the .05 level according to chi-square criteria). Eight of eighteen comparisons are in fact significant.

4 The Appraisals

4.1 Accuracy

Our survey respondents are very well satisfied that their appraisals were essentially accurate (Figure 4-1). After up to three years of experience since the appraisals, almost all of them still say that their appraisals were generally accurate in describing their organizations' major problems with software process.

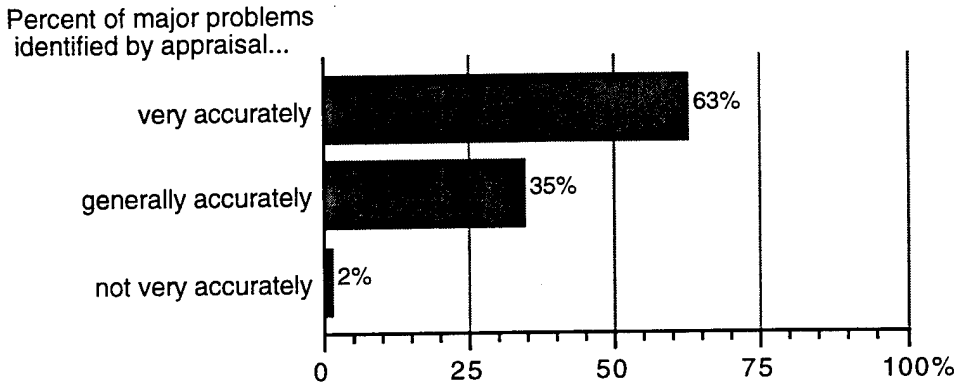


Figure 4-1: Accuracy in Identifying Major Software Problems

While software process appraisals may do a good job of identifying problems, critics sometimes complain that the appraisals do not give proper credit for existing strengths. If true, such a situation would not contribute well to buy-in for improvement efforts based on appraisal results. Our respondents tend to disagree with such sentiments. As seen in Figure 4-2, they are less satisfied with their appraisals' ability to recognize strengths than weaknesses. Over 90 percent, however, report that the appraisals did indeed characterize their organizations' strong points at least reasonably well.

Various other concerns are often heard about the reputed inadequacies of process appraisal methods. Rather few of our respondents share such concerns. Eighteen percent do say that the "results were too dependent on the expertise and judgment" of those who conducted their

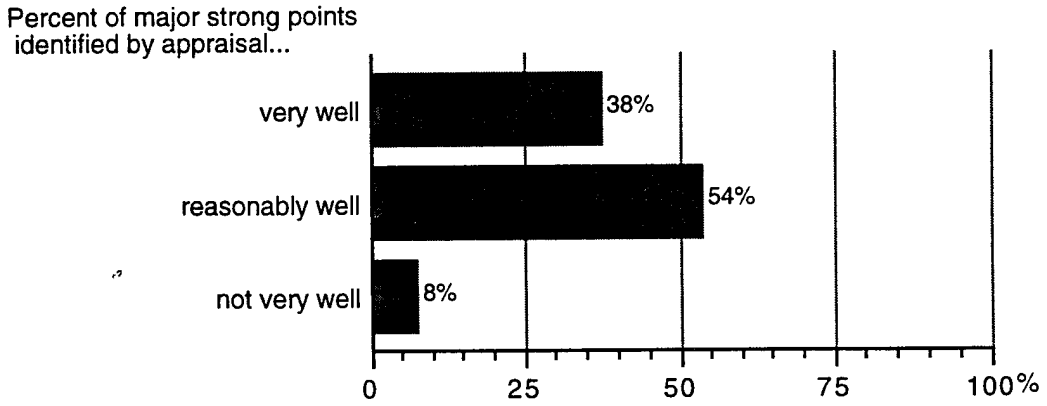


Figure 4-2: Accuracy in Identifying Strong Points

appraisals. However, very few (eight percent) say that the wrong people were chosen to participate in the appraisal (be interviewed, fill out questionnaires, etc.), and only six percent say that the participants were not fully honest with the appraisal team. Even fewer (four percent) complain that there was insufficient room for the team to exercise its judgment during the appraisal.

4.2 Actionability

Beyond being accurate, an appraisal must provide useful, practical information on the basis of which managers and process champions can successfully take action. Based on their experience over the past one to three years since their respective appraisals, our respondents generally are well satisfied that the appraisal results were actionable. As seen in Figure 4-3, over two-thirds report that their organizations' software process improvement efforts were largely determined by the findings and recommendations that were raised in the appraisals. Fewer than 10 percent say that "very little" of the SPI effort was based on the appraisal results.

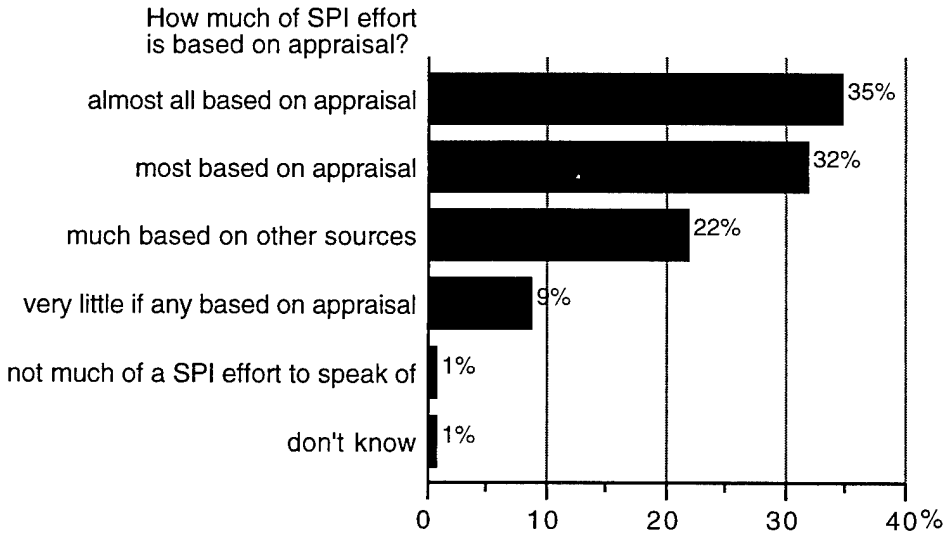
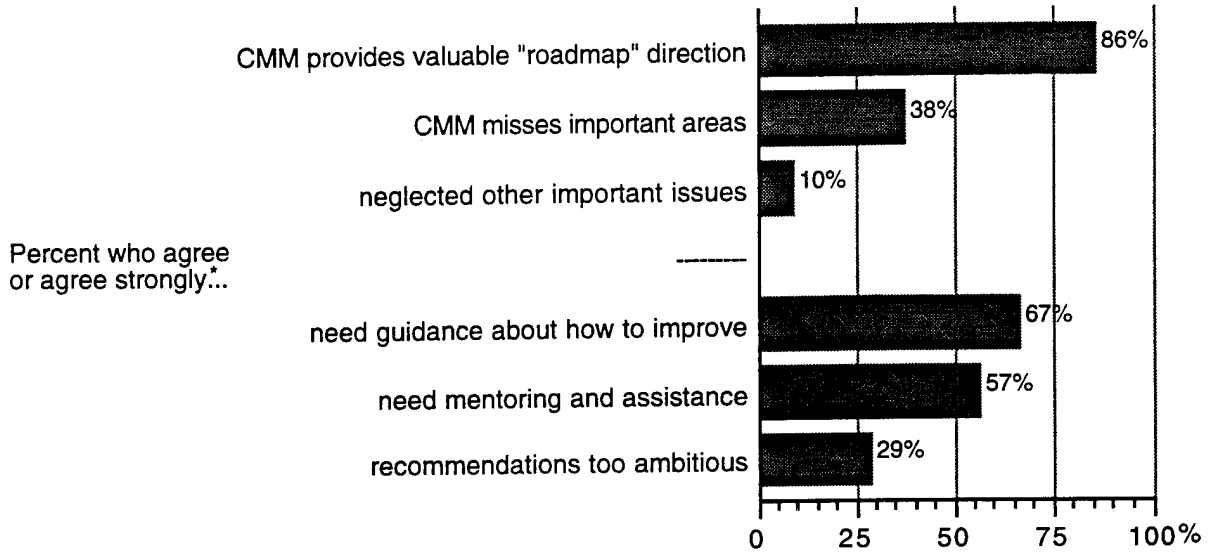


Figure 4-3: Impact of Appraisal on SPI Effort

As seen in the top half of Figure 4-4, over 80 percent of the respondents continue to believe that the "CMM provides valuable direction about the order in which process improvement should be made." The value of the CMM as a "road map" notwithstanding, almost 40 percent do believe that the CMM fails to address important areas. Still, only 10 percent think that the appraisal and/or the CMM caused the neglect of important issues facing their own organizations.

The data in the bottom half of Figure 4-4 do present a somewhat different picture though. First of all, over one-fourth of the respondents say that the recommendations resulting from their appraisals proved to be too ambitious to accomplish in a reasonable time period. Perhaps in



* Each bar in the graph summarizes answers to a separate question, so the percentages do not total 100%.

Figure 4-4: Acting on the Appraisal Results

a related vein, large numbers of the respondents agreed that they need more assistance and guidance about exactly *how* to implement successful process improvement programs.

By now, much is known about how to appraise process maturity and identify those areas most in need of process improvement. More and more, though, we hear concerns that we know a lot less about how actually to achieve tangible improvement in the areas identified by the appraisals. The process improvement community clearly needs to address such issues in more detail.[3]

3. Current work in this area includes that by Peterson 94, Basili 92, and Weller 93, as well as new work by Priscilla Fowler and others at the SEI on the use of detailed "transition packages."

5 Progress Since the Appraisals

The survey respondents' overall judgments are quite positive about the progress of process improvement since their appraisals. Almost three-quarters of them agreed to the rather strongly worded assertion that:

> The assessment was well worth the money and effort we spent:
> it had a major positive effect on the organization.

"Buy-in" and support for software process improvement appears to have improved (Figure 5-1). We asked our respondents to tell us about support for SPI both prior to and since their appraisals. Perhaps not surprisingly, the respondents report that support for SPI has increased most markedly among the people who actually participated in the appraisals. However, they also report considerable improvement in levels of commitment among their organizations' management and technical staffs, and even among the appraisal sponsors.

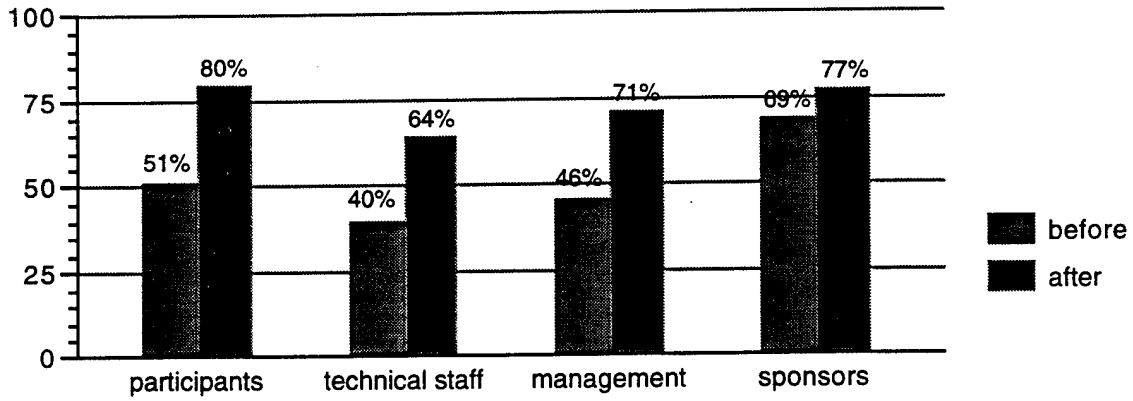


Figure 5-1: Support for Process Improvement Efforts

The respondents also report that their organizations have made good progress in the typical sequence of post-appraisal activities (Figure 5-2). Close to 100% of them report that their organizations created action plans for improvement based on the results of their appraisals. Almost 90 percent said that they had formed process action teams (PATs) to implement the action plans.

Over 70 percent said that their organizations had piloted process changes in demonstration projects as a result of their appraisals, and/or had implemented changes throughout the organizations based on the appraisal results. Clearly, these organizations have progressed beyond the planning stage in their process improvement efforts.[4]

4. In future analyses, we will focus in more detail on the nature of the changes they implemented and on how they map to the key process areas (KPAs) of the CMM.

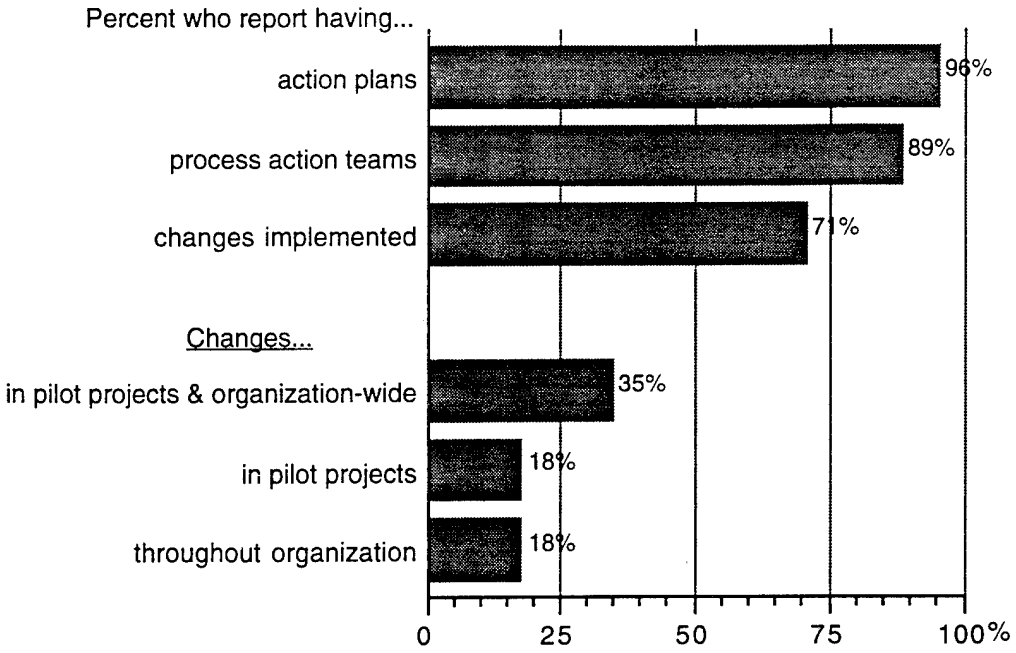


Figure 5-2: Post-Appraisal Activities

Although most of the respondents do report that their organizations have made reasonable progress in taking action as a result of their appraisals, not all of these actions have been equally effective. We asked our respondents about the extent of success their organizations have had in addressing the findings and recommendations that were raised as a result of their appraisals. As seen Figure 5-3, their answers vary considerably. As we will see in Section 6, a number of characteristics of the organizations and their SPI efforts distinguish those who have had the most success from those who have been less successful.

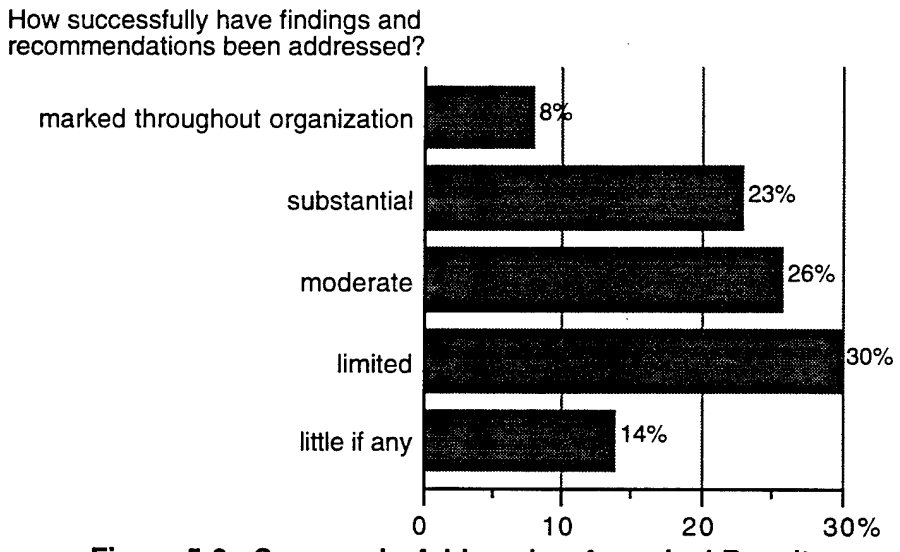


Figure 5-3: Success in Addressing Appraisal Results

While there is substantial variation in the extent of process improvement reported by our respondents, there is next to no evidence that the appraisals have negatively affected process improvement in the organizations where they were conducted. Very few (4 percent) of the respondents said that the appraisals had been counter-productive and that the progress of process improvement had actually worsened since their appraisals.

Contrary to some of the more loudly voiced criticisms of CMM-based process improvement, we found very little evidence that software processes have become more rigid and bureaucratic or that it has become harder to find creative solutions to difficult technical problems. A large majority of our respondents (84 percent) disagreed or strongly disagreed with these assertions. Indeed, respondents from more mature organizations in the commercial and governmental sectors reported that it took *less* "paperwork to get things approved" than did respondents from less mature organizations.[5]

That said, many of our respondents do report difficulties in maintaining their process improvement efforts. Over a quarter of them (26 percent) agree that "nothing much has changed" since the appraisal, almost half (49 percent) say that there "has been a lot of disillusionment over the lack of improvement," and 42 percent say that process improvement has been overcome by events and crises and that other things have taken priority. Almost three-quarters (72 percent) report that process "improvement has often suffered due to time and resource limitations." Over three-quarters (77 percent) say that process improvement has taken longer than they expected, and over two-thirds (68 percent) say that it has cost more than they expected.

The reasons for these difficulties are not unique to SPI efforts, and often afflict organizations when they attempt to achieve challenging goals. Clearly, though, there is a need to counter unrealistic expectations about process improvement in some software organizations. Process champions must do a better job of managing those expectations if they wish to maintain long-term support for continuous process improvement.

5. The relationship between higher maturity and lessened paperwork does not hold up among government contractors, where the amount of paper is often a function of contractual obligations.

6 Prospects for Successful Process Improvement

Many potential barriers exist that may make process improvement difficult to achieve. Similarly, there may be organizational characteristics that help make some process improvement efforts more likely to succeed than others [Fowler 90, Miller 92, Maher 94]. We included several questions meant to capture such differences among the organizations in our survey, and then correlated each of them with the question (summarized in Figure 5-3 on page 20) about how successfully the organizations had addressed the findings and recommendations of their appraisals.

6.1 Success factors

Successful SPI efforts as characterized by our respondents differ from less successful efforts in several ways.[6] For example, as seen in Figure 6-1, *all* of those who say that the findings and recommendations raised by their appraisals have been addressed with marked success throughout their organizations also report that their managers actively monitor the progress of process improvement. Such management commitment is considerably less common in the organizations with less successful improvement efforts.

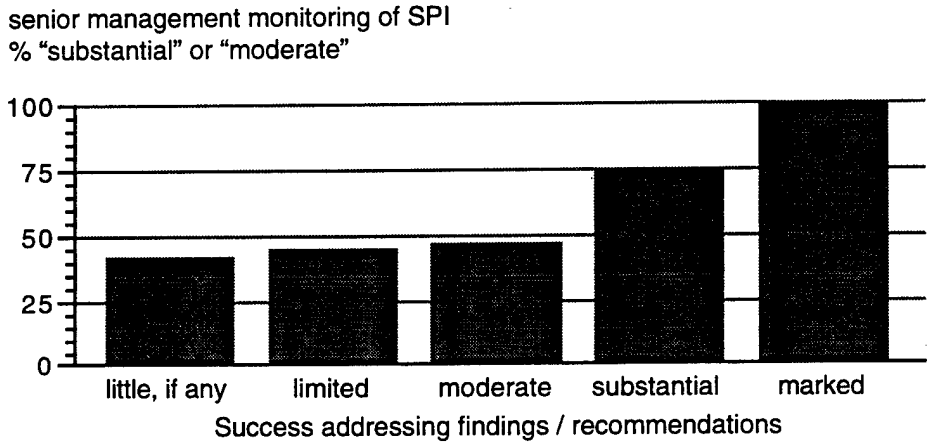


Figure 6-1: Successful SPI and Senior Management Monitoring of SPI

Resource issues appear to be quite important. For example, we asked our respondents whether there "has been clear, compensated assignment of responsibilities for process improvement" in their organizations. As seen in Figure 6-2, those who report more success in their improvement efforts also are much more likely to tell us that there is such explicit assignment of responsibility for SPI in their software organizations.

6. For reasons of space, only a few characteristic figures are included in Section 6. Figures for the other good predictors of SPI success ($p \leq .05$ by chi-square criteria) are reproduced in Appendix C

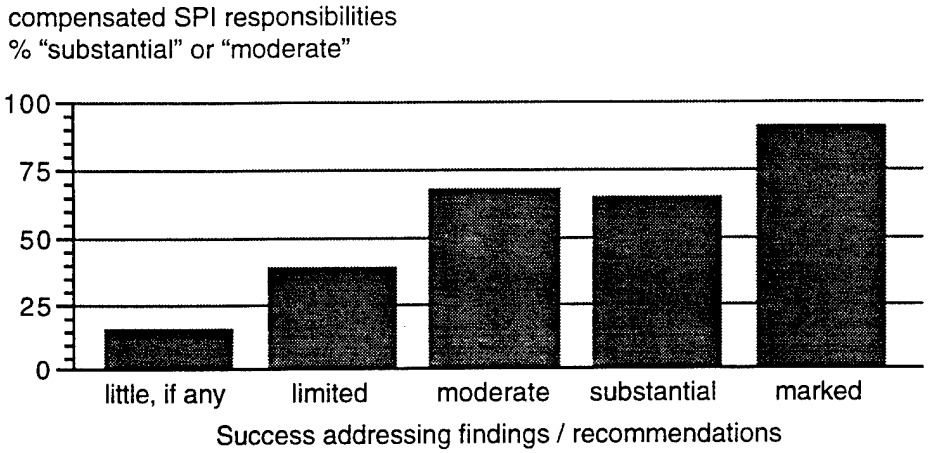


Figure 6-2: Successful SPI and Compensated SPI Responsibilities

Four other factors are comparably associated with successful SPI efforts. Those who claim greater success in addressing the improvements suggested by their appraisals also are more likely to report that

- the people involved in process improvement have been well respected in their software organizations (Figure C-5)
- there has been more involvement of technical staff in the SPI effort (Figure C-6)
- the amount of staff time and resources dedicated to process improvement has been good or excellent since their appraisals (Figure C-7)
- process improvement goals are clearly stated and well understood in their organizations (Figure C-8)

6.2 Barriers

Not surprisingly, we also have evidence about barriers that can inhibit successful software process improvement. As can be seen in Figure 6-3, excessive "organizational politics" seem to be particularly damaging. Barely a quarter of our respondents who claim marked success for their organizations' SPI efforts also report an inordinate amount of organizational politics. Three-quarters of those who report little if any success in addressing the findings and recommendations of their appraisals say that organizational politics are commonplace.

Three other factors are comparably associated with less successful SPI efforts. Similar results exist for

- "turf guarding" (Figure C-9)
- discouragement and cynicism from previous experience (Figure C-10)
- the feeling among the technical staff that process improvement gets in the way of their "real" work (Figure C-11)

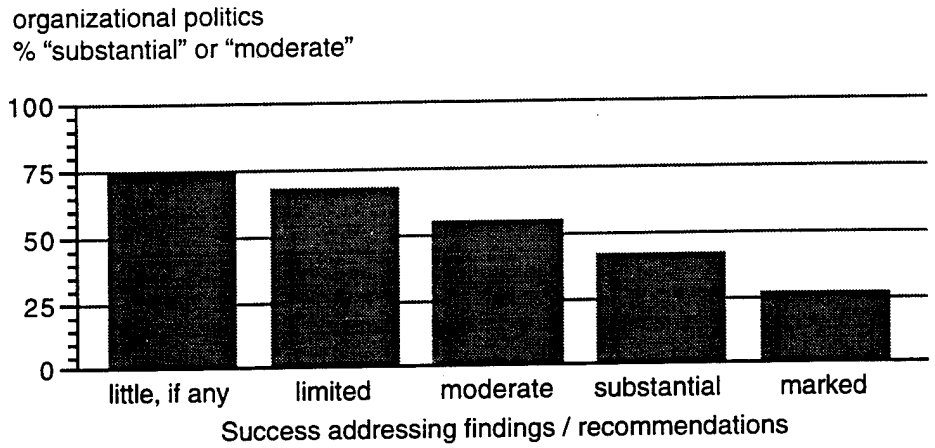


Figure 6-3: Successful SPI and Organizational Politics

Figure 6-4 shows the relationship between reported success of SPI and our respondents' answers to the question about the scope of the findings and recommendations raised in their appraisals. Those with less successful process improvement efforts are also more likely to say that their appraisals' recommendations were too ambitious. Similar results exist for the two questions about need for more guidance, mentoring, and assistance in implementing the improvements suggested by the assessments (Figures C-12, C-13, and C-14).[7]

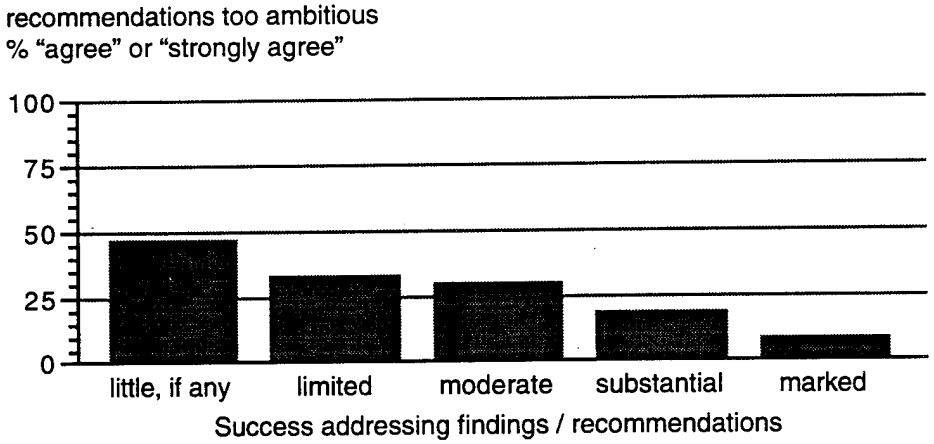


Figure 6-4: Successful SPI and Recommendations Too Ambitious

7. The relationship in Figure 6-4 is not quite significant by chi-square criteria, and the data in Figure C-13 are rather "noisy" (the more characteristic differences exist for the respondents who "strongly" agree or disagree that there is a need for mentoring and assistance in their organizations). However, all three relationships are very unlikely to occur together by chance alone. See the discussion of Figure C-14 on page 48 for more detail.

Four other inhibiting factors are moderately related to our measure of overall SPI success since the assessments. The correlations are only marginally significant statistically ($p > .05$ by chi-square criteria). However they are of sufficient interest to mention here, and quite possibly worthy of further consideration in future work. They are

- turnover in key senior management
- the need for paperwork to get things approved in the organization
- decreasing demand for the organization's products or services
- major reorganization(s) or staff down-sizing

6.3 What Doesn't Seem to Matter?

Not all of the potential success factors or inhibitors that we examined proved to be good predictors of SPI success. How the respondents answered these questions is unrelated to their answers to the question about overall success in addressing the findings and recommendations raised by their assessments

- whether or not software organizations provide special, tangible incentives and rewards for successful SPI
- turnover among middle management and technical staff
- management willingness to take risk
- the extent to which management understands the "issues faced by practitioners"

It is important, however, to interpret these results in the context of our results about factors that are in fact related to SPI success. For example, while special rewards for successful SPI do not appear to have a consistent effect, making sure that those responsible for process improvement are properly compensated as part of their regular work efforts is important (Figure 6-2). Detailed understanding of the technical work by senior management (and/or micro-management) does not have a consistent impact on the success or failure of the software process improvement efforts described by our respondents. However, senior management oversight is in fact quite important (Figure 6-1).

7 Conclusion

We began this report by enumerating three goals for the survey. Here, we briefly discuss the extent to which we were able to meet them, and then identify some important remaining issues for future work.

7.1 Discussion

Goal 1: Describe what typically happens to process improvement efforts after CMM-based appraisals.

This survey provides a much needed description of the experiences of software organizations that have based their process improvement efforts on the CMM and CMM-based appraisals. Compared to previous work, the survey is much more representative of the CMM-based SPI community. It is drawn from commercial and government organizations as well as government contractors, and it includes organizations that vary considerably in size. It includes both more and less successful SPI efforts, and it spans several maturity levels.

Our respondents are drawn equally from senior technical staff and software managers, as well as SEPGers and other process improvement champions. Our results are not dependent solely on people who are personally invested in the CMM. Indeed, there are no systematic differences among the three groups from which we sampled.

We sent questionnaires to every person we could identify who was in a good position to see what happened in the one to three years following an SEI software process assessment. We followed up aggressively to get a good (83 percent) rate of return and avoided self-selection problems.

Goal 2: Understand as much as possible about why some improvement efforts are more successful than others.

We found a number of attributes of software organizations, their SPI efforts, and organizational cultures that are strongly related to success in process improvement. Many of these are under direct management control. Some of the cultural factors may be difficult to overcome, but good managers deal with such issues every day.

Goal 3: Learn more about the relationship between process maturity and organizational performance.

We found a number of important differences in performance between more mature and less mature organizations. These results are largely consistent with the case studies in the literature and with our previous work.

7.2 Remaining issues

No single study can hope to test all of the important ideas and claims about the CMM and what happens as organizations implement SPI efforts based on it. The CMM is a complex reference model, and the effects of organizational change are difficult to measure and difficult to trace back to particular causes.

We currently are working on a coordinated series of studies to address in more detail the content of the CMM and the consequences of adopting it. One line of work we have recently undertaken is moving toward the establishment of a series of "collaboratories" with a small number of software-dependent organizations. The approach is within the spirit of the Software Engineering Laboratory pioneered by Basili and his associates [Basili 92], but it focuses primarily on software process improvement and on how to determine and achieve business results. In an attempt to provide more actionable guidance for SPI, other studies will focus in depth about factors that affect the success of improvement efforts within particular key process areas.

Acknowledgments

First and foremost, we thank those who returned their completed questionnaires to us, and we thank our many points of contact for the appraised organizations who helped us identify the respondents. Quite obviously, we could not have completed the survey without their help and cooperation.

We had many productive discussions with colleagues during the planning and design stages of this work. Thanks in particular go to Peter Bøttcher, Betty Deimel, Will Hayes, Priscilla Fowler, Mike Konrad, Linda Levine, Gene Miluk, Mark Paulk, Bob Stoddard, David White, George Winters, and Dave Zubrow. Joe Besselman, Mark Ginsberg, Russell Reed, Bob Stoddard, and Mike Webb provided valuable help in the pretest of the survey questionnaire.

Work of this kind requires a great deal of difficult and time consuming administrative effort. James High, and Suzanne Hite spent many hours tracking down names and addresses for the sample *via* phone, mail, and email, fielded queries from survey respondents and appraisal points of contact, handled a myriad of details for the multiple mailings of questionnaires and reminders, and assisted in the optical scanning of the completed questionnaires.

David White's help with the survey's conduct and contents was invaluable in many ways. Among other things, he both provided software and led the administrative effort necessary for constructing the survey sample, distributing questionnaires, tracking responses, and optically scanning the data. Mike Zuccher provided additional help with the PAIS database.

We first presented our results at the 1995 SEPG Conference in Boston. Thanks to our panel chair, John Howland, and to the SEPG reviewers.

Joe Besselman, Donna Dunaway, Wolf Goethert, Will Hayes, Bob Lang, Tom Miller, Bill Peterson, Bob Stoddard, and Dave Zubrow reviewed the report manuscript and provided several useful suggestions for its improvement.

Any errors or omissions, of course, are our own.

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Appendix A The Survey Sample

A.1 The Appraisals

The sample for this survey was drawn from the Process Appraisal Information System (PAIS) database maintained at the Software Engineering Institute. It includes software process assessments (SPAs) that were conducted in the United States and Canada during calendar years 1992 and 1993 - long enough ago for genuine change to have taken place, yet recent enough to expect accurate recall from people familiar with the appraisals and their aftermaths. Appraisals conducted outside of North America were excluded to avoid undue administrative costs.

The sample was created in September of 1994. At that time, 155 SPAs in the PAIS database met our time and geographic selection criteria. We were able to obtain information allowing us to contact specific individuals for the survey from 61 appraisals - slightly less than 40 percent of those eligible.

Not all of our original points of contact from the database were equally accessible or accommodating, and we did have difficulty in finding individual contact information. However, there is no *a priori* reason to expect any bias in the sample of 61 appraisals as compared to the 155 eligible appraisals.

In particular, the appraisals in the sample do *not* appear to be self-selected. The appraisals for which we were unable to obtain individual contact information were conducted at a variety of software organizations, including some well known for their successful improvement efforts. As seen in the main body of this report, the survey respondents reported widely varying degrees of success in the process improvement efforts subsequent to their appraisals. Even if the organizations we included are somehow more successful than the others in their process improvement efforts, there would have to be very substantial bias in the sample to invalidate our basic results, especially those comparing success among different types of organizations.

The present survey contains a series of questions that we had used in an earlier survey based on a very different sample [Deephouse 95]. Results from both surveys are very similar about the extent of process improvement following comparably recent appraisals. (See the discussion of Figure 5-2 for further details.) Such consistency improves our confidence in both samples.

Of course, we have no way of knowing the extent to which the PAIS database itself is fully representative of all CMM-based appraisals. Although the database has grown considerably in recent years, it undoubtedly is incomplete. We expect that appraisals will be logged in PAIS much more regularly in the future given the requirements for authorization of lead assessors under the program for CMM-Based Appraisals for Internal Process Improvement (CBA IPIs) .

As will be seen momentarily, the individual respondents to our surveys have been very accommodating. We have achieved very good return rates, so we can be confident that our results are not biased by self-selection effects among the respondents. However it bears repeating here that the quality of our analyses depends ultimately on the degree of cooperation we receive from the CMM-based process improvement community.

A.2 The Respondents

People who fill different roles in an organization can sometimes have differing perspectives about the same events. For example, one often hears that the views of software developers and managers typically are quite unlike those of the champions of software process improvement in their own organizations. Similarly, managers and technical people often are seen as being widely divided. Hence we designed the survey sample to allow comparisons among people whose perspectives might be expected to differ as a result of their differing roles

We asked our original database points of contact for each appraisal to nominate individuals to fill four roles: 1) the project level software manager most knowledgeable about the appraisal; 2) the most knowledgeable and well-respected senior developer or similar technical person available; 3) an organizational level SEPG manager, or someone with equivalent responsibilities, if such a person existed; and 4) the senior manager who was the appraisal sponsor, or his/her replacement.[8] Excluding the appraisal sponsors, we obtained contact information for 167 individuals representing the 61 appraisals.[9]

Interestingly enough, it turns out that there are *not* characteristic, systematic differences among the respondents who fill the three different roles. We correlated organizational role with the respondents' answers to all of the other survey questions described in this report, and found only two statistically significant relationships ($p \leq .05$ by chi-square criteria). A third approached significance ($p \leq .10$). With enough comparisons, one can always find a few apparently significant differences, but such a consistent pattern of nonrelationship is highly unlikely to occur by chance.

If anything, the SEPGers actually tend to be slightly *less* satisfied than the others about the progress of software process improvement since their appraisals. However the differences are minor, and exist by the most generous criteria in fewer than one fourth of the role comparisons we made. More often, we simply find no differences attributable to role.

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8. We chose not to include the appraisal sponsors in the current survey. Many of the current questions are of a more technical than managerial nature, and we wanted to tailor a more focused set of questions for the sponsors based on what we would learn from the broader survey.

9. There are not three people for all of the appraisals. Not all three roles (senior technical, project management, and/or process champion) were always filled. In a few instances the same person held more than one role. More than one person shared a single role in a few other instances.

   There was no requirement that any of these people were on the appraisal teams, nor even that they personally participated in the appraisals. However, they all were required to be familiar with their respective appraisals, and with the progress of software process improvement in their organizations since the appraisals.

The overall agreement among people who fill different organizational roles gives us more confidence in the survey results than we would have had if we relied entirely on process champions. Since there are no characteristic role differences, we have combined all respondents for the analyses presented in this report. The larger number of individual respondents also gives us more confidence in the overall results than we would have if there was only one respondent per organization.

A.3 Response Rates

We sent questionnaires by mail to the 167 individuals in our sample during the period from November 1994 through April 1995. Follow-up reminders and replacement questionnaires were sent as necessary. The analyses in this report are based on 138 completed questionnaires, which is 83 percent of the total number sent.[10] They represent 56 of the 61 appraisals (92 percent) from which we sampled. We can be quite confident that there is little if any self-selection bias among our respondents.[11]

A.4 About the Appraised Organizations

Our survey respondents represent a variety of software organizations. The largest single proportion (37 percent) are from organizations that do contract work for the federal government. Another 22 percent are from the federal government and U.S. military services. These figures are not surprising given the long-standing experience with software process improvement among such organizations. As expected from recent updates from the PAIS database [Zubrow 95], firms selling products in the commercial market are the second largest category (36 percent) of software organization represented by our respondents. Another 5 percent fall into the "other" category.

The organizations represented in our sample vary considerably in size. Approximately one-third of the survey respondents say they come from organizations that have 200 or more software employees. Another third come from organizations that employ 70 or fewer people who are primarily engaged in software.

Firms selling products in the commercial market are smaller than those in the military and federal government; 43 percent of the commercial organizations have 70 or fewer software employees, as opposed to only 14 percent of the government organizations. The government contractors vary more in size; 40 percent have 200 or more software employees, while 34 percent have 70 or fewer.

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10. We received two additional questionnaires after the analyses were completed.

11. Mail surveys tend to suffer from disturbingly low response rates. Worse, there is evidence that people who fail to return completed questionnaires without additional prodding typically differ in important ways from those who do respond right away. However, as our experience attests, it is possible to attain high response rates to mail surveys when proper attention is paid to implementation issues.

Most (83 percent) of the respondents report that their organizations have software engineering process groups (SEPGs) or other units that perform similar functions; 46 percent report having SEPGs in their parent (e.g., corporate level) organizations. The overall effort devoted to software process improvement varies considerably. One-fourth say that they employ 3 or fewer full-time-equivalent (FTE) people who have specifically assigned responsibilities for process improvement and/or quality management.[12] Half employ 5 or fewer such people FTE, but another one-fourth employ 12 or more.

As expected, the survey respondents are pretty much evenly distributed among the roles that we sampled: 31 percent are SEPGers and other process champions; 34 percent each are software managers or senior technical people respectively. One person filled both the management and SEPG roles concurrently.

The respondents have a considerable amount of software experience. Half of them have worked on software for 16 years or more; a quarter of them have worked in the field for 22 or more years. All but the least experienced 10 percent of our respondents have worked on software for 10 years or more.

12. FTE is defined in the survey as "full timers plus the hours worked by part timers and consultants."

Appendix B Differences Due to Organizational Size

Whether or not CMM-based process improvement scales down well to smaller organizations has been the subject of a continuing and sometimes heated debate in the process improvement community [Brodman 94]. Our survey contributes at least some limited, objective data to the dialog.

First of all, (as mentioned in Section 3.1) organizational size *per se* is not related to process maturity. There are no statistically significant or consistent differences in maturity level among the different sized software organizations. Neither is size alone directly related to organizational performance in a consistent manner.[13]

As mentioned in Section 3.3, the relationships we found between maturity level and organizational performance persist among organizations of varying size. All of the relationships controlling for size approach statistical significance (at the .05 level according to chi-square criteria). Among the smaller organizations with 70 or fewer software employees, there are significant correlations between maturity level and two performance factors (ability to meet schedule and staff morale / job satisfaction). There are also two statistically significant relationships (product quality and staff productivity) among the larger organizations that employ over 200 software personnel. Four of the relationships are significant among the reportedly mid-sized organizations (all but customer satisfaction and staff productivity).

Organizational size alone is unrelated to overall SPI success (as discussed in Section 5). Respondents who represent larger organizations are no more, or less, likely to claim such success than are those who come from smaller organizations.

In fact, we are able to find very few characteristic differences that are directly attributable to organizational size. However, this lack of variation due to size does speak to the on-going debate. We fail to find differences that some might expect. In particular, respondents from small organizations are no more, or less, likely than those from large organizations to complain that software processes have become more rigid and bureaucratic since their organizations embarked on their CMM-based process improvement efforts. Neither do the respondents from the varying sized organizations differ in their likelihood of saying that their appraisals and/or the CMM have led to neglect of other important issues facing their organizations. They are equally likely to say that their appraisals represented money well spent, and that the appraisals had a major positive effect on their organizations.

If anything, our survey data provide some limited evidence that the smaller organizations may be more amenable to successful process improvement than are the larger ones. After all, it typically is difficult to accomplish change in large organizations in general.

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13. Staff productivity may be an exception. Sixty-nine percent of the respondents from organizations with 70 or fewer software employees say that their staff productivity is excellent or good. The comparable figure for organizations with over 200 software employees is 45 percent.

Our respondents from smaller organizations are less likely to report unrealistic expectations about the cost or time necessary to accomplish tangible process improvement. For example, 73 percent of those from organizations with over 200 software employees agree that the effort is costing more than they expected; 47 percent of those from organizations with 70 or fewer software employees say the same. Similarly, 80 percent of those from the largest organizations say that the effort is taking more time than they expected; 62 of those from the smaller organizations agree.

Perhaps not surprisingly, organizational politics and turf guarding are more difficult problems in the larger software organizations. Turf guarding is identified as a substantial issue by 32 percent of those from the large organizations in our sample; only 7 percent of those from the smaller organizations report a similar situation. Somewhat similarly, 45 percent of those from the large organizations report a substantial amount of organizational politics; 20 percent of those from smaller organizations do so.

Again not surprisingly, more paperwork is necessary to get things done in the larger organizations. Of those from organizations with over 200 software employees, 70 percent say that a substantial or moderate amount of paperwork is required; the comparable number is 47 percent for those who come from organizations with 70 or fewer software employees.

Finally, those from smaller organizations are somewhat less likely to report that there is a common feeling among their technical staffs that process improvement gets in the way of their "real" work. Of those from organizations with 70 or fewer software employees, 33 percent say that SPI is perceived to be "in the way" at least moderately often; the comparable number is 57 percent for those who come from organizations with over 200 software employees.

Appendix C Predictors of Process Improvement

C.1 Possible Barriers and Success Factors

Adequate commitment to process improvement, and the existence of sufficient resources, are often thought to be crucial for ensuring successful SPI efforts. As seen in Figures C-1 and C-2, our respondents report sometimes substantial differences in commitment and resources for SPI in their software organizations.

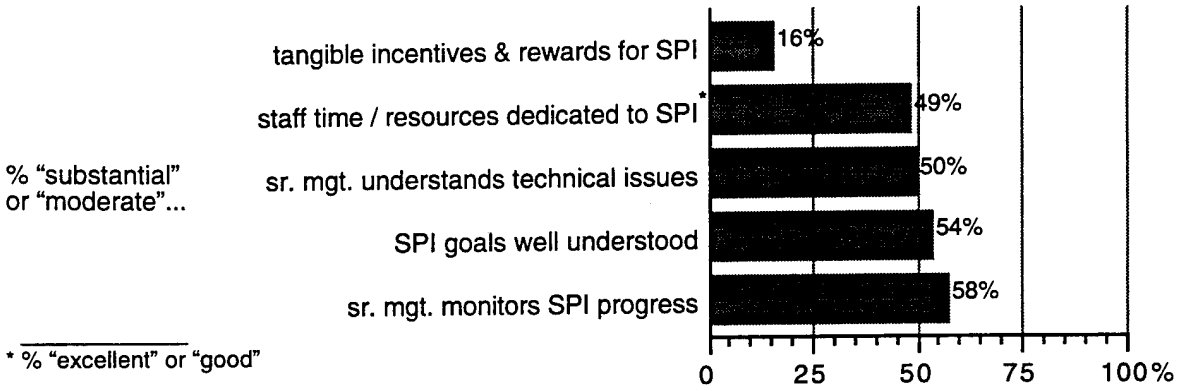

Figure C-1: Commitment and Resources: Possible Success Factors

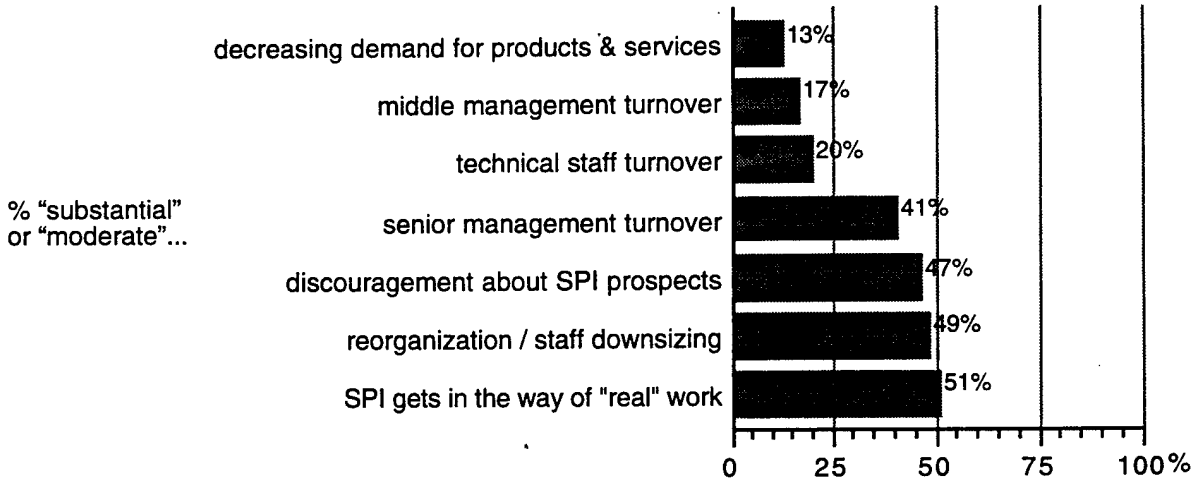

Figure C-2: Commitment and Resources: Possible Barriers

Similarly, management style and organizational cultural differences are often cited as important determinants of success or failure in software process improvement. Variations in the respondents' reports about a set of such factors are summarized in Figures C-4 and C-3.

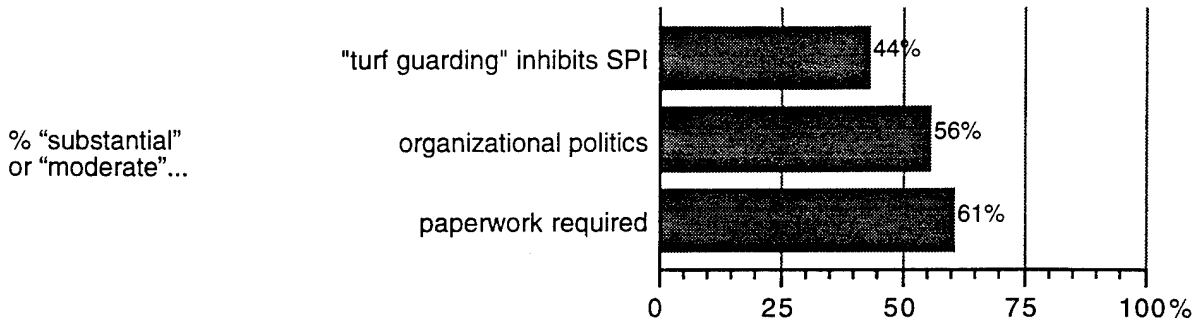

Figure C-3: Management Style And Organizational Culture: Possible Barriers

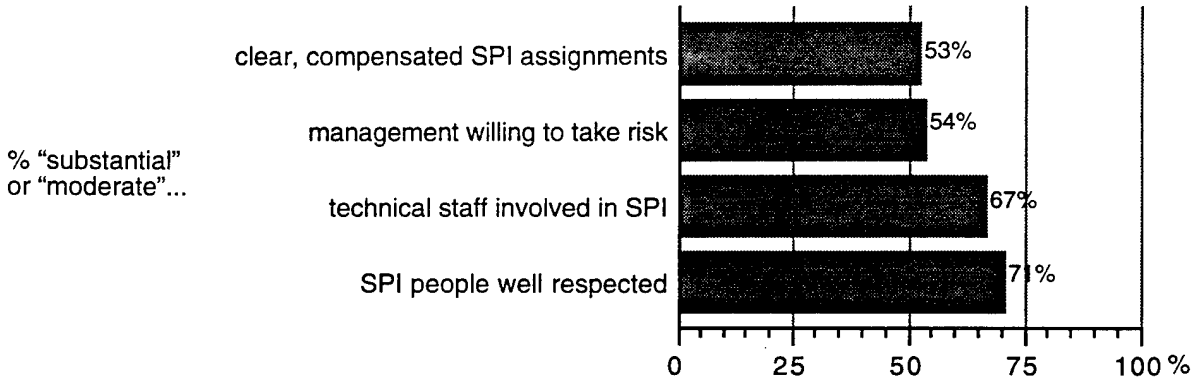

Figure C-4: Management Style And Organizational Culture: Possible Success Factors

Other factors might also affect the likelihood of success in a process improvement effort. Among those we discussed in Section 6 are the scope of the findings and recommendations raised in the appraisal, and the need for guidance, mentoring, or assistance in implementing the improvements suggested by the appraisal.

We correlated each of these factors with the question (summarized in Figure 5-3 on page 20) about overall success in addressing the findings and recommendations of the appraisal. The different factors distinguish among more and less successful SPI efforts in several interesting ways.

C.2 Impact on Process Improvement

Following are the figures not included in Section 6 that show statistically significant relationships ($p \leq .05$ by chi-square criteria) with reported success in addressing appraisal findings/recommendations.

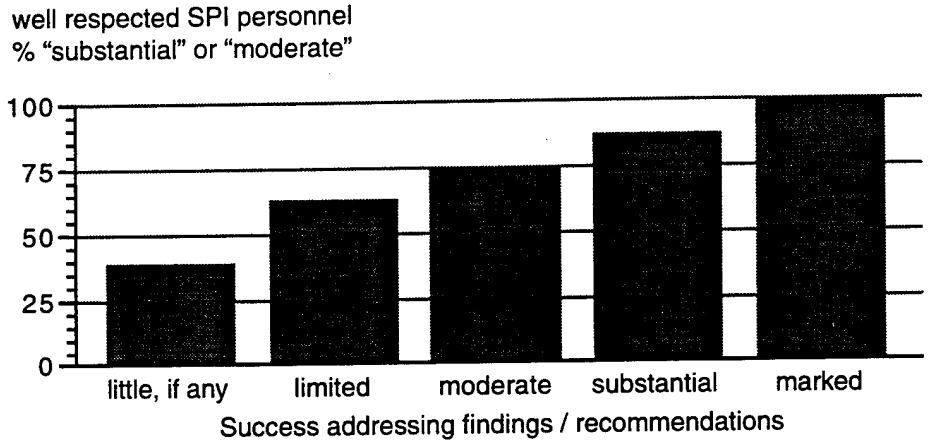

Figure C-5: Successful SPI and Well Respected SPI Personnel

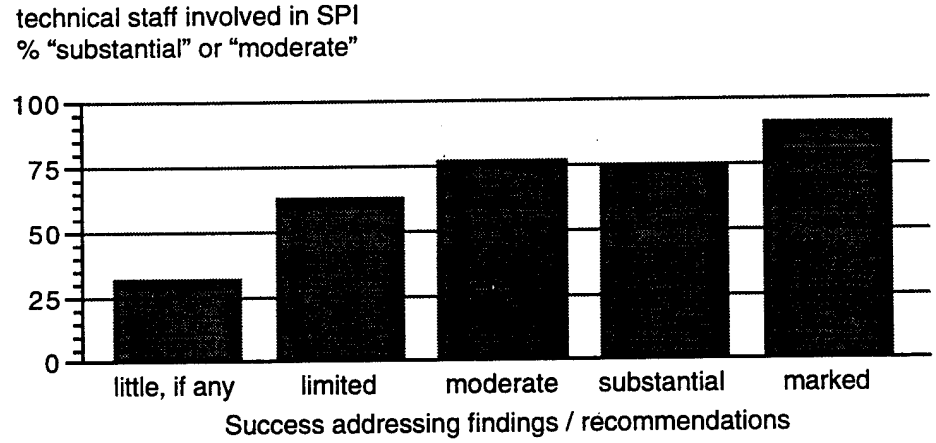

Figure C-6: Successful SPI and Technical Staff Involved in SPI

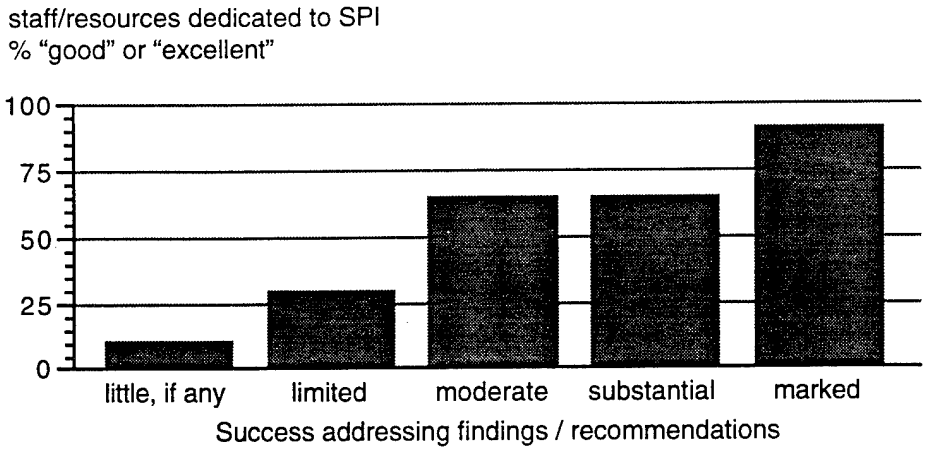

Figure C-7: Successful SPI and Staff/Resources Dedicated to SPI

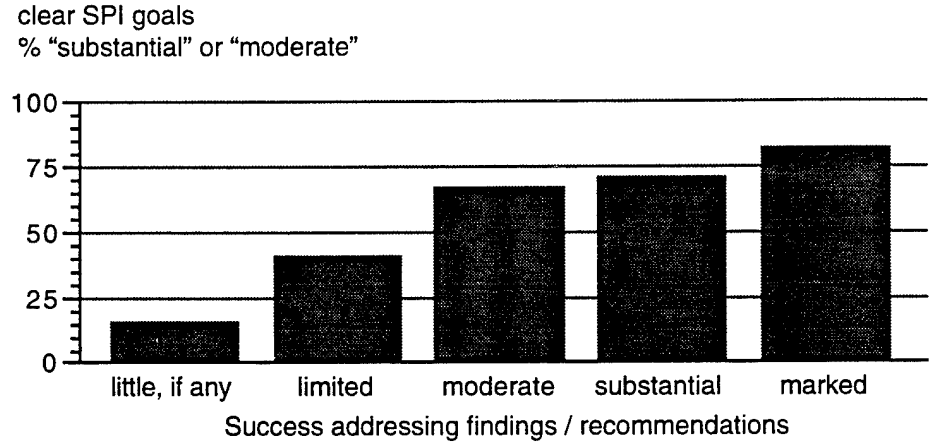

Figure C-8: Successful SPI and Clear SPI Goals

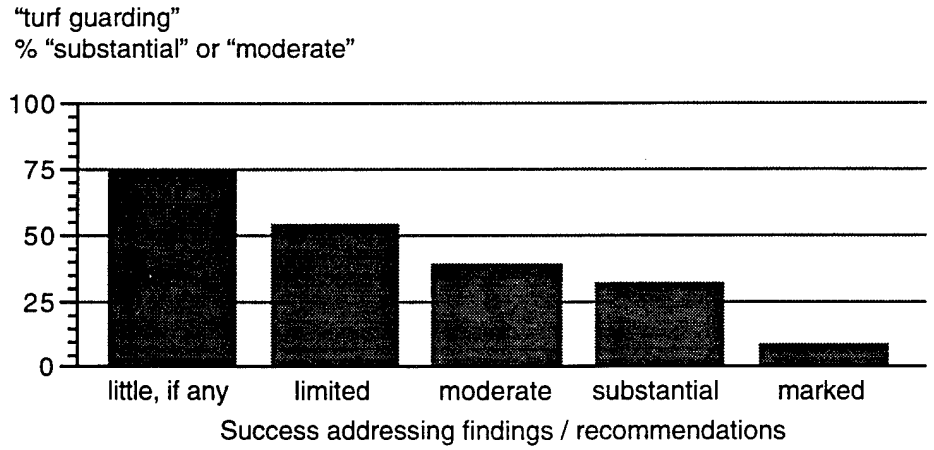

Figure C-9: Successful SPI and "Turf Guarding"

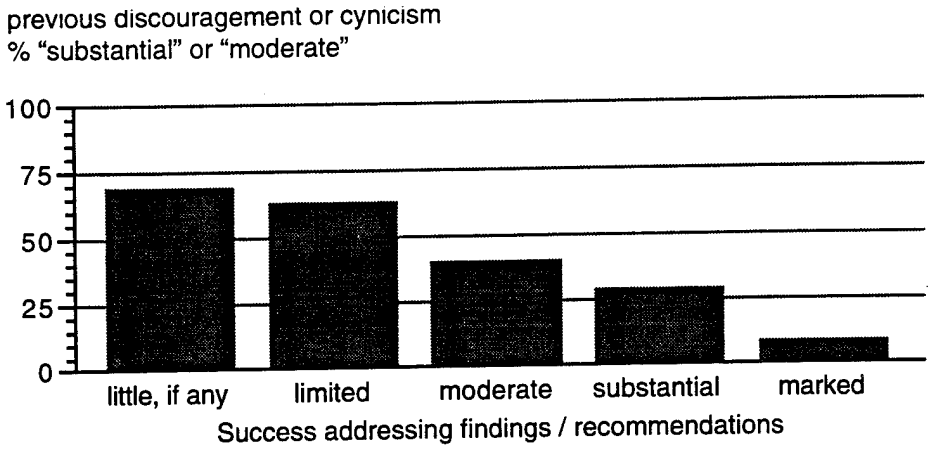

Figure C-10: Successful SPI and Previous Discouragement or Cynicism

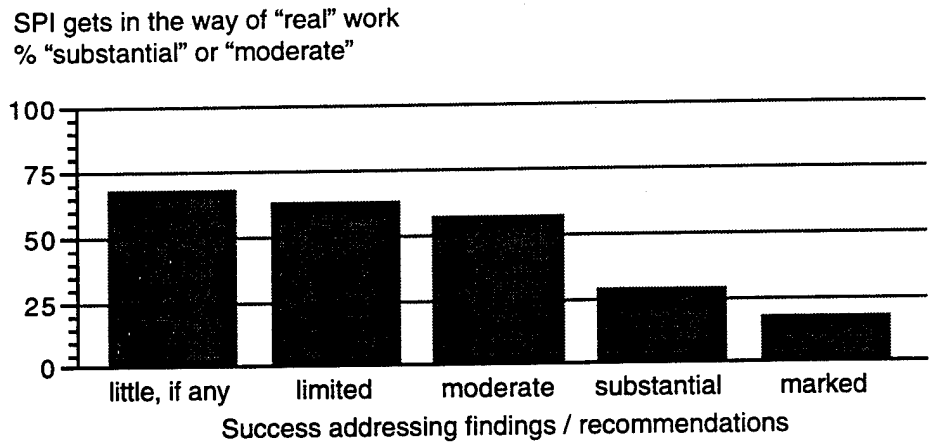

Figure C-11: Successful SPI and SPI Gets in the Way of "Real" Work

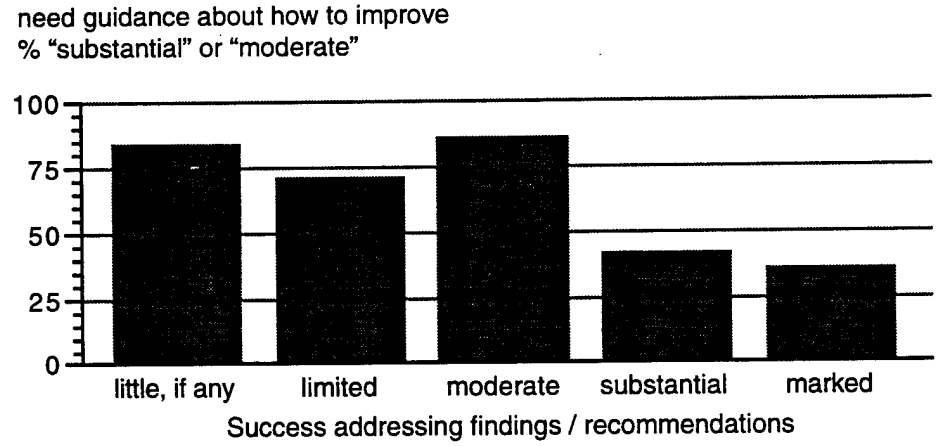

Figure C-12: Successful SPI and Need Guidance About How to Improve

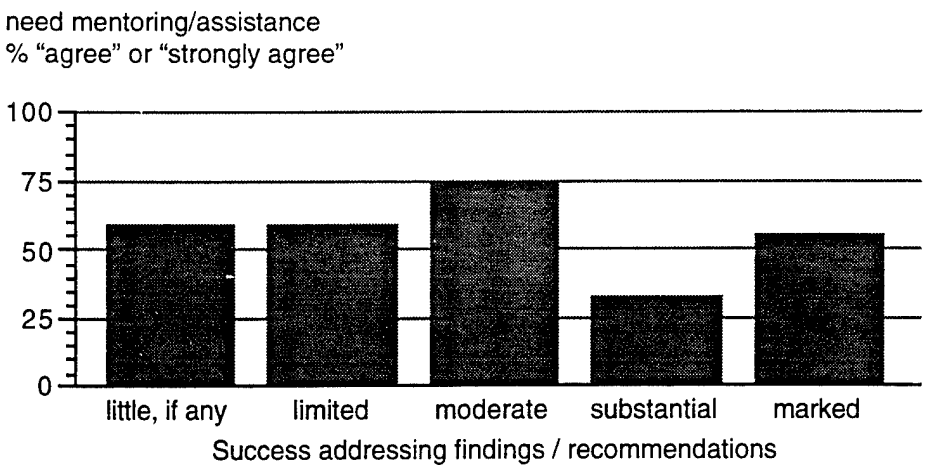

Figure C-13: Successful SPI and Need for Mentoring/Assistance

As noted in the footnote on page 25, the data in Figure C-13 are "noisy": there is in fact a statistically significant relationship between the respondents' answers to the two questions, but it is masked by the way we combined the answers for the full series of bar graphs. As seen in Figure C-14, more characteristic differences exist for the respondents who either strongly agree or strongly disagree that there is a need for additional mentoring and assistance in their organizations.[14]

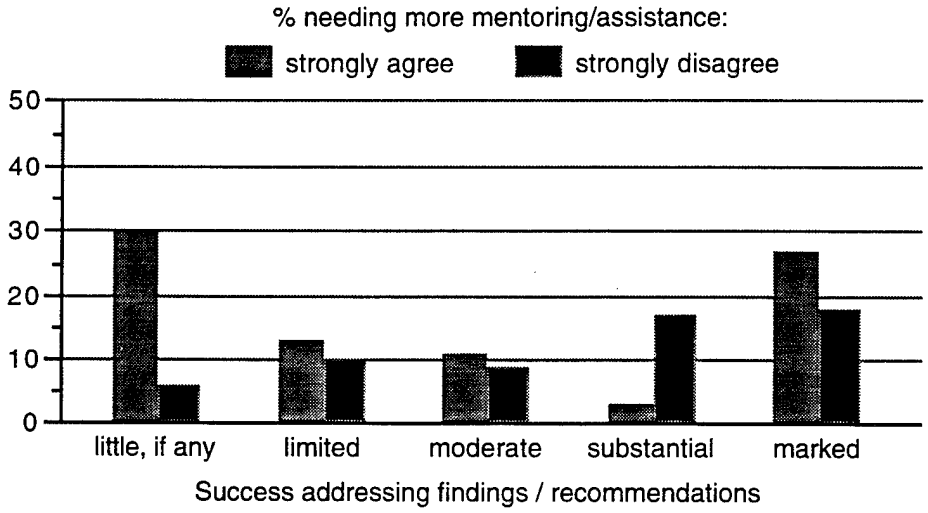

Figure C-14: Successful SPI and Varying Need for Mentoring/Assistance

14. There is an unexplained upturn among those who say they have had marked success in addressing the findings and recommendations of their appraisals *and* agree strongly that there is a need for more mentoring and assistance, but there are too few respondents to tell whether or not it is due simply to chance.

Appendix D The Questionnaire

The survey questions focus on the value and accuracy of the appraisal, and the success with which the findings and recommendations of the appraisal have been addressed. Of particular interest to the process improvement community, we included a number of questions about organizational performance, e.g., product quality and ability to meet schedules. For comparative purposes, we also asked a series of questions about the organization that was appraised.

Ideas for the content of the questionnaire came from several sources. These include feedback from informal "birds of a feather" sessions at the 1994 SEPG National Meeting in Dallas and the 1994 Software Engineering Symposium in Pittsburgh. We also reviewed published and unpublished critiques of the CMM and process appraisal methods, and sought out the views and concerns of various SEI stakeholders. We pre-tested an initial draft of the questionnaire with SEI resident affiliates (experienced software developers and managers) in November 1994.

Most of the questions are phrased in a closed-ended manner. That is, we pose a question to the respondents and provide a series of pre-coded answers from which they are asked to choose. Other questions ask for the respondents to supply numerical estimates. In general, we avoided open-ended questions in which respondents are asked to provide free form, textual answers.[15]

All survey data rely on the self-reports of their respondents, and we cannot know with certainty on what they base their answers. However, survey data are necessary if we wish to generalize beyond a few selected instances. Well defined process and performance metrics still are uncommon, especially in level 1 organizations, and metrics based on the same, shared definitions are not widely available for different organizations. Regular recording of information does not ensure its accuracy in any event, even in existing metrics programs.

Surveys can ask for factual information as well as opinions, and there is evidence that people do try to answer survey questions honestly. For example, self reported and appraised maturity levels are quite consistent in this survey (see Section 3.1). People also differ substantially in their descriptions of process improvement in their organizations, and those descriptions vary among each other in understandable ways.

A facsimile of the questionnaire on which this report is based is reproduced on the following pages.

15. It is difficult to phrase good open-ended questions, especially in a self-administered survey without the intervention of a skilled interviewer. Hence, it is difficult to elicit comparable results. Providing meaningful answers is difficult for the respondents, who tend to write little.

Software Process: Assessments and Improvement

This document contains questions about a software process assessment that was held recently at your organization. The questions ask about the conduct and results of the assessment, and about what has happened to process improvement in your organization since the assessment.

This is the first comprehensive survey ever done of assessed organizations. The results will be used to provide guidance for future SEI process improvement efforts. The results also will allow you to make valuable comparisons among organizations similar to your own. Of course you will receive a summary of the survey results.

Your answers are very important. You are part of a carefully chosen sample. It is very important that you return your completed questionnaire in order for the results to be accurate and useful. Combined with others from many software organizations, your answers will ensure as broad a description as possible of experiences with software process assessments and subsequent process improvement.

The survey should take about fifteen or twenty minutes to complete. Please complete your questionnaire right away, while it's still on your mind. Return it to the SEI in the enclosed, postage-paid envelope.

Please read and answer all of the questions. Feel free to write in any available space if you wish to comment on any questions or qualify your answers. Your comments will be read and taken into account.

Your answers will be held in strict confidence. Specific answers will not be identified by organization, individual, or in any other manner. Any information identifying you will be used for administrative purposes within the SEI only.

Thank you for your help.

Software Engineering Institute
Carnegie Mellon University

We will be using optical scanning technology, so please print or write neatly.

- You may use a pen with dark ink or a dark pencil. Please do not use green.
- Please keep your marks within the check boxes. Any mark will do: ■ ☒ ☑
- Feel free to use any available white space if you need extra room for your written answers or other comments, but please don't write over the answer boxes or page border lines.

● ● ● ● ● ●

The Assessment

In this survey, we will be asking you about the following software process assessment:

1 What were the main goals of the assessment? *(Please mark as many as apply)*

- ☐ PREPARE FOR SOFTWARE CAPABILITY EVALUATION (SCE)
- ☐ COMPETITIVE / MARKETING PRESSURE TO DEMONSTRATE PROCESS MATURITY
- ☐ GENERATE MANAGEMENT SUPPORT AND BUY-IN FOR SOFTWARE PROCESS IMPROVEMENT
- ☐ GENERATE TECHNICAL STAFF SUPPORT AND BUY-IN FOR SOFTWARE PROCESS IMPROVEMENT
- ☐ ESTABLISH BEST PRACTICES TO GUIDE ORGANIZATION PROCESS IMPROVEMENT
- ☐ ESTABLISH BASELINE AND/OR TRACK THE ORGANIZATION'S PROCESS IMPROVEMENT
- ☐ OTHER *(Please describe briefly)*

- ☐ DON'T KNOW

2 To the best of your knowledge, how accurately did the assessment describe the organization's major problems with software process? *(Please mark one box)*

- ☐ VERY ACCURATELY - IT IDENTIFIED ALMOST ALL OF OUR PROBLEMS
- ☐ GENERALLY ACCURATELY - IT MISSED, OR MISDIAGNOSED, A FEW PROBLEMS
- ☐ NOT VERY ACCURATELY - THERE WERE IMPORTANT ERRORS OF OMISSION AND/ OR COMMISSION

3 How well did the assessment characterize the organization's strong points? *(Please mark one box)*

- ☐ VERY WELL - IT GAVE CREDIT WHERE CREDIT WAS DUE
- ☐ REASONABLY WELL - IT DID HIGHLIGHT SOME IMPORTANT STRENGTHS
- ☐ NOT VERY WELL - IT FOCUSED ONLY ON PROBLEMS AND WEAKNESSES

4 Following are several statements that are sometimes made about software process assessments and the Capability Maturity Model (CMM). Do you agree or disagree with the statements? *(Please mark one box for each)*

	STRONGLY AGREE	AGREE	DISAGREE	STRONGLY DISAGREE	DON'T KNOW
4.1 The assessment's findings and recommendations were too ambitious to complete in a reasonable period of time.	☐	☐	☐	☐	☐
4.2 We understood what needed to be improved, but we needed more guidance about how to improve it.	☐	☐	☐	☐	☐
4.3 The assessment results were too dependent on the expertise and judgment of the assessment team.	☐	☐	☐	☐	☐
4.4 There wasn't enough room for the assessment team to exercise its judgment.	☐	☐	☐	☐	☐
4.5 The wrong people or projects were chosen to participate in the assessment (be interviewed, fill out questionnaires, etc).	☐	☐	☐	☐	☐
4.6 There was a lot of "gaming" - people weren't fully honest with the assessment team.	☐	☐	☐	☐	☐
4.7 Reports and training courses are all well and good, but we need more individualized mentoring and assistance to have any real hope of improving our software process.	☐	☐	☐	☐	☐
4.8 It seems like we're always having to take new training courses to keep up with changes in SEI assessment methods.	☐	☐	☐	☐	☐
4.9 The CMM provides valuable direction about the order in which process improvements should be made.	☐	☐	☐	☐	☐
4.10 There are important areas that the CMM does not address *(Please describe briefly)*	☐	☐	☐	☐	☐

Process Improvement

1 How successfully have the findings and recommendations of the assessment been addressed? *(Please mark one box)*

- ☐ LITTLE IF ANY APPRECIABLE SUCCESS THUS FAR
- ☐ LIMITED SUCCESS
- ☐ MODERATE SUCCESS
- ☐ SUBSTANTIAL SUCCESS
- ☐ MARKED SUCCESS THROUGHOUT THE ORGANIZATION
- ☐ DON'T KNOW

2 To what extent has the organization's software process improvement effort been determined by the findings and recommendations that were raised in the assessment? *(Please mark one box)*

- ☐ ALMOST ALL OF IT IS BASED ON THE ASSESSMENT (≥ 80%)
- ☐ MOST OF IT IS BASED ON THE ASSESSMENT (≥ 50%)
- ☐ MUCH OF IT IS BASED ON SOURCES OTHER THAN THE ASSESSMENT (< 50%)
- ☐ VERY LITTLE IF ANY OF IT IS BASED ON THE ASSESSMENT (< 20%)
- ☐ THERE REALLY HASN'T BEEN MUCH OF AN EFFORT TO SPEAK OF
- ☐ DON'T KNOW

3 Since the assessment... *(Please mark one box for each)*

	YES	NO	DON'T KNOW
3.1 Did the organization that was assessed create an action plan for improving its software process based on the results of the assessment?	☐	☐	☐
3.2 Were process action teams (PATs) or similar working groups established as a result of the assessment to address specific process improvements?	☐	☐	☐
3.3 Have process changes been implemented in pilot or demonstration projects based on the results of the assessment?	☐	☐	☐
3.4 Have process changes been implemented throughout the organization based on the results of the assessment?	☐	☐	☐

4 To the best of your knowledge, what now is the software process maturity level of the organization that was assessed? *(Please mark one box)*

- ☐ CMM LEVEL 1
- ☐ APPROACHING LEVEL 2
- ☐ CMM LEVEL 2
- ☐ APPROACHING LEVEL 3
- ☐ CMM LEVEL 3
- ☐ HIGHER
- ☐ DON'T KNOW

5 In your judgment, how much "buy-in" and support for process improvement has there been among the...
(Please mark one box in each column for each question)

	Prior to the appraisal...				Since the appraisal...			
	SUBSTANTIAL	MODERATE	SOME	LITTLE IF ANY	SUBSTANTIAL	MODERATE	SOME	LITTLE IF ANY
5.1 participants in the assessment?	☐	☐	☐	☐	☐	☐	☐	☐
5.2 organization's technical staff?	☐	☐	☐	☐	☐	☐	☐	☐
5.3 organization's management?	☐	☐	☐	☐	☐	☐	☐	☐
5.4 assessment sponsor?	☐	☐	☐	☐	☐	☐	☐	☐

6 In the organization that was assessed... *(Please mark one box for each)*

	SUBSTANTIAL	MODERATE	SOME	LITTLE IF ANY	DON'T KNOW
6.1 How much risk is management generally willing to take?	☐	☐	☐	☐	☐
6.2 Are there tangible incentives or rewards for successful software process improvement?	☐	☐	☐	☐	☐
6.3 How much does "turf guarding" inhibit the progress of software process improvement?	☐	☐	☐	☐	☐
6.4 Is there much organizational politics?	☐	☐	☐	☐	☐
6.5 How much paperwork is needed to get things approved?	☐	☐	☐	☐	☐
6.6 Does senior management actively monitor the progress of software process improvement?	☐	☐	☐	☐	☐
6.7 Has previous experience led to much discouragement or cynicism about the prospects for successful process improvement?	☐	☐	☐	☐	☐
6.8 Is there a feeling among the technical staff that process improvement gets in the way of their real work?	☐	☐	☐	☐	☐
6.9 To what extent are process improvement goals clearly stated and well understood?	☐	☐	☐	☐	☐
6.10 To what extent does management understand the issues faced by practitioners?	☐	☐	☐	☐	☐

7 Overall, how would you characterize the progress of process improvement since the assessment? *(Please mark **one** box for each)*

	STRONGLY AGREE	AGREE	DISAGREE	STRONGLY DISAGREE	DON'T KNOW
7.1 The assessment was well worth the money and effort we spent; it had a major positive effect on the organization.	☐	☐	☐	☐	☐
7.2 Because of the assessment (and/or the CMM), we have neglected other important issues facing the organization.	☐	☐	☐	☐	☐
7.3 Process improvement was overcome by events and crises; other things took priority.	☐	☐	☐	☐	☐
7.4 Process improvement has often suffered due to time and resource limitations.	☐	☐	☐	☐	☐
7.5 Nothing much has changed since the assessment.	☐	☐	☐	☐	☐
7.6 Process change has been easier than we expected.	☐	☐	☐	☐	☐
7.7 The assessment was counter-productive; things have gotten worse.	☐	☐	☐	☐	☐
7.8 Software processes have become more rigid and bureaucratic; it is harder to find creative solutions to technical problems.	☐	☐	☐	☐	☐
7.9 Process improvement is taking longer than we expected.	☐	☐	☐	☐	☐
7.10 Process improvement is costing more than we expected.	☐	☐	☐	☐	☐
7.11 There has been a lot of disillusionment over the lack of improvement.	☐	☐	☐	☐	☐

8 How would you characterize the organization's... *(Please mark **one** box in each column for each question)*

	Prior to the appraisal...				Since the appraisal...			
	EXCELLENT	GOOD	FAIR	POOR	EXCELLENT	GOOD	FAIR	POOR
8.1 customer satisfaction?	☐	☐	☐	☐	☐	☐	☐	☐
8.2 ability to meet budget commitments?	☐	☐	☐	☐	☐	☐	☐	☐
8.3 ability to meet schedule commitments?	☐	☐	☐	☐	☐	☐	☐	☐
8.4 product quality?	☐	☐	☐	☐	☐	☐	☐	☐
8.5 staff productivity?	☐	☐	☐	☐	☐	☐	☐	☐
8.6 staff morale / job satisfaction?	☐	☐	☐	☐	☐	☐	☐	☐
8.7 staff time / resources dedicated to process improvement?	☐	☐	☐	☐	☐	☐	☐	☐

About the Organization

1 Does the organization that was assessed still exist? *(Please mark one box)*

- ☐ YES - IN ESSENTIALLY THE SAME STATE
- ☐ YES - BUT IT WAS SOLD OR BOUGHT OUT
- ☐ YES - BUT IN A REORGANIZED STATE
  (e.g.,with changed reporting channels, or as part of a larger organizational unit)
- ☐ NO - IT NO LONGER EXISTS (i.e., the employees have been reassigned or fired)

For the remaining questions in this section: Please describe the organization as it existed at the time of the assessment.

2 Approximately how many people are employed in the organization that was assessed?
*(Please specify a number for each • Please do **not** use commas)*

_____ TOTAL NUMBER OF EMPLOYEES

_____ NUMBER PRIMARILY ENGAGED IN SOFTWARE DEVELOPMENT OR MAINTENANCE

3 In the organization that was assessed... *(Please mark **one** box for each question)*

	SUBSTANTIAL	MODERATE	SOME	LITTLE IF ANY	DON'T KNOW
3.1 Has there been turnover in key senior management?	☐	☐	☐	☐	☐
3.2 Has there been involvement of technical staff in the process improvement effort?	☐	☐	☐	☐	☐
3.3 Have the people who are involved in process improvement been respected for their technical and management knowledge, and their ability to get things done?	☐	☐	☐	☐	☐
3.4 Has there been clear, compensated assignment of responsibilities for process improvement?	☐	☐	☐	☐	☐
3.5 Has there been a decreasing demand for the organization's products or services?	☐	☐	☐	☐	☐
3.6 Has there been a major reorganization(s) or staff down-sizing?	☐	☐	☐	☐	☐
3.7 How much growth has there been in staff size?	☐	☐	☐	☐	☐
3.8 How much turnover has there been among middle management?	☐	☐	☐	☐	☐
3.9 How much turnover has there been among the technical staff?	☐	☐	☐	☐	☐

4 Approximately how many people in the organization have responsibilities for software process improvement and/or quality management - as part of their explicitly assigned work efforts?
(Please specify a number for each • Please do not use commas)

_____ FULL TIME

_____ PART TIME

_____ CONSULTANTS

_____ TOTAL FULL-TIME-EQUIVALENT PEOPLE
(full timers plus the hours worked by part timers & consultants)

5 Does the organization that was assessed have a software engineering process group (SEPG), or other unit(s) that performs similar functions? *(Please mark one box)*

☐ YES

☐ NO

6 Does the parent organization of the organization that was assessed have a software engineering process group (SEPG), or other unit(s) that performs similar functions? *(Please mark one box)*

☐ YES

☐ NO

☐ DOES NOT APPLY

7 Does the organization concentrate its efforts on...? *(Please mark as many as apply)*

☐ A CORE PRODUCT LINE OR APPLICATION DOMAIN
(e.g., switches, guidance systems, or information-systems)

☐ A CORE TECHNOLOGY
(e.g., distributed systems, real-time embedded systems, object-oriented design, or simulators)

☐ A FEW SIGNIFICANT CUSTOMERS

☐ REUSE OF EXISTING SOFTWARE

☐ EXTREMELY LARGE OR COMPLEX SYSTEMS

☐ NEW OR POORLY UNDERSTOOD DOMAINS OR TECHNOLOGY

☐ OTHER SPECIAL FOCUS *(Please describe briefly)*

☐ NO SPECIAL FOCUS

8 How frequently are the organization's technical staff in contact with the customers and users of the software they develop? *(Please mark one box in each column)*

	Customers	Users
WEEKLY OR DAILY	☐	☐
MONTHLY	☐	☐
LESS OFTEN	☐	☐
RARELY IF EVER	☐	☐

8.1 Are they in contact as often as necessary? *(Please mark one box in each column)*

	Customers	Users
MORE OFTEN THAN NECESSARY	☐	☐
ABOUT RIGHT	☐	☐
LESS OFTEN THAN NECESSARY	☐	☐

9 How frequently do the development projects have to deal with changes in customer requirements? *(Please mark one box)*

- ☐ WEEKLY OR DAILY
- ☐ MONTHLY
- ☐ LESS OFTEN
- ☐ RARELY IF EVER

Your Background in Software

1 What is your software experience in: *(Please specify for each category - rounded to the nearest year)*

Your present organization? ..... _____ YEARS

Your present position? ..... _____ YEARS

Your overall software experience? ..... _____ YEARS

Software process improvement/quality management? ..... _____ YEARS

2 About how much of your work-related time did you spend over the past year on software process improvement or quality management?
(Please specify an approximate percentage - rounded to the nearest whole number - with no % sign)

_____ APPROXIMATE PERCENTAGE

Thank you very much for your time and effort!

Software Process: Assessments and Improvement

Please return this form at your earliest convenience.
Use the enclosed envelope, or send it to:

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Abstract: Very little published evidence exists about the impact of the Capability Maturity Model[sm] (CMM) or CMM-based appraisals on subsequent software process improvement and organizational performance. A few credible case studies do exist, but it is uncertain how widely their results apply. We present evidence here from a much broader cross section of software organizations. Our results suggest that process maturity does indeed pay off in better product quality, ability to meet schedule

[sm] Capability Maturity Model,[sm] CMM,[sm] and IDEAL[sm] are service marks of Carnegie Mellon University.

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commitments, and other indicators of organizational performance. The vast majority of survey respondents also report that their appraisals proved to be highly accurate and useful in guiding their subsequent process improvement efforts. Not all organizations have been equally successful, however, and improvement often takes longer and costs more than expected. We identify several factors, most of them under management control, that distinguish more successful from less successful organizations.