Software Process Automation: Interviews, Survey, and Workshop Results

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FOR THE COMMANDER

(signature on file)

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Software Process Automation: Interviews, Survey, and Workshop

Abstract: This report describes the results of a two-year study of experiences with the adoption and use of software process automation. The work was motivated by a desire to provide insights and guidelines to those planning to implement this technology. The focus of the study was primarily, but not exclusively, on end-user organizations. The study was conducted in three stages: First, in-depth interviews were conducted to assess the state of the practice. Second, a survey questionnaire was distributed to a wider number of organizations to obtain more quantitative data. The populations in these two groups turned out to be quite different—a fact that we believe enriches the content of this report. Finally, a one-day workshop was held, the objective of which was to explore with practitioners why the gap between the theory and practice of software process automation is as large as it is. A previous report by Alan Christie, et al. [Christie 96] documented the results of the in-depth interviews in detail. This report now summarizes the results of the interviews, and describes in more detail the questionnaire survey and the workshop. It also provides both insight for process automation tool developers and guidelines for adoption to process-automation end users.

1 Purpose and Structure of the Study

Software process automation is a technology that may be viewed as a two-edged sword. On the one hand it can be viewed as a productivity and quality enhancer, while on the other hand, it can be viewed as a mechanism to control, routinize, and de-skill work. These views both have elements of truth, but with appropriate design and adoption considerations, we believe that it is possible to enhance the positive elements while reducing the negative ones.

This report looks at the issues that have arisen for the early adopters of process automation. These people are the innovators, the ones who have been through the "school of hard knocks," taken the brunt of an immature technology, and suffered from the fact that there are few experienced people to guide them. Some of the projects we saw succeeded, some failed, but few found the going easy. This technology is not for the feint of heart—at least not yet. However, we hope, through this report, to document experiences and lessons learned. We hope that we have extracted practical insights to provide insights to the developers of process automation tools and guidance to those who wish to automate their processes.

As described by Christie [Christie 96], the specific objectives of the study are to

- Identify the technical, social, and organizational inhibitors to the adoption of process automation:
  - Assess the prevalence and scope of software process automation.
  - Categorize the technologies and practices that are currently being used.
  - Identify effective and ineffective technologies and practices.
  - Develop guidelines for process automation implementers.
- Support vendors and researchers in developing products more in tune with end-user needs:
  - Develop guidelines for researchers and vendors to improve product effectiveness.
  - Foster effective communications between researchers, vendors, developers and end users.

These general objectives have been met through a series of activities that include in-depth interviews followed by a questionnaire survey and a workshop. The specific objectives of these activities are as follows:

- The interviews are aimed at gathering practitioner experiences in a relatively unstructured way, to identify what individuals believe are the important issues in the adoption of software process automation, and to establish a basis for the more structured questionnaire survey. Some of the interviewees were contacted about a year after the initial interviews. This allowed us to estimate what progress (or lack thereof) organizations had made over an extended period of time, and to identify why some projects had been successful and others failed.
- The questionnaire survey assesses a wider cross-section of those involved with process automation and includes individuals outside the software community. Because the questionnaire respondents are following a standard format, the data in this phase of the study will be analyzed in a more quantitative fashion.
- Finally, the workshop was aimed at identifying success strategies for the introduction of software automation. The workshop brought together a widely diverse group of individuals with experience in research and development, adoption, management and end use of process automation, and to raise awareness of critical issues across these communities.

The following three sections of this report deal with the above items respectively. Appendix A provides a copy of the script that supported the interviews, Appendix B contains the survey questionnaire in its original form, while Appendix C describes how some composite measures associated with the survey questionnaire data were derived. Appendix D documents the position papers of workshop presenters, while Appendix E provides the output generated by the workshop participants. Appendix F lists the workshop participants.

2 The Interviews

This report is based upon interviews with individuals who are knowledgeable about and experienced with process automation. We performed a qualitative analysis of these interviews to arrive at the findings reported here. The material in this section closely follows that presented in an earlier report [Christie 96]. Readers interested in the details of the interviews should consult Appendix C of that report.

Three independent organizations were involved in performing the interviews reported here: the SEI, Nolan Norton and Company (a division of KPMG Peat Marwick), and Cap Gemini Sogeti (located in Grenoble, France).

2.1 The Interviewees

An extensive list of candidates was identified early on, including end-user organizations, commercial and in-house developers, and researchers. Our original goal was to interview mostly end users of process automation. However, that was not to be. Because of the immaturity of the technology, we interacted with relatively few experienced end users of the technology. Most of our interviews were with people who were involved in developing and implementing process-centered environments (PCEs).

These individuals came from a wide variety of organizations including

- a vendor of a major process-oriented configuration management (CM) product
- four DoD sites implementing process-centered environments (PCEs)
- two U.S. government contractors who were developing process tools and implementing PCEs
- two French government contractors who were implementing PCEs
- a French bank that is operating with a PCE
- a university group with strong ties to industry

2.2 How the Interviews Were Conducted

A total of 14 interviews were conducted with 12 projects.[1] In the large majority of these interview sessions, two interviewers were present. The number of interviewees in each interview ranged from one to eight. All interviews were taped to ensure that the comments were recorded accurately. The interviews took approximately 36 hours with an average length of 2.4 hours per interview. All in all, the interviews yielded 150 pages of transcripts.

1. In one organization, two different projects were interviewed. With two other projects, multiple interviews were conducted.

A standard script supported each interview. This script provided a consistent framework and ensured that we would have comparable information from each of the interviews. While the questions were used to support the interviews and to ensure coverage, they were not followed mechanically; areas of interest were often probed in depth. Christie provides further details of the interview format [Christie 96].

2.3 Overview of the Projects

Table 2-1 provides a summary of the projects studied. In addition, we identify whether the project is a commercial or military activity and provide its current status. Table 2-2 summarizes the major tools, technologies employed, and significant issues that were identified by the interviewees.

These tables are provided to introduce the reader to the individual projects, which we refer to throughout this discussion.

Table 2-1 Application Characteristics of Projects

Project	Activity	Duration	Org. Size	Org. Type	Lifecycle Component
A	Developing a process centered environment intended for general use	Jan 91 - Present	60-80	Military	Maintenance
B	Developing process tool	5 years		Commercial/ gov. funded	Maintenance
C	Developing a PCE, intended for commercial sale	1 year		Commercial	Project scheduling
D	Command/Control, inactive	Oct 92 +3 years		Military	
E	Creating simplified (less process-centered) version of the tool	5 years?		Commercial tool vendor	Full
F	Experimental research	Ongoing	1 prof.+ students	Academic	n/a
G	MIS, inactive (abandoned)	2.5 years	10-15	Military	Cleanroom, Maintenance
H	Inactive, but some effort to find commercialization interest	5 years	10 - 100 potential	Commercial	2167A S/W development
I	Automated problem tracking	Ongoing	5-10	Commercial	Maintenance
J	Automating specification/quality control and development/validation	Experimental/ongoing	1-5	Commercial	Development/Maintenance

Table 2-1 Application Characteristics of Projects

Project	Activity	Duration	Org. Size	Org. Type	Lifecycle Component
K	Automating a problem tracking/maintenance scenario	Pilot Effort	1-5	Commercial	Maintenance
L	Automating a reverse engineering scenario	Ongoing, Pilot	10-15	Military	Maintenance

Table 2-2 Technology Characteristics of Projects

Proj.	Technology	Supporting Tools	Major Issues
A	Synervision	CM, Language parsing (reengineering), static/dynamic analysis, document preparation, project management, requirements traceability	Process definition, selective use, support
B	Process Weaver, FlowMark, building own	Software Through Pictures, Interleaf, Paradigm Plus, Oracle	Money unavailable to buy licenses Not-invented-here syndrome
C	Process Weaver	Schedule Publisher, Oracle, Interleaf, Worldview, OpenInterface	
D	Process Weaver, and Custom process front ends	CAT/Compass, Amadeus, and contractor-developed software products	Resistance to massive amount of technology Integration of technologies, conflicting points of view between adopting org. and consultants
E	CM	FrameMaker	Labor/resource intensive, time consuming adoption, complex tool demands significant effort for adoption
F	System Factory Project	Internally developed tools to support modeling, analysis, simulation, visualization, enactment	
G	Process Weaver	ProcessWeaver, Oracle,	Tool instability, design restrictions placed on end users
H	CASE	Atherton S/W backplane	Development time exceeded sponsorship and customer patience, expectation drift.
I	Process Weaver	Database (supporting problems and solutions)	Integration of problem database

Table 2-2 Technology Characteristics of Projects

Proj.	Technology	Supporting Tools	Major Issues
J	Process Weaver	WordPerfect, All-in-One, Oracle, CM System	Integration of tools
K	Process Weaver	FrameMaker, CM System	Integration of CM tool
L	InConcert	Cadre, AutoPlan, DBStar	Ineffective process integration, poor training, time-consuming environment maintenance

2.4 Interview Findings

The interviewees represented one or more automation efforts that, loosely speaking, can be seen as pilot projects. These projects ranged in size from fewer than 10 to more than 60 people. For purposes of discussion, the numbers cited include the personnel for whom the automation was intended, as well as the developers of the automation if they are part of the same organization. Typical project size was toward the low end.

While we made no attempt to measure formally the process maturity level of the organizations/projects interviewed, some had previously undergone formal process assessments using the SEI Capability Maturity Model[SM1] (CMM®)[2] Framework [Paulk 93]. These projects ranged in maturity from level 1 (ad hoc/chaotic) to level 5 (optimizing). However, most can be characterized as relatively immature (at or below level 2). Other projects had not been assessed formally, but many characterized themselves as having a poorly defined set of software development processes. Two projects were attempting software development activities for the first time.

Of the twelve projects interviewed (seven currently active, four inactive, one experimental), only two were far enough along for the automation to be considered institutionalized. In one case, the automation was associated with a company that developed and distributed a configuration management product. This product has significant process capability that is used to support further development of the product. The other organization that effectively adopted PCE technology did so to support software problem tracking.

Four points may be made about the interviews and the findings derived from them. First, because of the immaturity of the technology, we interviewed few people who could be considered experienced end users of the technology. The great majority of interviewees were either developers of process-centered environments, developers of the process tools from which PCEs can be built, or managers of development projects. Second, the findings not only surfaced

1. Capability Maturity Model is a service mark of Carnegie Mellon University.

2. Registered in the U.S. Patent and Trademark Office.

problems but identified potential solutions to these problems. We hope that this information will be useful to organizations intending to build and use PCEs. Third, interviewees' experiences were not always consistent, and these inconsistencies may at times be reflected in the report. Fourth, as might be expected, we found that many of the adoption issues we identified have much in common with adoption issues associated with other technology areas.

The findings fall into three major categories

- drivers and inhibitors
- contributors to success
- technology issues

In the following discussions, we make heavy use of quotes (indicated in italics) from the interviews. A major reason for this is that interviewees were surprisingly frank in giving us their views about process automation and how their organizations were dealing with it.

2.5 Drivers and Inhibitors

2.5.1 Drivers

The following drivers were identified:

- cost reduction
- quality improvement
- maintaining process capability
- training
- project management support

We found that the most common issues driving organizations to process automation were the needs to remain competitive, improve quality, and reduce costs. As a manager with a large government contractor stated

> *The ideal is to do it cheaper, faster and improve quality. That's the reality of today's budgets.*

In another government-related organization we heard

> *The organization is currently downsizing, primarily by attrition. As personnel are transferred out, they are not replaced.*

In an era of shrinking government budgets and increasing commercial competitive pressures, it is not surprising that solutions such as process automation are being explored.

Another automation project was motivated strongly by cost reductions. It estimated that the return on investment would be 17 times the initial investment over a period of 10 years, with the break-even point occurring in the first year. Numbers were also generated to suggest that without automation, 48 people would be needed; with automation, half that number would be adequate. Given the current state of the project, these estimates are likely to be highly unrealistic, but they did convince management that automation was the way to go.

Another driver that we identified was related to the issue of maintaining process capability, particularly in organizations that were experiencing high turnover. In one DoD organization we heard

> *Process is critical to organizations because there is such a high turnover of personnel. I have been on this program for two and one half years and almost everyone is new. There is a going-away party every week or two. Another manager indicated: Management is pushing the sharing of information because you do not know how long you are going to be here... Younger people are saying "I have skills that can get me more money outside," so they are leaving.*

Thus organizations are finding that they cannot afford to maintain processes in people's heads, even if there is adequate documentation and training.

Training was identified as an area that process automation could support. Guidance provided by the automated environment was seen as a benefit. One interviewee stated

> *Training/ education will be greatly reduced with online context-sensitive help in leading you down the process. Instead of taking two years to get up to speed, it may take six months to get someone producing code.*

Project managers may be motivated to view process automation as a means to take control of the activities in the project. One interviewee suggested that senior management would like to see automated processes being schedule driven. Speaking in this role, he indicated

> *Any time you get a new work item it will key on a template that says... a change requires you to do these things and that will initiate lower level activities. This will allow me to track how many errors are being generated.*

Other expected drivers, such as support for process improvement or the automated collection of metrics, did not appear to be such significant factors. One example was described in which a drive was made to move a brand new project very quickly to CMM level 3. A process tool was introduced in an attempt to fix the resulting chaos; this simply compounded the problem.

2.5.2 Inhibitors

The following inhibitors were identified:

- reluctance to use someone else's technology
- lack of acceptance of external consultants
- resistance from "old hands"
- fears of first-line supervisors
- discrepancy between predicted and actual times for implementation
- inability to achieve consensus on process definition
- inability to predict return on investment

These are discussed in more detail below.

A major inhibitor uncovered was the reluctance of people in an organization to accept process automation if it is perceived as being driven from outside that organization. As one interviewee stated

> *Organizations are real resistant to change if it is perceived as being driven from outside the organization. "You developed that? then I won't use it." They may think they have a better idea and attempt to implement it. Then management edicts it and they use it as minimally as possible to be compliant. "I'll use it but use the minimal number of mouse clicks."*

In one case intergroup resentment pitted groups in the organization against each other. The issue that arose was the perception by some groups that those chosen to be in the test group for automation were not pulling their weight. The interviewee characterized the attitude with mock resentment:

> *These people have extra time on their hands, and we're over here dying!*

We heard from two consultants who independently voiced their frustration when working with clients. In one case, the consultant stated

> *We put all our energies into developing the environment and went down and gave it to them. And they said "that's nice but we don't want it." That was an eye-opener.*

In the other case, the consultant, who joined the project after it had started, said

> *In my opinion, a good consultant will never come in and say "everything you are doing is bad." You can't say that, so what you have to do is back into these things.... The only way you can reach people is through education. I have to write things out for you and make them so painfully obvious that if you ignore them you get what you deserve. If I haven't done that then I have not done my job as a consultant.*

In several organizations, "old hands" resisted the imposition of process automation, as they perceived this to be an intrusion into processes they knew well. This inhibitor was not present with less-experienced staff who more often welcomed the guidance that automation provided. One interviewee stated

> *The new people were enthusiastic, but experienced analysts said "I hate the screens that tell me what I have to do—can you make it so that there is a novice mode and an expert mode?" Another interviewee stated: Adoption is hard because some of the "old hands" are extremely resistant.*

The same interviewee also stated

> *It's the first, second, and third line coordinators who really fear this stuff. In reality these are the people who should be contributing to this, because they really understand the process best.*

Clearly, more senior people may resent the intrusion of process automation, as they have more to lose by its introduction. However, these may be the very people who can make the most valuable contributions to the design of the automated processes. Fear of being made redundant by automation may be very legitimate and could be a significant inhibitor if not addressed appropriately.

Consistently we saw that it took people much longer than they anticipated to develop effective automated processes. One interviewee stated

> *I think one reason why it's frustrating not getting product out is that it's taking much longer than everyone expects to go up the process automation learning curve.*

Management expectations with respect to the investments required in process automation can be unrealistic. Thus we heard

> *A reason for failure is the perception that process automation involves little more than the purchase of appropriate tools, and that tools are the major cost component. In reality, we found that adoption takes longer than everyone expects and that technical integration problems frequently cause unforeseen delays.*

This was supported by one of the few cases where process automation was institutionalized successfully, and where technical issues outweighed organizational/people issues. In this case we heard

> *The implementation has been quite long and difficult (eight months) but only for technical reasons.*

One of the activities for which schedules were delayed significantly was process definition; obtaining a consensus on what the detailed process should look like was often a long, drawn-out task. In one case, significant delays (i.e., years) were incurred:

> *While consensus can be reached at the higher levels of process, consensus on details was elusive. This appears to be due to differences in projects, differences in groups within a project, and differences in individuals.*

The same interviewee indicated that

> *The effort has involved two to six integrators/toolsmiths. A total of 19 person-years of effort was expended. However, the majority of the effort was in process definition. Most of the work had to be thrown away.*

However, another interviewee identified the same problem and offered some insight:

> *The interesting thing is that the actual implementation step is not that difficult if you take a structured, engineering approach... What we've seen is many people spinning up front for years until they reach some definition of a process. The catch is: architecture first, then a phased process definition plan, and then do it a piece at a time.*

This issue will be discussed further under Section 2.6.6, Using an Incremental Approach.

With respect to financial resources, one tool vendor we interviewed suggested that an inhibitor faced by management occurs because

> *Most companies have no way of figuring return-on-investment (ROI) in their own organization. It is easy to identify up-front costs, but difficult to figure the ROI over a long period.*

2.6 Contributors to Success

The following contributors that improve the chances for success were identified:

- obtaining management commitment
- addressing process definition issues
- encouraging communication
- providing training
- building effective development teams
- using an incremental approach
- minimizing risk

None of these issues is unique to process automation—each has to be faced when most complex technologies are introduced. However, because of the strong social impact of process automation, these issues are particularly challenging. Each issue is discussed below.

2.6.1 Obtaining Management Commitment

There is a need to sustain management commitment at all levels and throughout all phases of the automation project. Thus management expectations must be set appropriately. While different managers may react differently to process automation, we heard

> *The people who were going to use the technology seemed to appreciate it – especially the system engineers. They are really tool-oriented. The first-line manager was against it, while the second-line manager was for it.*

This may reflect the fact that first-line managers have to take the impact of an unproven technology directly, potentially disrupting their schedules and commitments. Another interviewee indicated

> *Make sure at the executive level that the expectations are set right, and that the limitations of the technology are understood. Many managers have the silver bullet syndrome – they all listen to the first good story they hear from a sales rep, and don't have anything to base their decision on other than the tool sounds good. Then it becomes law. That's how politics happens.*

Because process automation is still not a mature technology, convincing upper management to spend money may be challenging. We heard the opinion

> *It's difficult to get management to spend money on something that they are not sure they see the value in. They have so many hot irons in the fire anyway... The main reason that we were successful was that we had a strong proponent over in the contractor office, and in the system area that was going to use it. He took a lot of initiative, maybe exceeding his authority in some cases.*

2.6.2 Addressing Process Definition Issues

As mentioned previously, one of the most time-consuming activities is defining processes that are acceptable to all interested parties. In one organization, the process was intended to support a wide range of individuals. This diversity made it extremely difficult to reach consensus. Initially, a detailed 13-step process was developed, but consensus could not be reached. Currently they have a seven-step, less-detailed process, and even with this more general process, obtaining consensus was difficult. Developers of the automated process felt that the primary problem was identifying requirements—as the processes changed over time, so did the requirements. Developers noted that even seemingly trivial changes to the process could have significant ripple effects on the system's implementation.

Consistent with that experience, an interviewee from another project stated

> *Once the process is written down, review is a lot of trouble. I don't see any way around that. I don't see that improving the notation would help.*

Implementers may become carried away with the flexibility of a process technology and define processes that are too detailed. One interviewee stated

> *Some of our customers get carried away with the flexibility of the tool to the point that they define very convoluted, sophisticated, complex processes, because they know what they can do with the tool. However, there is a start-up cost associated with implementing that model. They use the model and find that they don't need all the bells and whistles they built in.*

One organization had developed a simple, low-tech approach to process definition that is worth repeating. Paraphrasing the interviewer's words

> *We took their process step by step with free input. If I say the input is a frog, then nobody else challenges that. So I start with "what do you call the first process step?" Since they know their jobs, they all know what they do first and we put that activity's name at the top of the stack. And then I'll ask what triggers this and usually they'll say – it's some management directive. Generally I'll have two or three people writing "sticky notes"[1] because people are frequently throwing out ideas. Initially I was sticking them on to a large sheet of paper, but then Jose had the idea of arranging the sticky notes on the paper into a process sequence—while the others were thinking up ideas. As they were throwing out scenarios, I just tried to keep them from going too deep into subprocesses.*

1. 3M Post-It Notes™

After the process is defined, I set the paper aside and put up a new one for the next phase. Then they may say, "Oh, the exit criteria for the last phase are the entrance criteria for the next phase." From here on they usually get the hang of it. About one and a half hours is all that anybody can take of this at one stretch.

On the issue of trying to extract process definitions from naive process users, there may be problems of completeness or enactability. One interviewee stated

What they had was a process, but when we asked them to write it down, they did so in what they believed was a very detailed fashion. When you started to look at it, you would come to dead ends in the process. When you asked them about that, they'd say "well sometimes we do this and sometimes we do that." We told them when you put it into a computer you have to state this way or that, or flip a coin... Just the idea of having to code the process into a computer caused them to sit down and define the process to the level that the computer needed.

2.6.3 Encouraging Communication

More than most software technologies, process automation requires close communication among those who are involved with it. This communication may be between technical staff and managers, or between members of different organizations. Mismatches in perception of what the technology will do for different roles may result in conflict. One interviewee stated

The person leading the effort (one of the senior bean counters) said "here is my idea of a process architecture – it will be schedule driven. Any time you get a new work item it will key on a template that says: a change [request] requires you to do these things, and that will initiate lower activities, and I will be able to track how many errors are being generated." People said this does not help me do my job. So his challenge at the end of the meeting was if you can come up with something better let me know, otherwise we are going to go forward and do this. That's when Bill and Mike came in from opposite ends of the spectrum and they went ahead and collaborated. Once we found out what real people needed to do their jobs, every bit of the data that the manager needed to view came from what they put in. When there are 240 worker bees to a dozen managers, I want the worker bees on my side. You show the managers that the metrics are going to be collected etc., you just need an SQL query to pull it out. Then the manager's light goes on.

Another issue was isolation of the group developing the processes from those who will subsequently use the process. One interviewee stated

The [end-user] group was reluctant because they were not included along the way. They perceived that processes were being developed off in a vacuum, then bestowed upon them.

Voicing the need to involve all aspects of the organization that will be involved in process automation, another interviewee suggested

> *You really need some technology advocates – people who can go proselytize out to the organization, people who are trusted in the organization. It's easy to get someone who wants to get on your band wagon, but who does not interface well with the group. So when you form your team get someone who is excited about it, and can go back and spread the word.*

2.6.4 Providing Training

Training developers in the technology and end users in the use of the automated processes is key to successful implementation. Because process automation technology does not produce a product (as does a compiler), it is harder to describe. One interviewee related the difficulty of describing process automation using a made-up dialog:

> *But what does [process automation] do?*
>
> *It does your process.*
>
> *Well, is it an editor?*
>
> *No.*
>
> *Is it a CASE tool?*
>
> *No.*
>
> *You mean I have to generate my own outputs?*
>
> *Yes.*
>
> *Then what advantage is it?*
>
> *Well, it's a process tool.*

In a similar vein, another interviewee stated

> *There was a small group who understood [process automation's] value. There was a smaller group that even understood what it was trying to do. And a lot of people said, "I just don't know what it is, but I don't even need it."*

These experiences indicate that end-user training needs to start with explaining the fundamental nature of process automation, and that training should not focus only on the detailed mechanics of what buttons to push and screens to fill in. Two other interviewees also suggested that simply holding training classes is not sufficient. One interviewee stated

> *Training has been conducted for individual tools. Also the automation group spends much time doing hand holding, consulting in order to facilitate tool use. The other interviewee said: Training was provided in both tools and process. Initial training was provided four to five months before actually starting the job. Personnel had to be retrained and lots of hand holding provided.*

This last statement also suggests that timing of the training is critical to its effective use.

2.6.5 Building Effective Development Teams

Implementing process automation requires a development team with the correct mix of technical and organizational skills and a strong team leader. One interviewee saw that the credibility of a strong leader made a significant difference to acceptance:

> *He said "trust me, this will be good for you," and they believed him. This is not always going to happen, but this was a small tight team and it worked.*

Another interviewee suggested that having a sufficiently senior person on the team was important:

> *You need a sufficiently senior person to capture the process to decide how deep or detailed you want to go. The tool can do anything you ask it to, but you do not want to have to excuse yourself to go to lunch.*

However another interviewee was hesitant about having management on the process definition team:

> *Representatives come from across the organization, all different levels of people. In the development group, we have one of the senior coordinators, four developers from different areas of systems software, generic coding. Managers are not there – managers inhibit that kind of thing.*

Two other team-related items were heard. In the first, the interviewee indicated that

> *A special project room was set up to force project personnel to come together in one place and develop team spirit. Such structural changes are critical because you must break up the organization in order to get the necessary changes.*

Another interviewee suggested the following strategy:

> *The biggest advantage that we have and admittedly most companies don't is that the people we hire for development are people who are really into process, and want to do process automation.*

2.6.6 Using an Incremental Approach

The majority of people we interviewed indicated that their process automation strategy was of the "great leap forward" variety. However most felt, in retrospect, that an incremental adoption approach should have been taken and that, given the state of the practice, the initial effort had been overly ambitious. As described by one interviewee

> *The baby steps approach says—get them so far, get them acclimated, then bring in the new technology as they can appreciate it. If you try to bring an organization a big bag of technology, the first thing they will do is take the bag and put it in the garbage. So you have to bring in a piece at a time. It's got to be supportive of human activity and it's got to be very goal oriented and produce immediate results.*

With respect to an incremental approach, we also heard

> *You need to bring [process automation] in a piece at a time. You need to see where they are at and how they are doing. Then pick one of their problems and try to solve that – so it's not too big. I think this is what we would do differently because we really didn't have a way to scale.*

A warning came from one interviewee with respect to management's expectations:

> *Management wants to see big bangs when they spend their money, not small steps. But the big bang approach doesn't work... They have to understand. Maybe software management education is needed to help them cross the chasm.*

The same interviewee voiced the opinion

> *If you are used to doing things in a certain way on your PC and they bring in a SUN Workstation with Interleaf and CADRE, it's too much. They can't change that fast. If you then tell them they are going to get a list, and you can only open the tools when the system tells you, people have a hard time with that.*

With respect to tool introduction, another interviewee suggested

> *Process comes before [process] tools. We are very strong over that. A tool is a tool...You can't throw a switch and enact a process. Tools should be chosen to match your needs.*

However, one interviewee indicated that having experience with application tools prior to automating the process made sense:

> *Get [application] tools in use ASAP, even before automation is available. This gives users some experience, acceptance of the technology, as well as helping them define the real requirements.*

Finally, one interviewee suggested the following step-by-step adoption strategy:

> *I believe in starting on a pilot basis, defining a manually enactable process first. I'd be very reluctant to jump on [process] tools first. By manually implementing first, you wring out a whole lot of methodology issues and end up with good appreciation of what a balanced approach to the definition and enactment is. That will arm you with the ability to impose a set of quite realistic requirements on the next tool developer/ vendor who comes along and says I can solve your process problems. Talk to tool developers based on sound knowledge of what's really involved so that you will be less inclined to accept at face value what the tool developer says. Another thing—you don't have to swallow process automation all in one go. You can start with a database for metrics, defining artifacts and their states in repository—manage the artifacts, and let process drift by itself. Have people own and be responsible for changing artifacts from this state to that state by that date. Later add prescribed methods for doing these things, add process activities, link them together, define exit criteria, and form a process network. By keeping process definition. divorced from management of artifacts, you get the flexibility to throw out a process that's not working well and substitute a new process without perturbing the products or artifacts that you are working on. You can add several processes, working from multiple viewpoints on the same artifact without perturbing the artifacts themselves. These things you learn from first enacting manually. Users may*

say, "You didn't prioritize any of my activities but I wish you would. I have 30 activities I need help in prioritizing." But don't tell them what they have to do or it will be rejected. These things allow you to gradually work your way up the automation scale.

2.6.7 Minimizing Risk

Because experience with process automation is still limited, implementing a risk minimization strategy makes sense. Risks can come from many places, and one project's risks may be quite different from another's. One tool vendor we interviewed was quite strong in suggesting that risk assessment should be part of the adoption effort, to be applied not only at the start of the automation project, but on a periodic basis throughout.The interviewee stated

When I do risk management with the customer, out of it comes a set of risks. Generally I find that everyone gets about 30 risks. It always seems to work out to about 30. Even in-house for us, we came up with 30 risks when changing over to Lotus Notes. Only 10 percent to 25 percent came from the tool. Others are related to:

- *What are the politics?*
- *What is the culture?*
- *What are the people issues?*
- *What are the legacy problems that people have never had the courage, or been able to solve?*

The interviewee suggested the detailed risk categories listed in Table 2-3.

Table 2-3 Risk Categories

sponsorship	resources	network infrastructure
methodology	resistance to change	tool integration
heterogeneous platforms	legacy systems	scalability issues
culture change	training	tool limitations
what processes are defined	what processes to automate	system administration
handling roll-out		

While the interviewee suggested that serious risk can come from any category, in her estimation the first four (sponsorship, resources, network infrastructure, and methodology) often had the greatest impact.

2.7 Technology Issues

Process automation technology is still in its early days and interviewees (primarily PCE developers) suggested areas where capability could be improved. These areas are

- end-user support
- tool/data integration
- technology support for process
- prototypes
- control driven versus artifact-state driven
- system performance

2.7.1 End-User Support

Several interviewees felt that the less imperative a process-centered environment was with the end user, the better. One interviewee stated

> *The key is being unobtrusive. If you can do it and be unobtrusive then it is a win all around.*

Supporting this sentiment was the view

> *People, especially creative people, don't respond to a tool which says "you will start the activity now." For example, you cannot start implementing until your low-level design has been approved.*

In other words, people feel more comfortable performing multiple tasks concurrently. Thus PCEs (and the underlying process-centered frameworks[1]) should provide mechanisms to allow this and should not place unnecessary restrictions on task sequencing.

A variety of other functional issues were raised and are quoted below:

On "to-do" lists

> *We originally had the concept of a to-do list. We would check off tasks and other tasks would appear. This is a very narrow view. Now we have the concept, not just of looking at today's to-do list but you can look at tomorrow, or next week, based on what we know now. It will be a best guess, based on durations and planning for future tasks.*

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1. Process framework is used here to connote the product with which process-centered environments can be built. See Appendix A for a more detailed definition.

On interfacing with email and office scheduling

> *An interface to email and a calendaring system would be very nice, because we like to keep online calendars to schedule meetings etc. You can go out and say "find for me between this day and this day, a conference for a design review with these five people for an hour" and this could all be done automatically by the tool because it has all the information. Why should I pay a librarian to make a thousand phone calls?*

On managing processes

> *Every time someone had an instance of a process, they would take one of these forms, copy it, and put it in the book. So the process now becomes a book of forms. I said "This is silly—let's automate it and use that as a front end with which to manage the processes."*

2.7.2 Tool/Data Integration

Unfortunately tools often do not have consistent or compatible capabilities—a design tool may have overlapping functionality with a development tool, and each tool may present its information through a very different user interface. In addition, two tools that need to share data may use different data schema. These technical challenges can result in an integrated system that neither looks nor performs in an integrated manner. Unfortunately resolving functional, data, and user interface incompatibilities is usually a very hard problem. Another integration problem that surfaced in one organization was incompatibilities between two process definition notations that were used, and between these and the notations that were implemented in other process support tools.

Some of these problems were voiced by developers of PCEs, particularly the challenge of data integration between application tools embedded in the PCE. One interviewee stated

> *The big data integration problem was between two tools. These had totally different views of process.*

Another interviewee stated a similar opinion:

> *The technical problems can be worked but data integration is an exception—it's a hard problem.*

Tool integration concerns were described by a third interviewee:

> *Like a lot of other things in the PCE, you find tools are not very well separated... As soon as you have a lot of different tools, all of which have their unique knowledge of process and artifact management, how do you get them to work together? If you take a total system view, there are encapsulation decisions you would ideally make if you were the PCE god, but which you can't do, because you are getting software off the shelf that has a lot of built-in assumptions.*

The process management component provided primarily textual guidance on task activities while the application tools environment provided the technical means to carry out the task. In this way some of the integration issues were separated. As the interviewee stated

> *We were not originally thinking this way. Then we saw that the application tools seem to cluster here while the process tools seem to cluster there. And there are some ties between them. Metrics are collected and displayed up here [through the process component] for management purposes. So there is a coupling through metrics.*

2.7.3 Technology Support for Process

A process-centered framework must provide a range of capabilities that help the PCE developer do his/her job. Areas where interviewees indicated that such support is desirable were

- graphical modeling capability with which to build processes
- support for multiple role perspectives
- a library of standardized process components that can be incorporated into larger processes

One interviewee felt strongly that graphical support was needed both in the process development and process execution phases. The next three quotes are from one interviewee who had experiences with both ProcessWeaver and FlowMark®. With respect to process development he stated

> *I think one of the great advantages to both of these tools is the graphical way you can build a process.*

He also noted the advantage of minimizing the time necessary to develop user interfaces:

> *ProcessWeaver has a feature that I really like. I don't need a GUI builder to build all the screens to interface – it builds its own forms, it has its own agendas, and work contexts, and that was very nice. In FlowMark, we had to go out and build our own screens, because it is only a process tool. If you want to put a panel in front of someone you have to build it yourself (there is no interface tool).*

This interviewee also suggested that both tools were harder to learn than he would have liked:

> *One of the things that people around here didn't like about both tools was that you had to be an expert. In other words, they would like a process tool which has a very simple English-like language.*

Another interviewee supported the need for a graphical development environment to support process design reviews:

> *We felt we needed a tool we could use during process design. We needed to design a process, have someone come in and take a look at it, see if they approved of the way the tool interactions worked given, of course, that they recognized automation was coming.*

Finally one interviewee voiced the need for role-based views in the process:

> *If you are a developer you only see developer steps, not management or QA views, for example. The user just interacts through a to-do list. It would come up and sort priority. The person could see it and select the task to do. The process manager would get the artifacts from the repository, check them out and return them to the user. It would also open up the tool.*

2.7.4 Prototypes

Divergent views were heard on the use of PCE prototypes. On the one hand we heard the view

> *Prototypes are very formal around here. They are a big part of what we do. Fundamentally I don't trust anything but a prototype. I don't trust my own opinion, let alone anyone else about that something will be useful.*

On the other hand we heard the view

> *We unfortunately used the word prototype the other day, but that's a bad word around here. It has a bad connotation—it implies that you get a half-way product and then it becomes the real product.*

Clearly different cultures see prototypes in quite different lights.

Being a new technology, PCEs are more prone to being developed in an ad hoc, exploratory manner. For this reason, a third interviewee emphasized that PCE prototypes have to be managed in a disciplined way if they are to be effective. Perhaps this provides an insight into the different views expressed above:

> *You need to interject some notions of functional decomposition and functional verification for each of the prototype levels, so that you can say "given the fact that I'm going to make this my prototype goal, I'll actually do some algorithmic development on paper, reason about it and then I can go deeper into the prototyping." In that way you can probably eliminate much of the code-and-go activities.*

With respect to a disciplined approach, the same interviewee also made the following comment about managing prototypes:

> *We had the issue of having to manage prototypes as prototypes—you'd better make sure of configuration management. That's a lesson we forgot a couple of times.*

2.7.5 Control Driven Versus Artifact-State Driven

Process end users need to feel that they are in control of their immediate work, not micro-managed by their supervisors or unreasonably constrained by an arbitrarily imposed process sequence.

This issue translates into whether the automated process should be driven purely by changes in artifact state, or whether the process should also allow for the explicit modeling of external control.[1] We found that interviewees generally had a desire to minimize the amount of overt, externally imposed control. One interviewee stated

> *[Software developers] see changes between states. They don’t think of this as process, but the natural progression of their software through the organization.*

However, another interviewee suggested that overt control could not, realistically, be entirely eliminated:

> *Bob and I spent a lot of time talking to [an organization] and Bob convinced them that state-change architecture was a good thing. They got this idea that they could handle all process enactment by just modeling artifact states. There is no notion of process control – they thought that process control could all be derived from artifact state.*

The fear of an all-controlling machine was allayed in one case after the end user had a chance to actually get some hands-on experience.

> *A representative of a trade union who was on the team said that the tool was something like big brother, but he said this only once and then forgot it, because the manager took care of the problem. The tool is very open to everybody and is not used to control people.*

The concern over unnecessary machine constraints was voiced by another interviewee:

> *People, especially creative people, don't respond to a tool which says “you will start the activity now.” For example, you cannot start implementation until your low-level design has been approved. They cannot work this way. It is better to define the artifacts that are to be produced and the goal states that these artifacts can be in. As a process definer, I can say, ‘here are the exit criteria which I will impose on you under which you can officially declare that a goal state has been reached.’ As a project manager I have every right to impose these criteria on you. I overstep my bounds if I tell you to use this method, or you will start this process at that point, and not do so until you have finished something else.*

The same interviewee provided some further insights into this area. He indicated

> *Typically a programmer has 20 things going on at once, none of which are finished. An engine that assumes things are serial or sequential will not work—it will last about two days. In a similar vein, he stated: End users may say [to the manager] “you didn't prioritize any of my activities but I wish you would. I have 30 activities and need help in prioritizing.” But don't tell the end users what they have to do or it will be rejected.*

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1. For example, a state-change driven approach implies that the new activity, *build*, can be initiated when a code module is transformed from the state *not-debugged* to the state *debugged*. The control-driven approach implies that a manager (or the machine) deems, somewhat arbitrarily from the end-user perspective, when it is appropriate to start the build.

2.7.6 System Performance

Slow performance, indicative of immature systems, was a common theme. One interviewee indicated

> *We had a problem that the environment was incredibly slow – we had an underpowered processor. We were doing a lot of processing so this added a burden to the workers who were trying to code as fast as they could on their projects but they found that they had to spend 15, 20, or even 30 minutes a day messing with process enactment stuff. We thought that was too much of a burden. One of the requirements of process enactment is that it can't make life a lot more difficult for the individual workers. If we want them to get through a few screens to get to their work then it can't take too long for them to do that.*

The same interviewee indicated

> *Every time there was an actively running process, we would actually have two operating system processes running on the server. The server has a limit. These were all running off the same administration ID, not the worker's IDs. So there would be 50, 60, or 70 processes running, and eventually the system would hit a limit.*

This problem has not been overcome in an improved version of the process-centered framework, but it does point out practical issues with the implementation of large-scale processes.

Another interviewee voiced similar frustrations:

> *One of the things we are trying to do is to keep the tool very small on the client side because PCs just don't have the power, memory etc. FlowMark took a big wad of disk space even for the client.*

The same interviewee indicated

> *Some of the difficulties we had were with tools. We had many people with 386 machines and didn't have large hard disks. Anything we had to do with the X-windows emulator really slowed things down. There was a lot of network traffic. People don't want slow response times. You have to make sure that whatever solution you give them is going to fit into their environment. No way can people around here afford to go out and buy 250 Pentium processors, or X stations. That's not going to happen.*

With respect to crash recovery, several interviewees voiced difficulties. In one case, thunderstorms frequently initiated system crashes. The interviewee stated

> *Of course that was not only a burden to the administrator, but was a hassle for everyone. People would have to check files out, while in the middle of performing tasks and would have to figure out what the status of each of these tasks was.*

With another system, crashes also occurred fairly regularly at first:

> *The system administrator didn't feel too confident in the architecture due to the implementation of the database, and the fact that in the beginning he had to reboot the system regularly. However, despite these problems, users were satisfied with the system response times and the reboot rate has decreased, currently to five reboots per month.*

A third interviewee indicated similar frustrations:

> *There were problems with graceful recovery from power loss. Each time we needed to bring the system back up, an expert was needed to put things back in order.*

2.8 Conclusions on the Interviews

We originally set out to focus on end users but found ourselves talking more often to process-centered environment developers. The reason for this was that we found few software organizations using process automation on a day-to-day basis. We talked mostly to quite large government-funded efforts, and while we would like to have examined small "home grown" initiatives, we did not find many. To date, experience with software process automation appears to be limited, but we did find some people who were struggling with many of the technical and non-technical issues pertaining to the adoption of process automation. These experiences were the subject of this section of the report. The following points summarize what we heard from interviewees:

- **On institutionalization:** We interacted with many pilot projects, but saw few successfully institutionalized environments. Many organizations were building prototypes and doing technology assessment. However, in only two organizations did we see automated processes that were institutionalized. These organizations were a bank (where process automation helped maintain their software) and a commercial company (where their process-oriented CM product was used to upgrade this product).
- **On primary motivators:** Productivity and cost reduction were primary motivators, while quality and process improvement appeared to be secondary motivators. Because of high turnover (particularly in the military) there was interest in support for training and maintenance of legacy systems.
- **On maturity of the technology:** Process automation tools do not yet appear to be stable or mature. Some interviewees experienced frequent crashes with resulting restart difficulties. GUI builders were limited in some tools, while in others there was a limited ability to query information graphically. There were also some performance and network traffic problems.
- **On process definition:** Process definition was identified as being one of the most time-consuming aspects of process automation. It requires a level of precision that is very time consuming, and obtaining consensus can be a quite contentious process. The devil is in the details.

- **On external consultants:** We found that resistance could be high to process automation if it was perceived as being imposed by outside agents or consultants.
- **On application to software development:** Some people viewed themselves as innovative and viewed process automation as inhibiting this creativity. This was particularly true when process automation was applied in a software development area, as software processes are often nonroutine, and end users are highly educated. Software tasks tend to be of low frequency, and software processes vary too much from project to project.

3 The Survey

The aim of the questionnaire survey was to gather a consistent set of data from a wide variety of organizations that were involved with the application of process automation. This data allowed us to obtain quantitative profiles of PCE users and generate correlations between different groups. The discussions below reflect this: The first subsection provides profiles of the respondent organizations, the second subsection describes the organizations' automation characteristics, and the third subsection analyzes some correlations that were made between the data. Finally some conclusions are drawn.

The questionnaire is quite long, consisting of over 120 questions, and the interviews conducted earlier were invaluable in scoping out its content. The questionnaire (see Appendix B, page 61) was broken down into seven sections:

- business/product characteristics
- implementation team characteristics
- application focus
- process characteristics
- the development technology
- transition and adoption
- impacts and insights

The questionnaire was distributed to a large number of organizations (approximately 150), but, despite follow-up letters, the return rate was somewhat disappointing; we received only 35. Part of this we believe is due to the size of the questionnaire, and part of it may be due to the fact that many questions dealt with issues of adoption and use that respondents had not yet had much experience with. In analyzing the results, there are two kinds of bias with which we have to deal. The first relates to the population to whom the questionnaire was distributed. Because of the relatively specialized area and widely varying organizational cultures, it would be close to impossible to select a controlled population for the study. The second type of bias is introduced as a result of who, among the first population, returns the completed questionnaire. Because of the low return rate, there is always a question of bias (e.g., were successful groups more motivated that unsuccessful groups to return their responses?). Bias may also have been introduced by the fact that the large majority of respondents were managers and analysts, and not those who were directly supported by the automation (i.e., end users). Thus, when interpreting the results, the exploratory nature of this study should be kept in mind.

3.1 Organizational Characteristics

We first look at the business and product characteristics of the organizations surveyed. Of particular interest are the organizations' cultural characteristics and how these relate to the ability to adopt process automation successfully. The results, shown in Figure 3-1, are derived from the survey questions A.5.1—A.5.10 (see Appendix B). These questions each asked, "How would you characterize your organization's culture?" along different cultural dimensions—for example, high turnover vs. stable staff. A neutral category (not shown in the figure) was also included in the questionnaire. The main point to note in the figure is the fact that, along all dimensions, the organizations with the more "innovative" characteristics tended to be more successful in adopting process automation than organizations with "laggard" characteristics.[1]

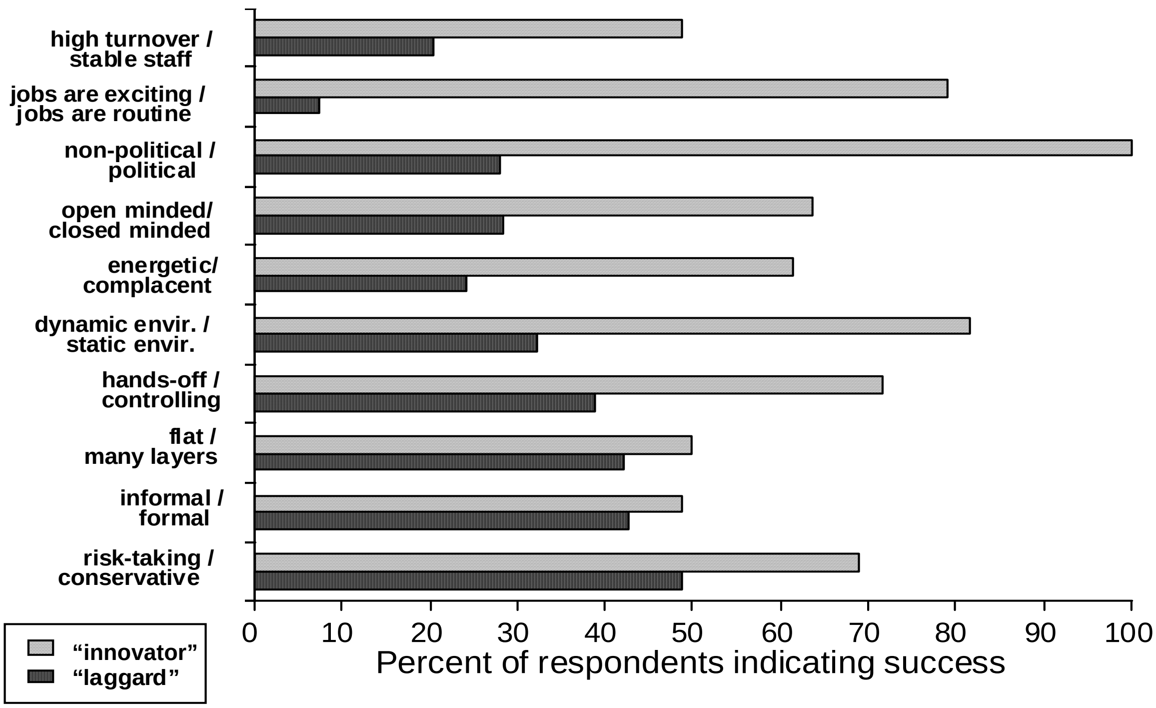

Figure 3-1 Correlation Between Success Rates and Cultural Characteristics

Summarizing other characteristics of the organizations, we found that a large majority of participants developed one-of-a-kind products (37 percent), while the next largest category was customized products (20 percent). The software and aerospace businesses dominated the industries (42 and 33 percent, respectively) while other industries represented were electronics, science, finance, communications, energy, transportation, and weather. With respect to the responsibilities of the participants, analysts made up the largest category (34 percent), followed by first-line managers (31 percent). We wanted to get significant representation from the end-user community but (as with the interviews) found that such individuals were very hard to come by.

1. It should be noted that the somewhat judgemental descriptors "innovator" and "laggard" were not used in the questionnaire.

3.2 Characteristics of Individuals

In this section, we look at characteristics of the people involved in the process automation project. This primarily covers the roles of those who responded to the questionnaire and the length and breadth of experience of the respondents and the automation team leads.

Figure 3-2 indicates that the great majority of the respondents were analysts or managers. The lack of end-user participation was disappointing, but is consistent with our interview experience. We believe that this reflects both the immaturity of the technology and the fact that end users may lack the seniority in their organizations. In interpreting the results, this distribution of respondents should be kept in mind.

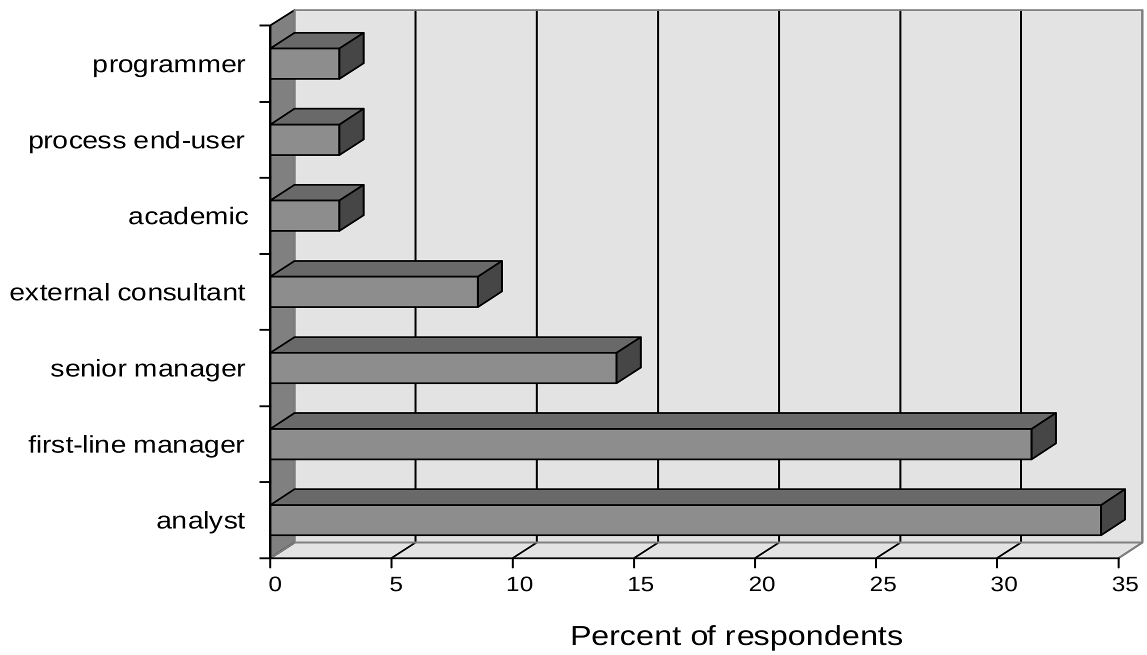

Figure 3-2 Distribution of Roles

Figure 3-3 shows that the people involved in the development of the automated process(es) are mostly quite experienced, the majority having over 10 years of experience in software development.

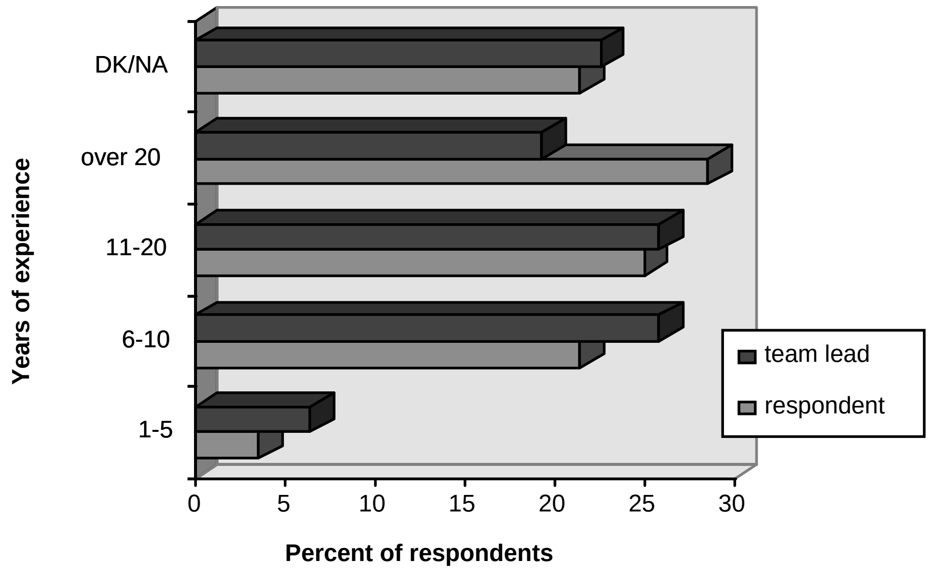

Figure 3-3 Distribution of Experience (Years)

Most implementation teams were small; 43 percent of the respondents indicated that they were in a team of one to five persons, while 23 percent indicated that there were between six to ten team members. The teams appeared to have a broad range of applicable skills; the breakdown of team skills was: process definition (85 percent), tool integration (70 percent), PCE development (68 percent), networking (62 percent), adoption (55 percent), and training (52 percent).

3.3 Application Focus

A motivating factor behind this investigation is how process automation can help in the development of software. However, it is clear that in many ways process automation helps not by directly supporting the production of code, but in supporting the attendant management activities. This can be seen in Figure 3-4. Software development is clearly important but not the predominant activity.

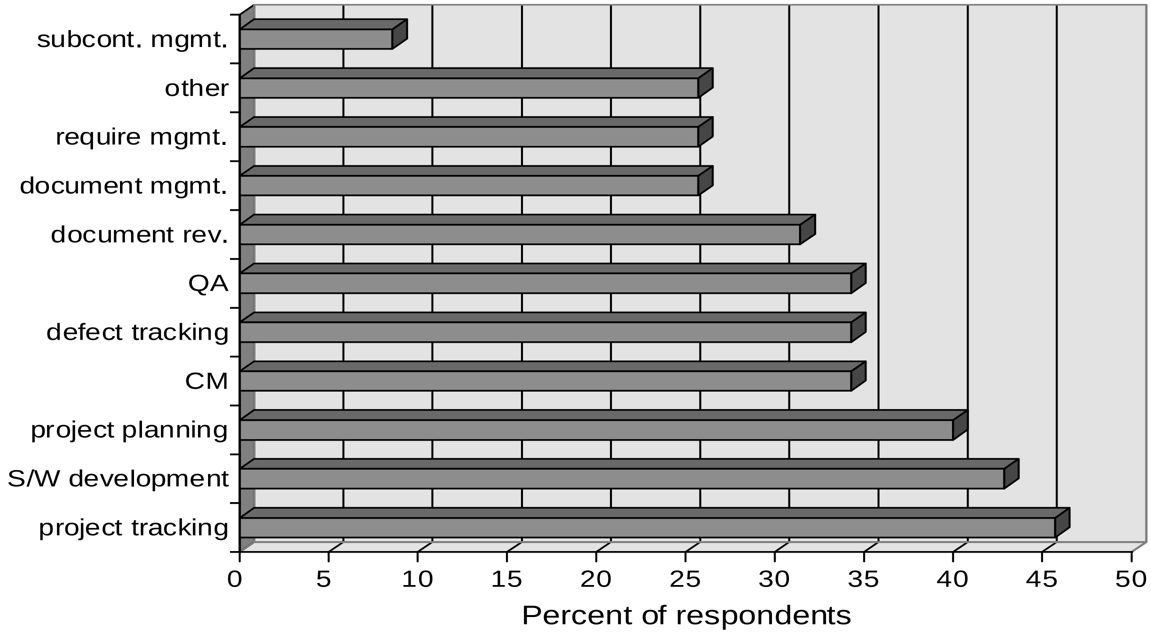

Figure 3-4 Automation Applications

Unlike in our interview results, the questionnaire results indicate that process improvement was the most common motivation behind the use of process automation. This is shown in Figure 3-5. Productivity improvement came in a close second. Interestingly, management oversight was quite low in the priority list—perhaps indicating that management "control" over subordinates is not being abused.

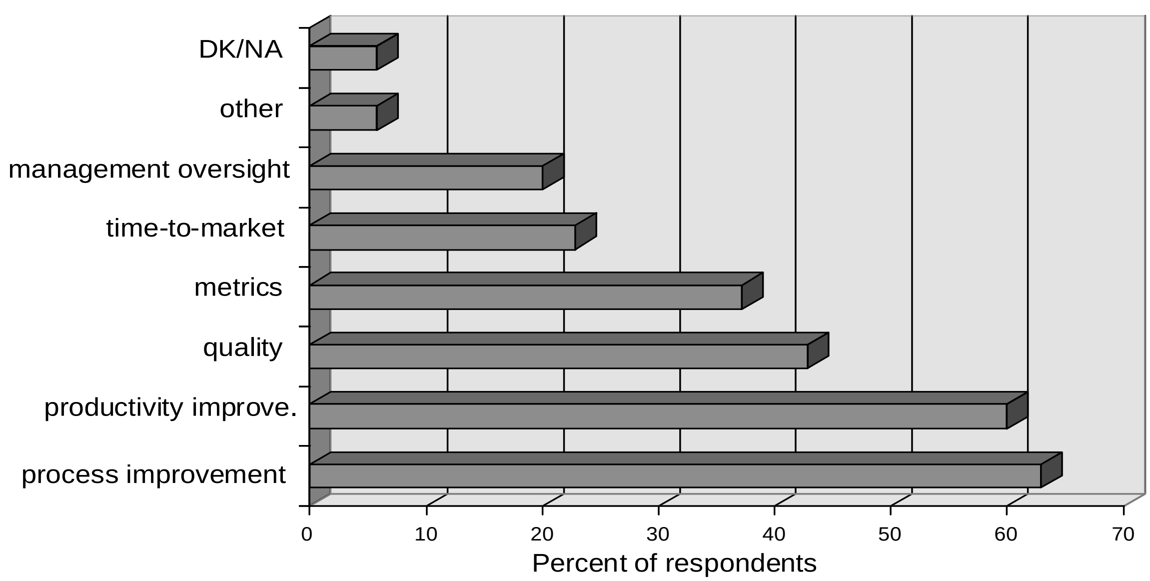

Figure 3-5 Management Motivation

We also looked at the duration and frequency characteristics of the processes that were automated. Results are shown in Figure 3-6 and Figure 3-7. Figure 3-6 correlates the duration of processes with how frequently these processes are performed. It is clear that most commonly, processes are both of short duration and frequently performed and that long duration (greater then 100 days), low frequency (less than one execution per month) are rare. Figure 3-7 then correlates the time it takes to complete the process with the success of the process automation project. In this case, however, the correlation among these variables appears to be weak. This lack of good correlation may be because we did not have a sufficient number of long duration processes in the study.

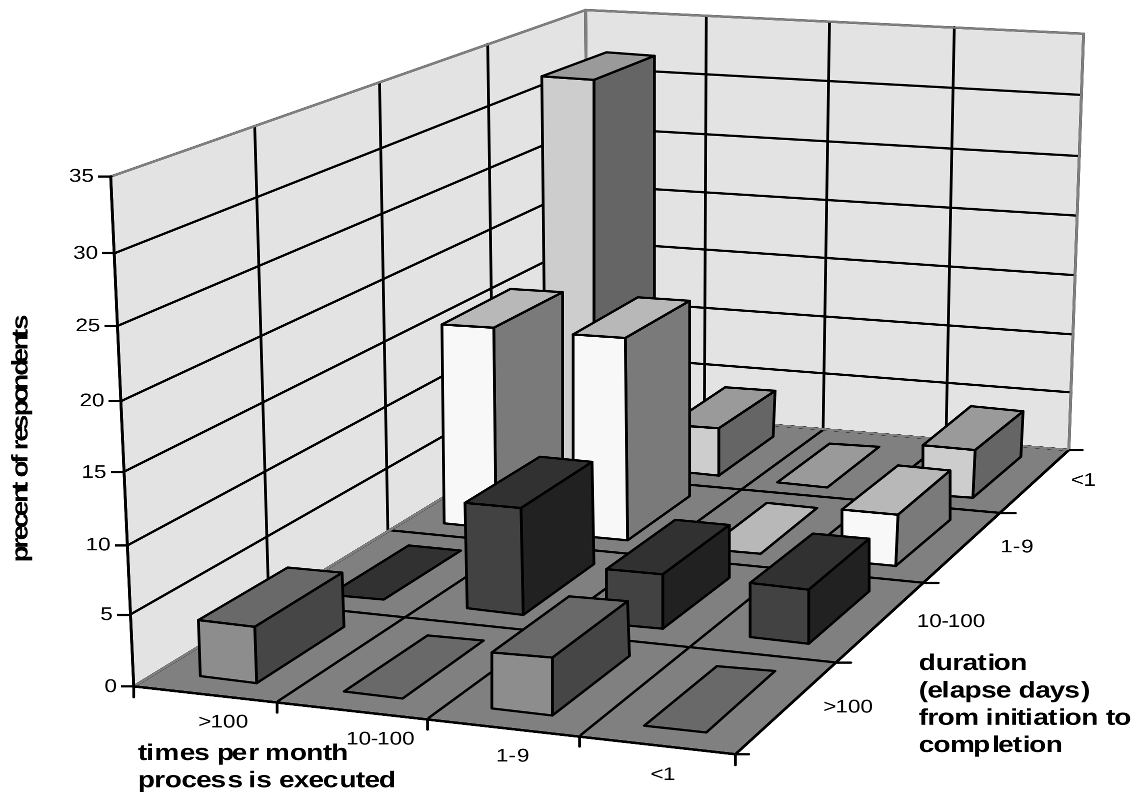

Figure 3-6 Correlation Between Duration and Frequency of Execution

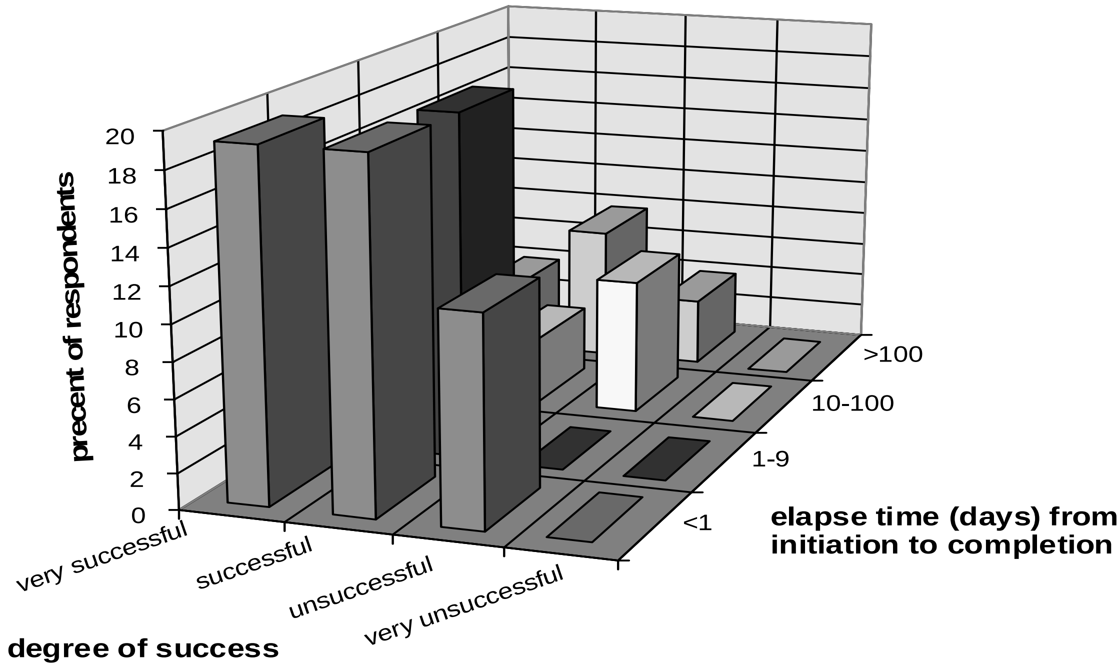

Figure 3-7 Process Automation Success vs. Process Duration

In summary, we found that process automation was applied to a wide range of management activities, although there was also a significant focus on software development. Process and product improvement were primary goals and most applications were of short duration and of high frequency. While process duration appeared to correlate with frequency of use, the results did not indicate any clear correlation between process duration and success with process automation.

3.4 Process Characteristics

The goal of the questions in this section is to assess the process characteristics of the responding organizations. We wanted to know if

- management practices of the organizations were effective
- documented processes were being followed
- organizations were using known process definition notations to define their processes

With respect to the first item, respondents were asked if they agreed to the six statements shown in Figure 3-8 (with respect to practices in place prior to the automation implementation). These data clearly indicate a variety of capabilities, although the number of “no” responses would imply that many of the organizations are at CMM level 1. These results were correlated with the success of the automation projects and the results are shown in Figure 3-9. (See Appendix C for an explanation of the scale used to assess management effectiveness.)

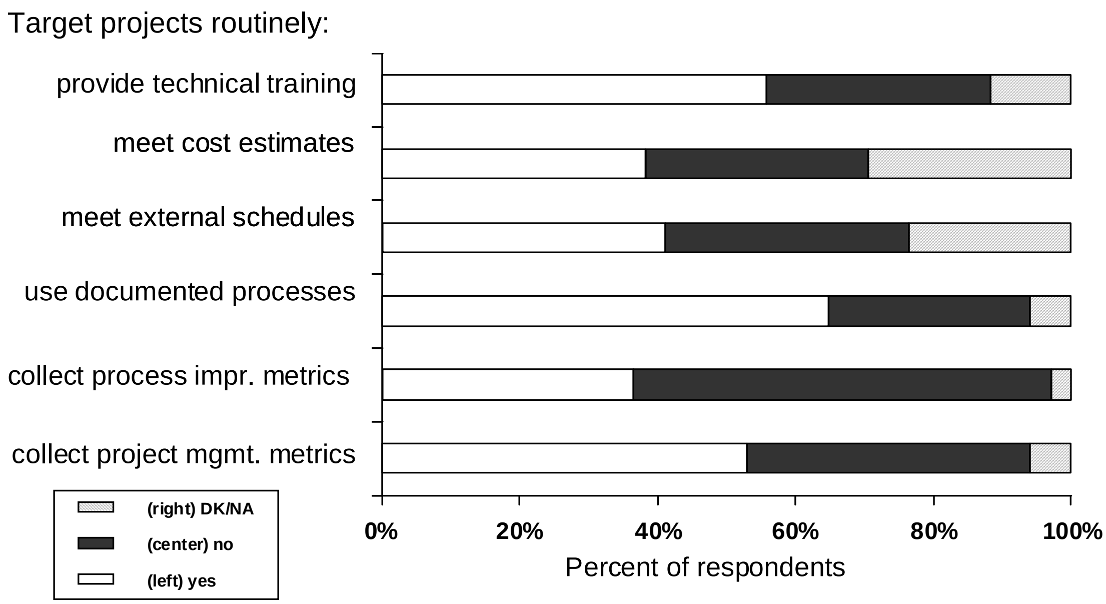

Figure 3-8 Practices Reflecting Process Maturity

The use of documented processes appears to be quite high. However, this could be a reflection of the fact that a significant percent (46) of respondents were managers whose perceptions of the use of documented processes may be unrealistically high.

Figure 3-9 indicates that organizations with effective management practices (ME<11) were all either successful or very successful in applying process automation.[1] (There were no unsuccessful cases.) On the other hand, organizations with less effective management practices (ME>11) were either in the unsuccessful or successful categories. (There were no very successful cases.) The implication is that effective management practices are contributors to the successful application of process automation.

1. See Appendix C for the definition of *degree of management effectiveness*.

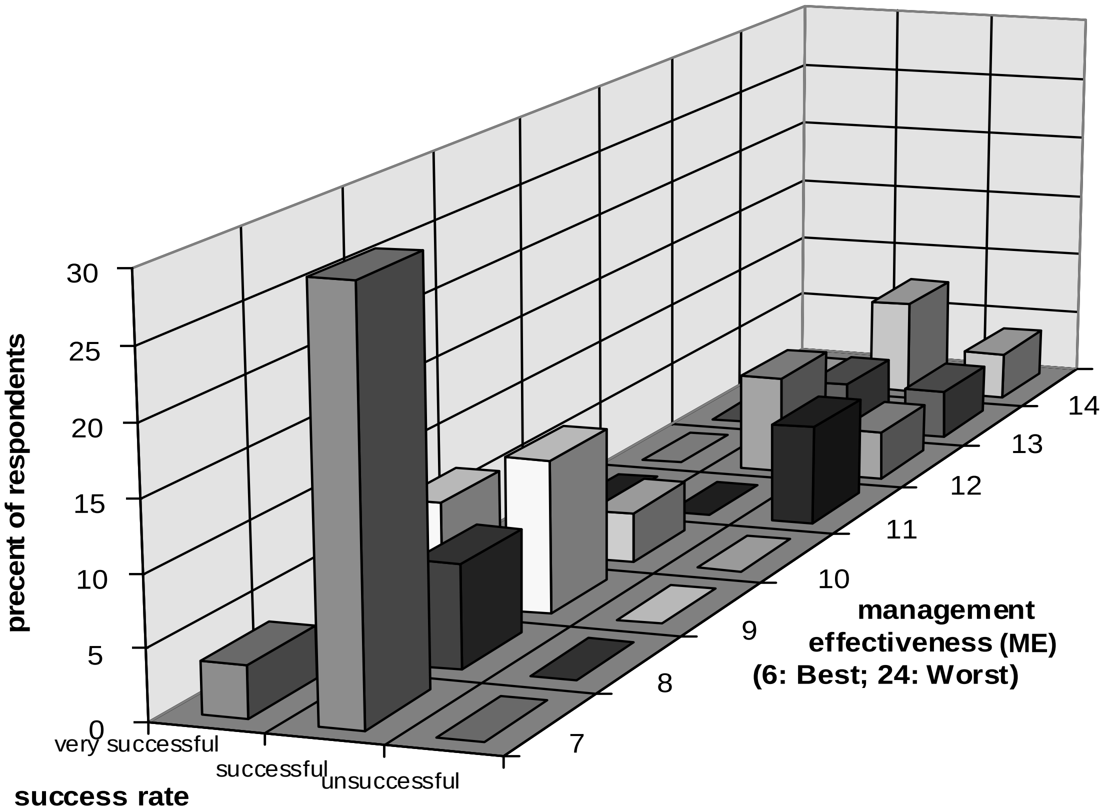

Figure 3-9 Process Automation Success vs. Management Effectiveness

Figure 3-10 indicates the breadth of processes that were *documented* and performed manually. Most of the applications focus on work-flow support, rather than on actual software development (although the latter case is well represented). While it is not surprising to see *quality assurance* and *document review* processes high on the list, it is somewhat surprising to see *defect tracking* and *document management* so meagerly represented (three and eight percent, respectively). It is interesting to compare these data to the data in Figure 3-4: Automation Applications, on page 31, where *defect tracking* and *document management* show much higher representation (34 and 26 percent, respectively).

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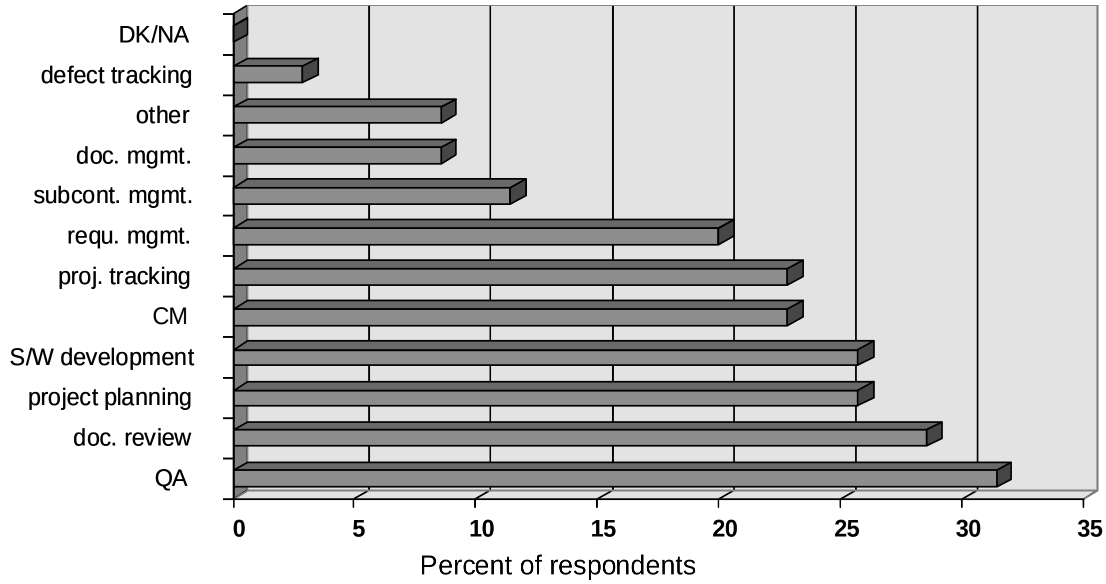

Figure 3-10 Documented Processes in Target Organizations

For process definition support, it is clear from Figure 3-11 that tried and true approaches are most popular. By far the most common method to describe processes was flow charts (20 percent). Given the familiarity that most software engineers have with this diagramming technique and the availability of templates to draw such diagrams, this is not surprising.

We also looked into the issue of whether prior manual operation of the process was an important precursor to success in its automation and whether that process should have been operated in a stable manner. While the large majority of respondents indicated that their process was indeed performed manually (69 percent), and a similar number indicated that the process was documented (66 percent), a much smaller percentage indicated that the process was stable (34 percent). Performing a chi squared test on these data against success in process automation did not reveal any systematic association between prior operation of the process and success in automation.

In summary, while most organizations appeared to be of low process maturity, effectiveness in applying process automation appeared to correlate with factors dealing with management effectiveness. Organizations generally used simple process formalisms such as flowcharts to define their processes. However, most respondents indicated that process definition (for the automation project) was more challenging than they anticipated (83 percent). Prior manual operation of the process did not appear to correlate strongly with success in automation.

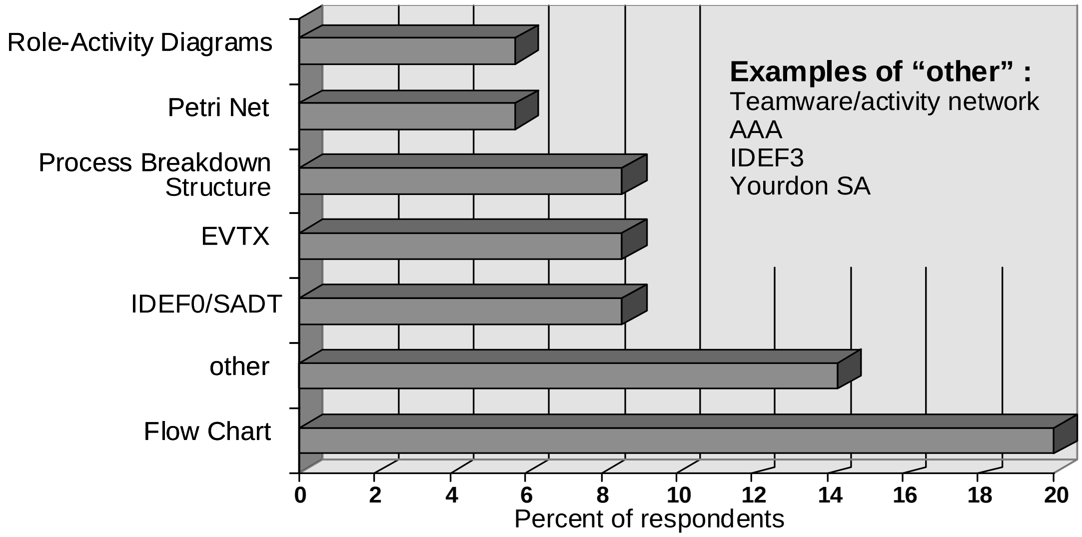

Figure 3-11 Process Definition Notations Used in Target Organization

3.5 Development Technology

We wanted to find out which tools people were using to support their automation efforts and how they felt about the effectiveness of these tools. We were surprised to find the diversity of approaches used. A minority of respondents implemented their processes with commercially available automation tools such as ProcessWeaver or InConcert, and in fact a few respondents did not appear to know which tools were being applied. The distribution of tools used is shown in Figure 3-12. In correlating the perceived success of these projects against the type of tool used (i.e., process automation tools vs. "other," as listed in Figure 3-12), no significant difference was observed. However, it is interesting to note that there was a bias towards using commercial automation tools for larger processes, "larger" being defined by the number of end users involved in these processes.

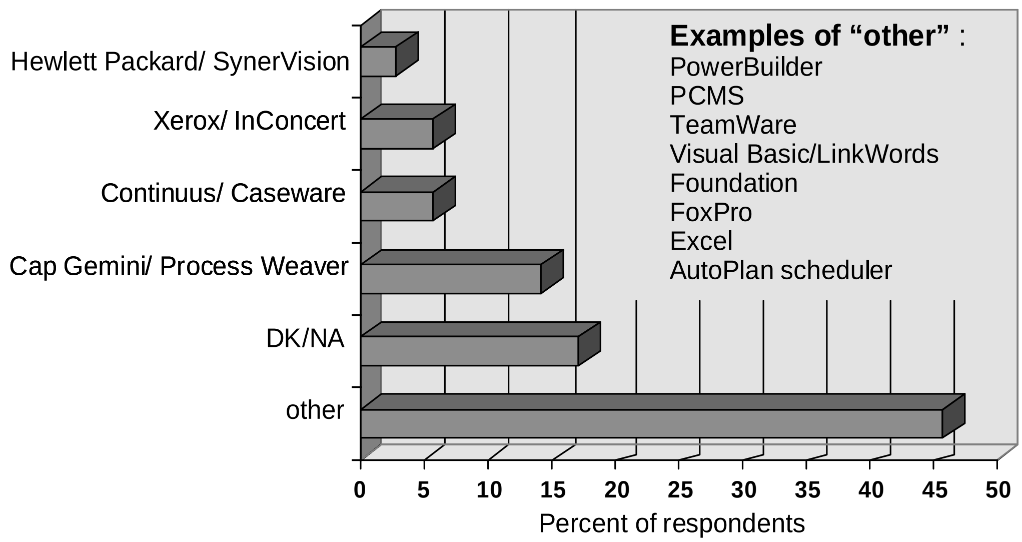

Figure 3-12 Process Automation Tool Used

Addressing the issue of satisfaction with their chosen tools, respondents indicted a fair degree of satisfaction with the process automation tool used. The responses are shown in Figure 3-13 and Figure 3-14. The degree of "don't know" may either be because the respondent was a manager and was not familiar with this level of technical detail, or it may have been because there was not yet sufficient experience with the tool. Of particular interest (and somewhat disconcerting) is the relatively small number (about 40 percent) who felt that, despite generally positive feelings towards the chosen process automation tool, the tool was not cost effective. However, this category did have a high "don't know" response rate (40 percent), indicating that the jury may still be out on this issue.

It was surprising to see that many respondents (over 70 percent) felt that the ability to integrate application tools into the environment was either good or excellent. This is in contrast to the respondents who we interviewed, who in general felt that such integration was a hard problem.

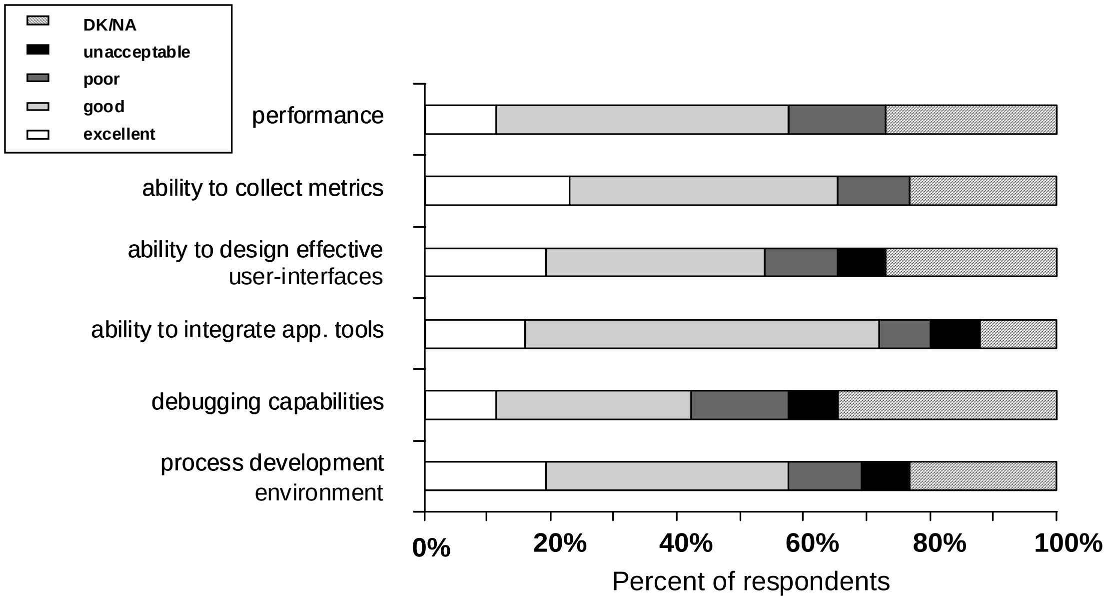

Figure 3-13 Perceived Strengths/Weaknesses of Automation Tools - 1

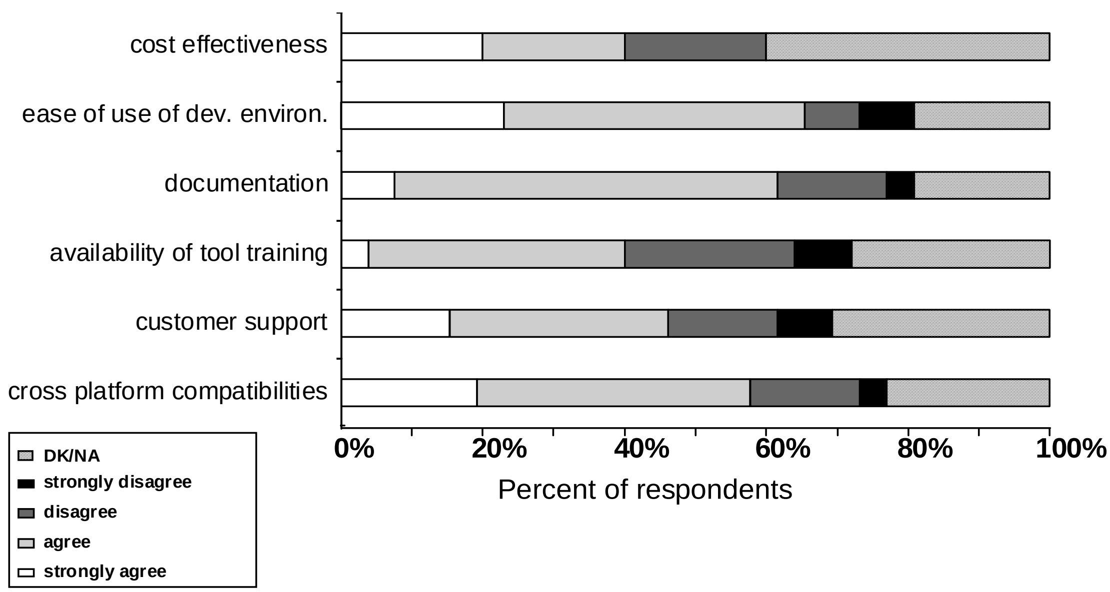

Figure 3-14 Perceived Strengths/Weaknesses of Automation Tools - 2

Finally, Figure 3-15 indicates experiences that respondents had with automation tools. From these data, it appears that, while system crashes and recovery from such crashes were not a major problem (as they were with some of the interviewees), tool defects were more common.

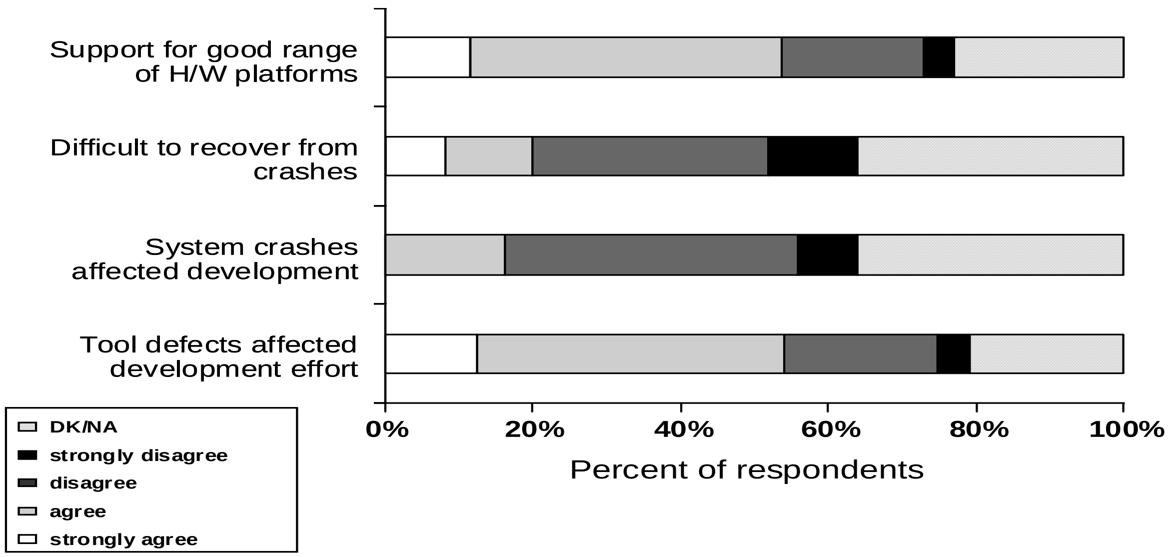

Figure 3-15 Characteristics of Process Automation Tools

In summary, we found that a wide variety and sophistication of tools were used to implement process automation. Most users were satisfied with the technology support for process automation, but there was still considerable uncertainty about cost effectiveness. It appeared that, while tool defects were a problem, system crashes were less so.

3.6 Transition and Adoption[1]

During the interviews we heard that transitioning to an automated environment took "longer than expected." However, transitioning times that the questionnaire respondents reported (shown in Figure 3-16) do not seem unreasonably long—typically three to twelve months. The difference may be due to the fact that the projects on which the interviews focused tended to be larger and more ambitious than those reported in the questionnaire. Note that for many of the cases, transition was still ongoing. In a surprising number of cases, the system was in actual production use—only 20 percent indicated that they were not yet up and running (see Figure 3-17). In the majority of cases, end users participated quite widely in the design of the system and specification of its user-interface characteristics. Training also appeared to be quite extensive—less than ten percent indicated that they received no training. These results are shown in Figure 3-18.

1. The results in this section that focus on end users should be tempered by the fact that there were very few end users in the responding population (see Section 3.2 for this distribution).

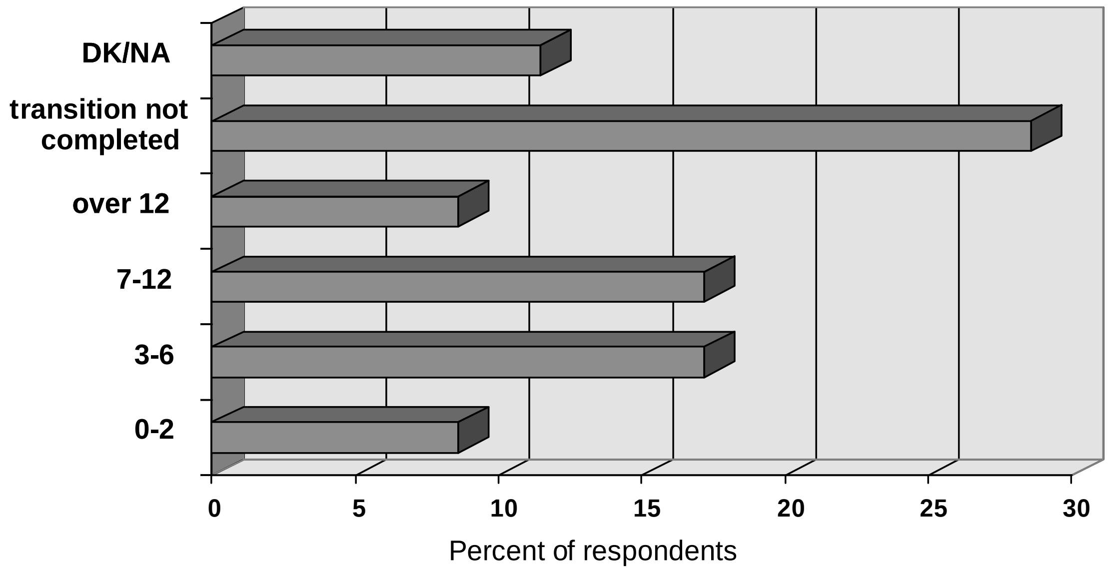

Figure 3-16 Length (Months) for Transition to Automated Environment

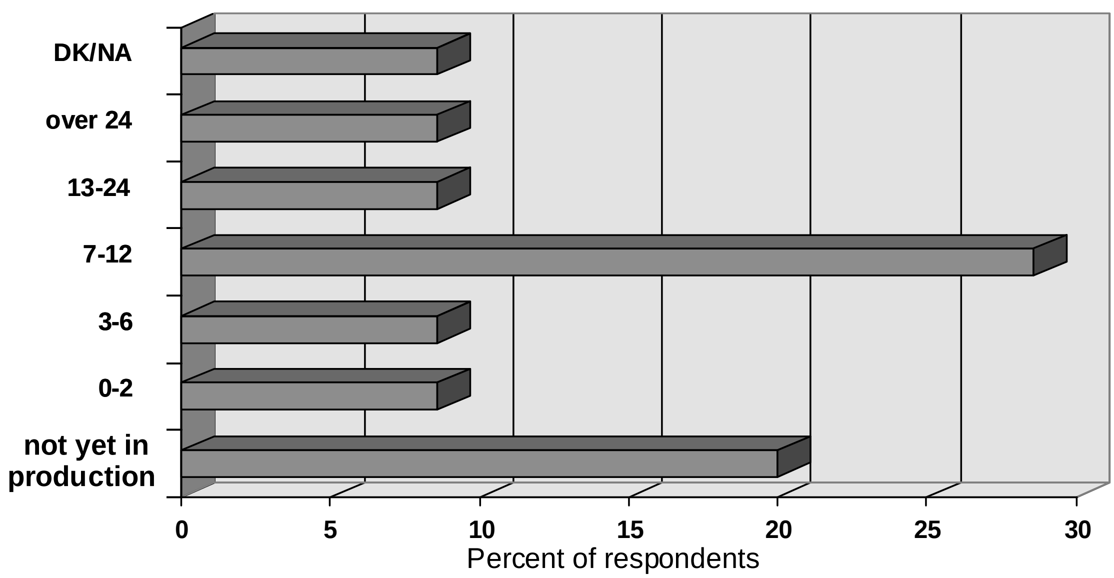

Figure 3-17 Time (Months) Automated System Has Operated in Production Environment

To assess the impact of user involvement on the success of the automated environment, a "degree of success" criterion was defined, based on the responses to the six "involvement" issues identified in Figure 3-18.[1] These data were correlated with how the projects' personnel perceived their level of success. The results are shown in Figure 3-19. While the data are skewed by the fact that most of the projects reported success, it is interesting to note that there were no failures with organizations exhibiting a high degree of end-user involvement. On the other hand, there were some successes when little end-user support was evident. These observations may indicate tentatively that end-user involvement is a sufficient but not necessary condition for "success."

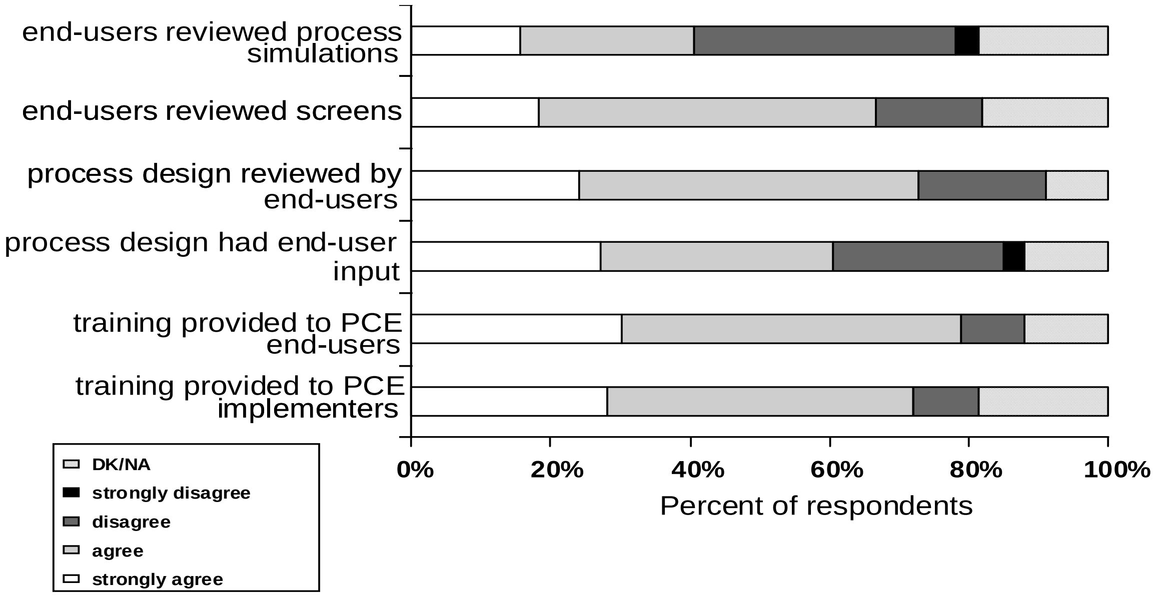

Figure 3-18 Process Automation Success vs. End-User Involvement

1. See Appendix C for an explanation of this success measure.

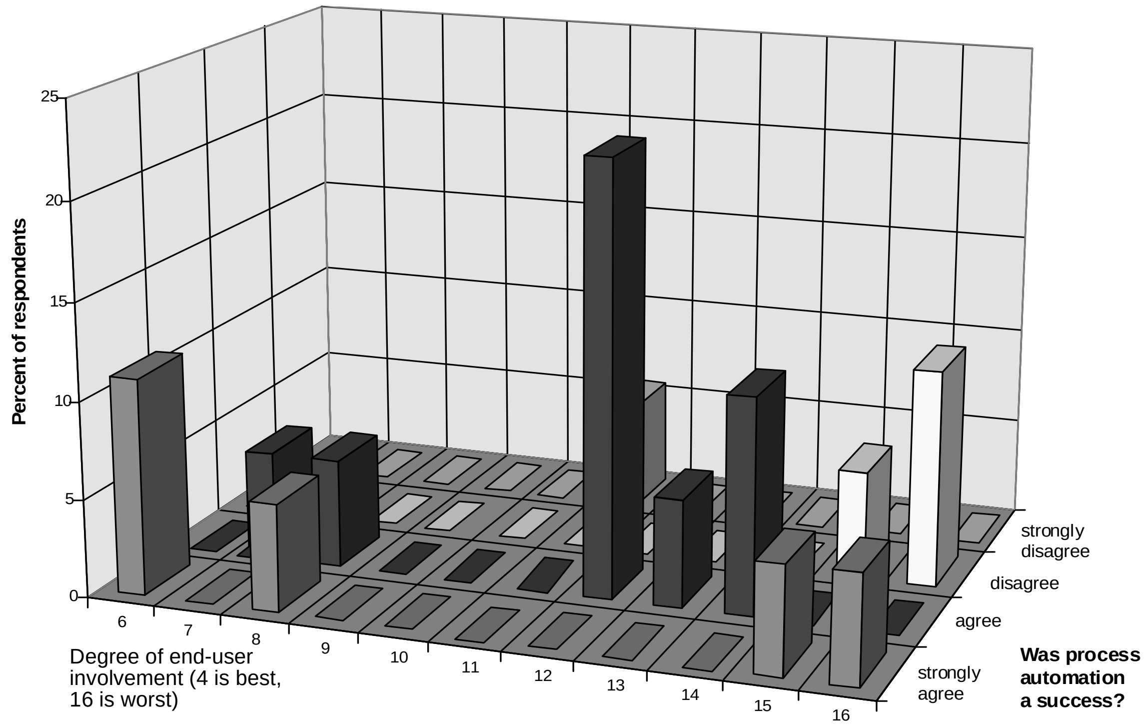

Figure 3-19 Responses to Adoption Support Questions

Figure 3-20 and Figure 3-21 indicate end-user operational experience with the system. A somewhat disheartening conclusion can be extracted from the data in Figure 3-20. In spite of the fact that over 70 percent of respondents indicated 1) that end users made suggested improvements and 2) that automation improved end-user effectiveness, end-user acceptance and feelings of ownership were still only around 35 percent. This may be partly, but not totally, explained by the data in Figure 3-21. This figure indicates that about 45 percent of respondents perceived process automation as being too controlling, being imposed externally, and generating fear of change. It may be concluded that, to raise the feelings of ownership within the end-user population, these three issues should be given more weight.

An issue that evoked a strong response from interviewees was that of building the system all at once as opposed to building it incrementally. Many had built their systems monolithically and regretted it. Thus, there was a strong feeling that using incremental builds was a better strategy for success. However, this conclusion was not clear from the questionnaire responses. While the incremental strategy was more prevalent among the respondents, the degree of success was not noticeably correlated to the build strategy (as indicated by a chi squared test of the data).

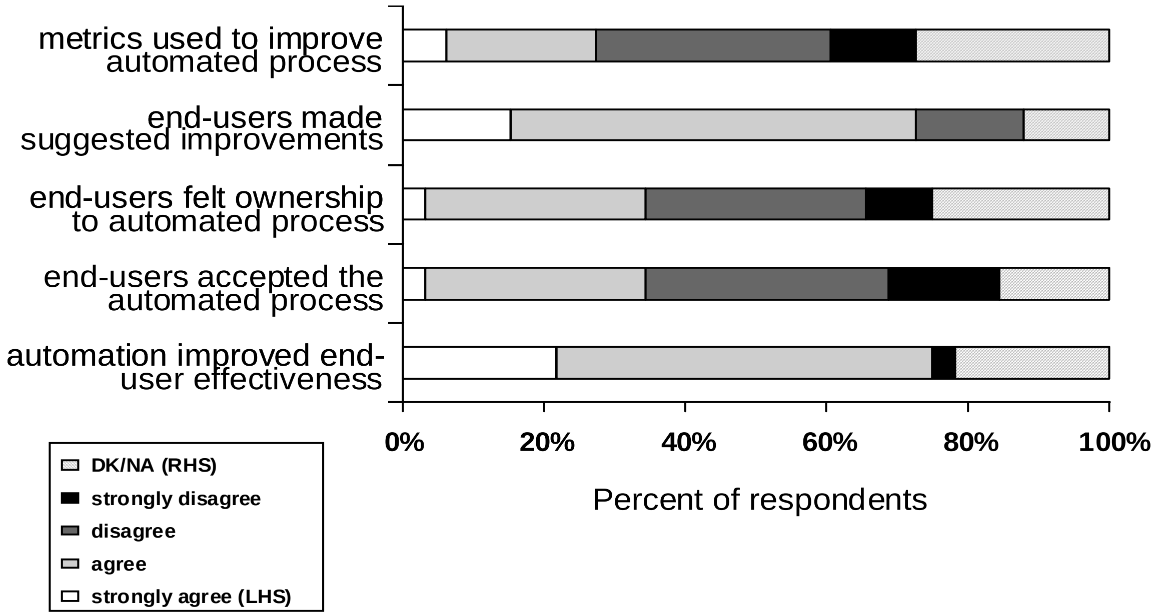

Figure 3-20 End-User Operational Experience - 1

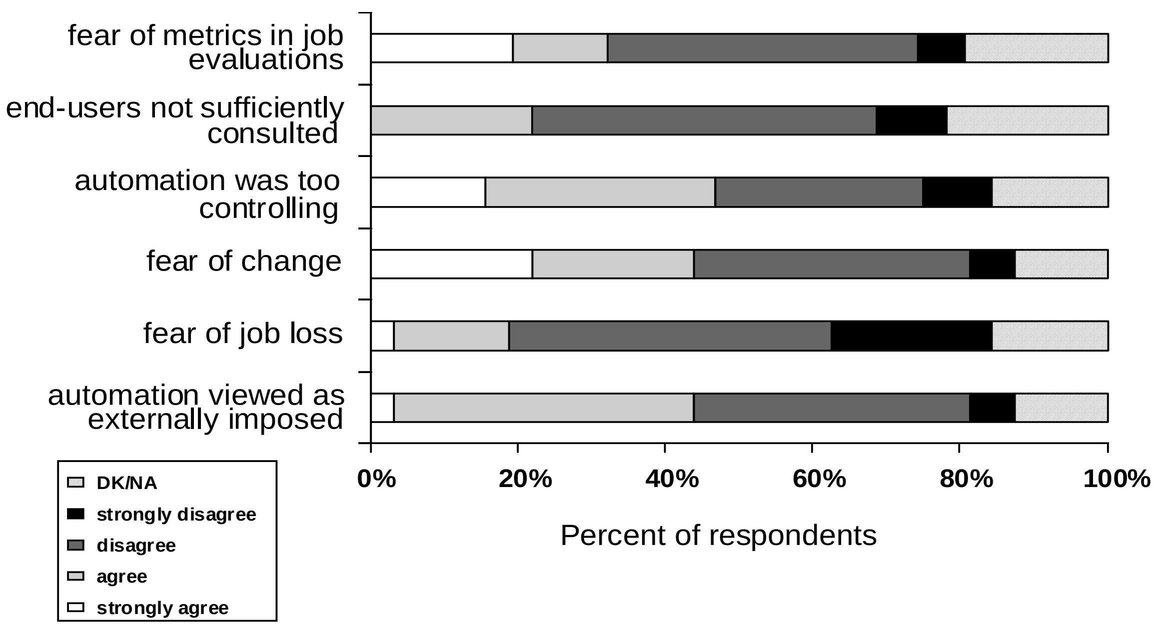

Figure 3-21 End-User Operational Experience - 2

Finally, in this section, we look at issues dealing with management sponsorship. The data in this area are presented in Figure 3-22. It is clear that sponsorship from senior and first-line management was very high (79 and 69 percent, respectively) and that the number of projects supported by a champion was also perceived as high (60 percent). While this strength is a very positive sign, it should be tempered by the fact that nearly half of all respondents were managers. We correlated the strength of management sponsorship against the perceived success of process automation projects. This result is shown in Figure 3-23. This figure indicates a relationship between these variables; namely where sponsorship was strong, success was likely and where sponsorship was weak, success was less likely. (The “degree of sponsorship” parameter was determined by combining the responses from Figure 3-22 as discussed in Appendix C.)

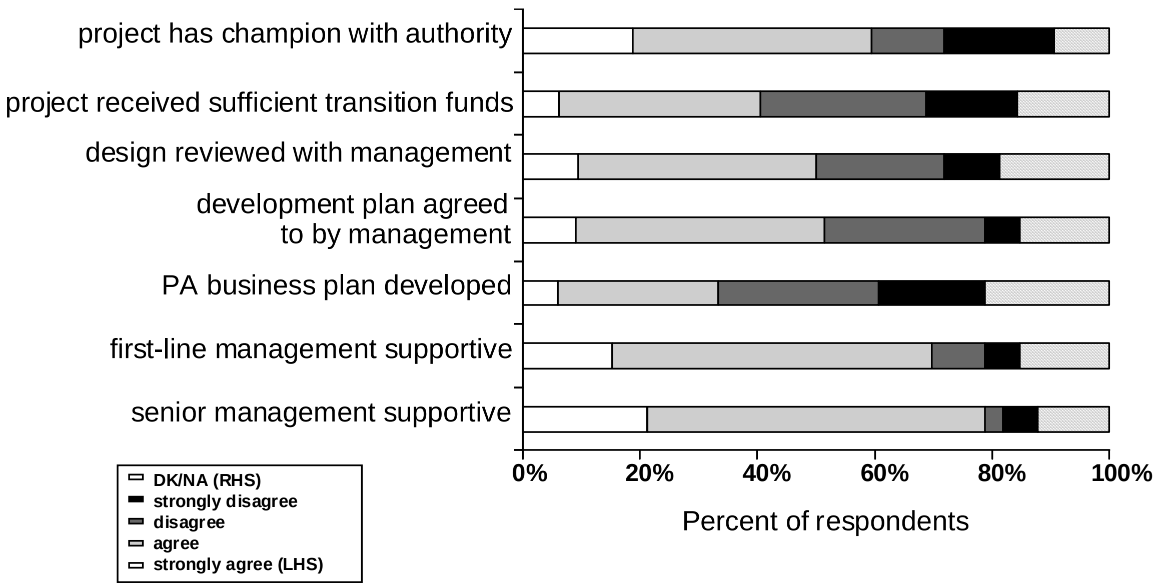

Figure 3-22 Management Sponsorship

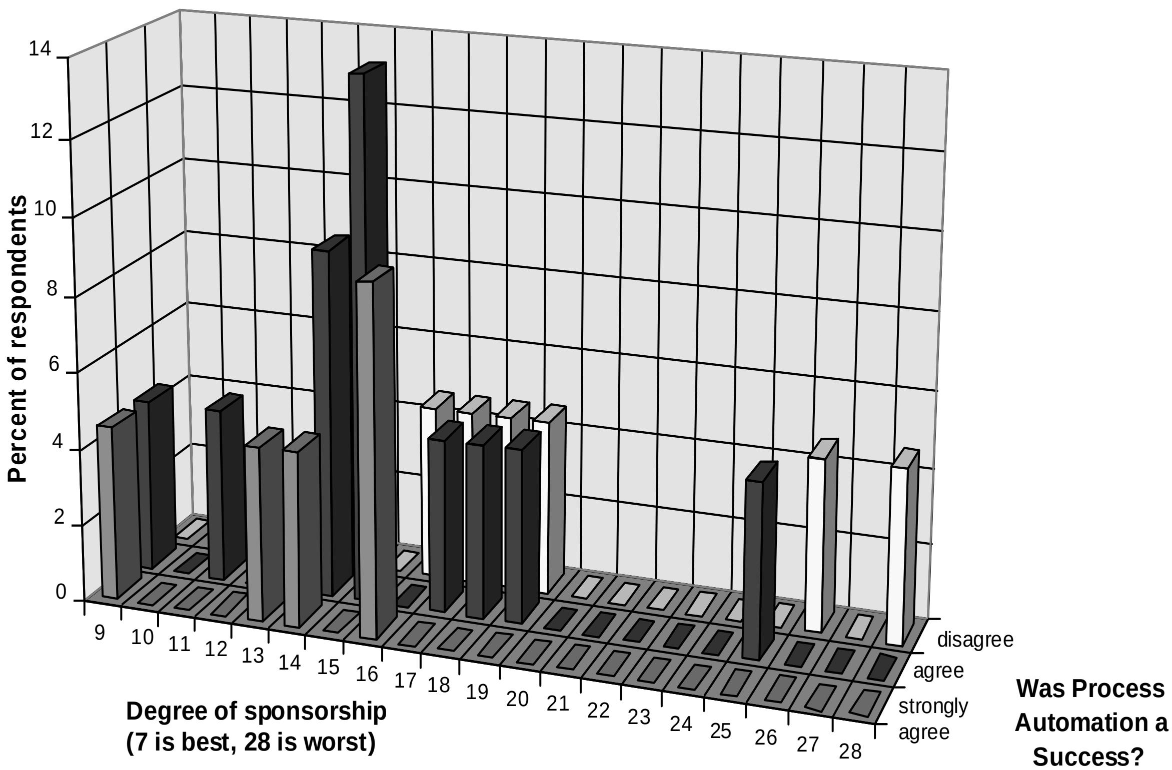

Figure 3-23 Process Automation Success vs. Management Sponsorship

In summary, it appeared that most projects transitioned their environment into use within three to twelve months. The degree of end-user involvement seemed to be a factor for success. There were indications that the projects received very high management support, and that strong management sponsorship is also an indicator of success. End-user involvement was apparently quite high, while feelings of end-user ownership were not reflected by this level of involvement. Incremental system builds (as opposed to all-at-once builds) were most common, although it was not obvious from the limited data that this in itself was an indicator of success. This is contrary to the strong responses supporting incremental builds as a success factor that we heard during our interviews.

3.7 Impacts and Insights

We asked respondents what lessons they learned from their experiences with process automation. This section reviews these responses. First, we found that delays were common. In fact, over 60 percent suffered delays of varying severity. Only 12 percent indicated on-time performance while no one was ahead of schedule. This is certainly consistent with the general experience that introducing process automation was harder than first anticipated.

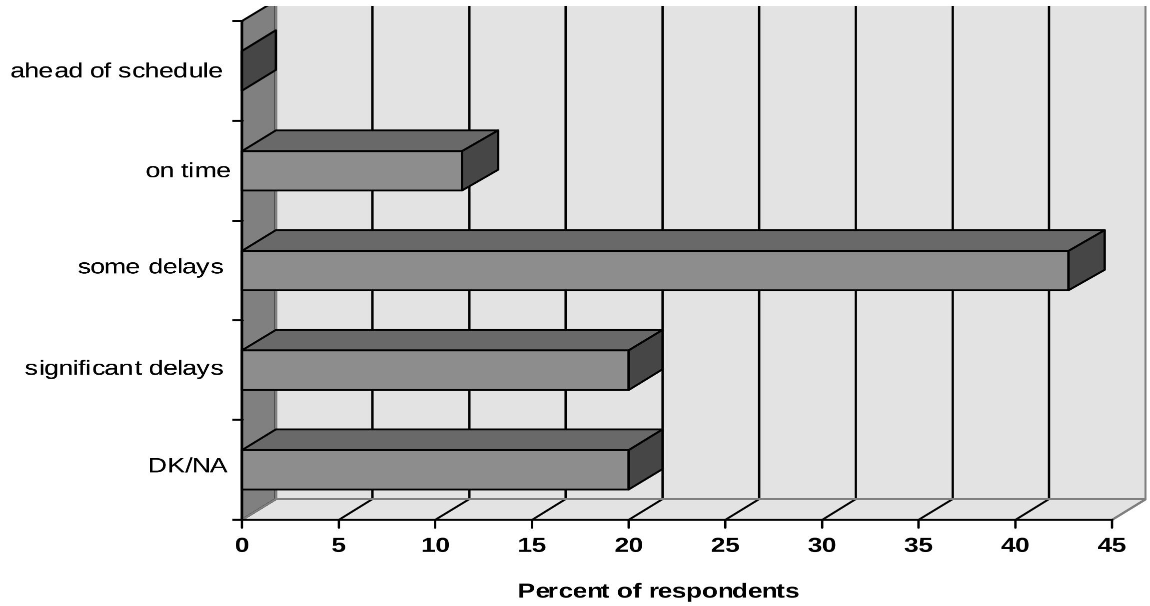

Figure 3-24 Planned vs. Actual Schedule

Next we look at the perceived benefits (or lack thereof) of process automation. These issues are summarized in Figure 3-25 and Figure 3-26. Almost equal numbers of respondents felt that process automation either improved or decreased end-user team building. One can only suspect that process automation may have the effect of isolating individuals since there is more of a focus on computer terminal operations. A similar conclusion may be drawn from the approximately equal numbers who indicated increases and decreases in end-user job satisfaction. Indicators reflecting management issues were more positive. Thus process automation appeared to preferentially support project management, quality, and productivity activities. Just over half of the respondents indicated that process automation reduced their costs, while about 70 percent indicated that process automation provided timely information, provided useful process guidance, and helped prevent errors. The highest response category was “supports administrative efforts” (about eighty percent). This high positive response rate is consistent with the popularity of work-flow applications for routine business tasks. The perceived bias that managers benefit primarily from process automation is of concern; the technology is likely to be successful only if it is seen as supporting all who use it. Thus there is a need to make sure that non-managerial benefits (e.g., reduction of tedium, improved information access, more effective task prioritization) are emphasized in the implementation of the system.

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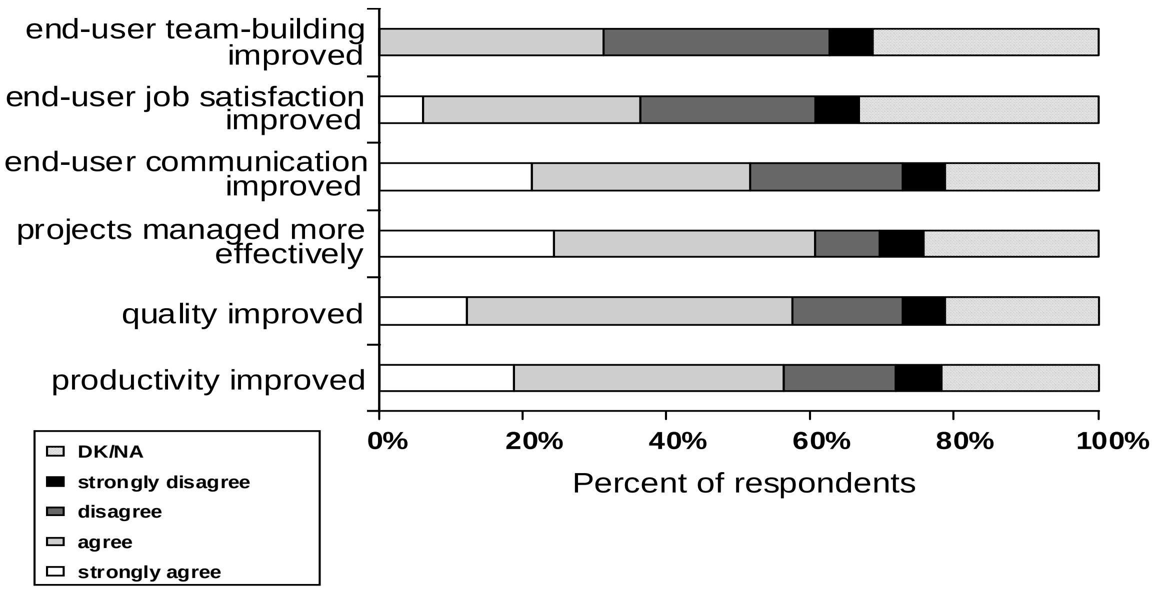

Figure 3-25 Benefits of Process Automation - 1

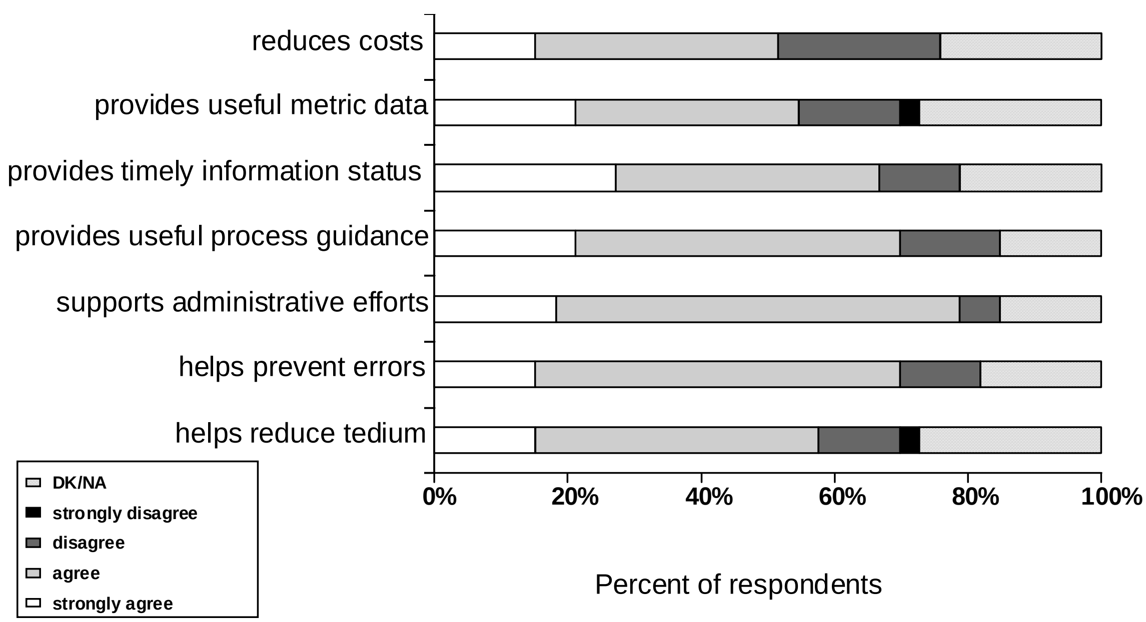

Figure 3-26 Benefits of Process Automation - 2

Figure 3-27 provides some insights gained from the process automation experiences. Only a quarter of the respondents indicated that they would be automating additional processes. This is quite surprising given the fact that process automation was viewed very positively in terms of cost reduction (twice as many respondents feel that it reduced costs as increased them), perceived success (over 65 percent indicated that the process automation project was a success), and its effectiveness in supporting many tasks (nearly 80 percent indicated it helped administrative tasks). On the negative side are the idea that process automation is challenging to put in place (over 60 percent felt this way), and the doubt that it improves job satisfaction.

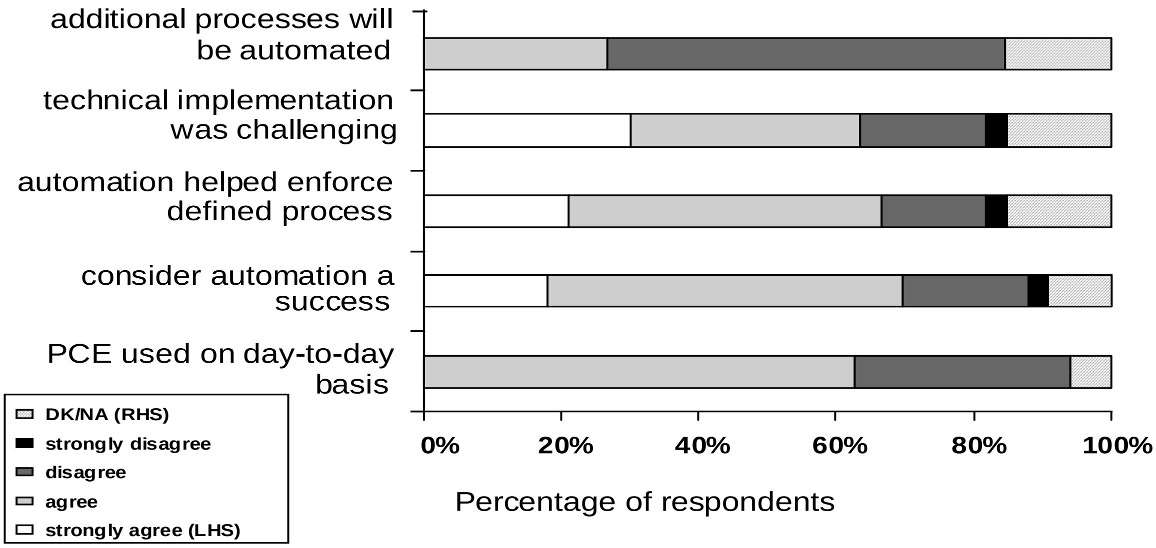

Figure 3-27 Insights Gained

In summary, most projects (65 percent) experienced delays, while no project was ahead of schedule. While quality and productivity improved, on average, job satisfaction did not. Many benefits were indicated strongly, such as providing timely status information, process guidance, administrative support, and, to a lesser extent, cost reduction. Finally, and somewhat surprisingly given the perceived benefits and the fact that automation was used routinely, only about 25 percent indicated that further automation would be implemented.

3.8 Conclusions from the Survey

As indicated earlier, the results from the questionnaire survey should be viewed with some caution because of the limited return rate and limited end-user input. While additional confirmation of the conclusions would certainly be desirable, the results reported here provide initial insights into the types of organizations involved with process automation, their process maturity, the tools and techniques they are using, transition experiences with the technology, and finally, insights gained through the use of the technology.

The following summarizes some of the observations from the completed questionnaires:

- Analysts were the largest category of respondents followed by first-line managers.
- There was little representation from the end-user community.

- Process and product improvement were primary goals in automating processes.
- Most organizations appeared to be of low process maturity.
- Process definition (for the automation project) was more challenging than they anticipated.
- Projects transitioned their environment into use within three to twelve months.
- End-user involvement was apparently quite high, while feelings of end-user ownership were not reflected by this level of involvement.
- Most projects experienced delays – some significant.
- Quality and productivity improved while, on average, job satisfaction did not.
- There was considerable uncertainty about the cost effectiveness of process automation.
- Only about a quarter of respondents indicated that further automation would be implemented.

From the results of the survey, the following factors appear to be important in promoting success:[1]

- Organizations exhibiting characteristics such as risk taking and being dynamic and informal appear to have had greater success than those exhibiting “laggard” characteristics, such as being conservative, closed minded, and political.
- Effective management practices were seen to correlate with success. Practices identified included the ability to meet costs and schedules and support for training.
- The survey data indicated a weak correlation between project size and success. This is consistent with the interviewed projects, where many of the larger projects were overly ambitious and not used on a production basis.
- The involvement of end users in automation projects appeared to correlate with success. We saw no project failures where end-user involvement was significant, although we also saw some successes where end-user involvement was not emphasized.
- Providing strong management sponsorship was seen as an important element in encouraging success. Indicators of sponsorship included first-line and senior management support. Transition funding was provided, and a development plan was agreed to by management.

1. Note that there may be other factors – we are only identifying those that are derived from correlations in the questionnaire data.

Finally, it is interesting to compare the interviewee and the questionnaire-respondent populations, which provided very different perspectives:

- government/commercial funding. A total of 73 percent of the interviews were conducted at sites that were either managed by the government or were contractors to government organizations. On the other hand, only 32 percent of the questionnaire respondents were government sponsored.
- all-at-once/incremental construction. Many of the interviewed sites were attempting to build PCEs using more traditional approaches to software development. There was insufficient recognition that, in a new field such as this, preliminary experimentation was needed to uncover problems early and in a manageable way.
- ambitious/small scale. This is similar to the all-at-once/incremental construction issue. Many of the government-funded efforts aimed at supporting major software development efforts, and hence they tended to be large and complex. Many of the questionnaire respondents had less ambitious goals and were developing smaller, more focussed systems where the human factors issues were less challenging.
- commercial PA tools/use what is available. The government-funded efforts often attempted to integrate existing tools that were large in their own right and were not integrated easily. Some of these organizations did develop their own process automation tools, but they were in the minority. The questionnaire respondents tended to be attached to organizations that used whatever tools were available and familiar to them, and not necessarily those developed for process automation. The funding levels for these projects were on average much less that those used to support the interviewee organizations.
- development oriented/“delivery” oriented. The level of expertise in the interviewed organizations was high, and there was a strong focus on the technology challenges. The questionnaire respondent organizations were less visionary and were focussed more on implementing operational systems within tighter time constraints.
- unsuccessful/successful. The interviewee organizations tended to have much more visionary goals than the questionnaire-respondent organizations; the former set much higher challenges for themselves and in many cases fell short of these goals. This does not diminish the excellent work that they performed. We hope that lessons learned from these projects will significantly reduce the likelihood that similar future projects will fail. We saw greater success levels with the questionnaire-respondent organizations. Perhaps this is to be expected given the more modest goals of many of these projects.

4 The Process Automation Workshop

4.1 Context for the Workshop

A workshop was held in 1996 during the Software Engineering Institute's (SEI) annual Symposium to confirm, refine, and augment the study's findings. An additional goal was to develop initial, rough "game plans" for improving process automation capabilities and identifying the extent of their use.

The workshop was organized into three major segments:

- Presentations: An overall context was established by a presentation of the study's findings to date, followed by presentations by people who have worked actively on transitioning process automation capabilities into common practice.
- Issue Scoping: A focus for the development of action plans (see next bullet) was established by identifying issues in five major areas: performer concerns, organizational dynamics, system functionality, process articulation, and system realization.
- Action Plans: The participants worked in small groups to develop organized sets of activities to address the issues listed above.

Position papers written by the presenters are provided in Appendix D. Detailed outputs from the workshop, as reflected in Section 4.2, Issue Scoping and Section 4.3, Action Plans*,* are provided in Appendix E. Finally, Appendix B lists the workshop participants.

The workshop began by explaining the workshop's purpose and agenda and establishing a common definition of process automation. This definition stated that process automation is a technology (strategies, methods, and tools) that provides automated support for process performance in which the computer is more than trivially involved in

- performing some of the process steps
- supporting
  - information flow among process performers
  - control flow among process steps
  - assuring adherence to role obligations and permissions
  - assessing progress towards goals and milestones

This introduction was followed by a overview of the results of the study's interviews and survey. The presentation materials are not included here since they duplicate the material presented in previous sections of this report.

Next, a number of presentations were given by people who had provided position papers earlier and indicated an interest in talking about their experiences about transitioning process automation technology to common practice.

4.2 Issue Scoping

The study's results to date and the comments of the presenters were used to identify issues that need to be addressed to make process automation technology more acceptable and remove the barriers inhibiting adoption of this technology.

The issues were identified by a group discussion focussed on five areas:

- Performer Concerns: Issues related to the feelings of the personnel performing the process regarding the need for, and personal impact of process automation.
- Organizational Dynamics: Issues related to the changes in organizational structure that follow from, or are required for, process automation.
- System Functionality: Issues related to providing attractive, effective functionality in process automation systems.
- Process Articulation: Issues related to defining and evaluating the automated process.
- System Realization: Issues related to implementing and realizing process automation systems that support well-articulated processes and have attractive, effective functionality.

Discussion of these topics led to the issues listed in the briefing charts that are provided in Appendix E.

4.3 Action Plans

Workshop participants formed four groups to develop initial, rough "game plans" for addressing issues in the areas of performer concerns, organizational dynamics, system functionality, and process articulation.[1]

Each group was asked to follow the approach depicted in Figure 4-1 and Figure 4-2. As shown in Figure 4-1, each group was asked to identify realistic approaches to adopting process automation over the next five years. With respect to making the approaches realistic, the groups were asked to consider issues such as feasibility (as reflected by current state-of-the-art, state-of-the-practice, and state-of-the-marketplace), resource requirements, and cost effectiveness. In focusing on adoption, the groups were asked to consider all the stakeholder audiences (technology producers, transfer agents, and adopters) and consider not only the factors that would inhibit and facilitate adoption, but also the basic factors which motivate adoption. The focus on a five-year period was intended to make the groups consider longer range issues and implied that the activities would be rather coarse-grained. For this reason, the groups were asked to give rough estimates for each activity's duration and specify the dependencies among the activities.

1. Only a few workshop participants were interested in the system realization area; these people joined the group addressing the issues in the system functionality area.

The specific approach to action plan development is depicted in Figure 4-2. The groups were asked to first identify a set of desirable states which would characterize the situation five years from now. They were then asked to prioritize the desirable states and pick the three target states that they collectively thought were the most important. In prioritizing, they were asked to factor in consideration of feasibility, resource requirements, and cost effectiveness. Finally, the groups were asked to develop a set of activities for each target state that would allow the states to be achieved. In defining the activities, they were asked to consider the needs of all audiences and specify what might motivate, facilitate, and inhibit accomplishing the activity.

All groups identified and prioritized desirable states. The group working on system functionality issues identified so many desirable states that they grouped them into six themes for the purpose of prioritizing them. All of the groups also identified activities for the target states, although only a few of the groups were able to identify durations and dependencies for the activities. The desirable future states, target states, and action plans developed by the groups appear in the briefing charts in Appendix E

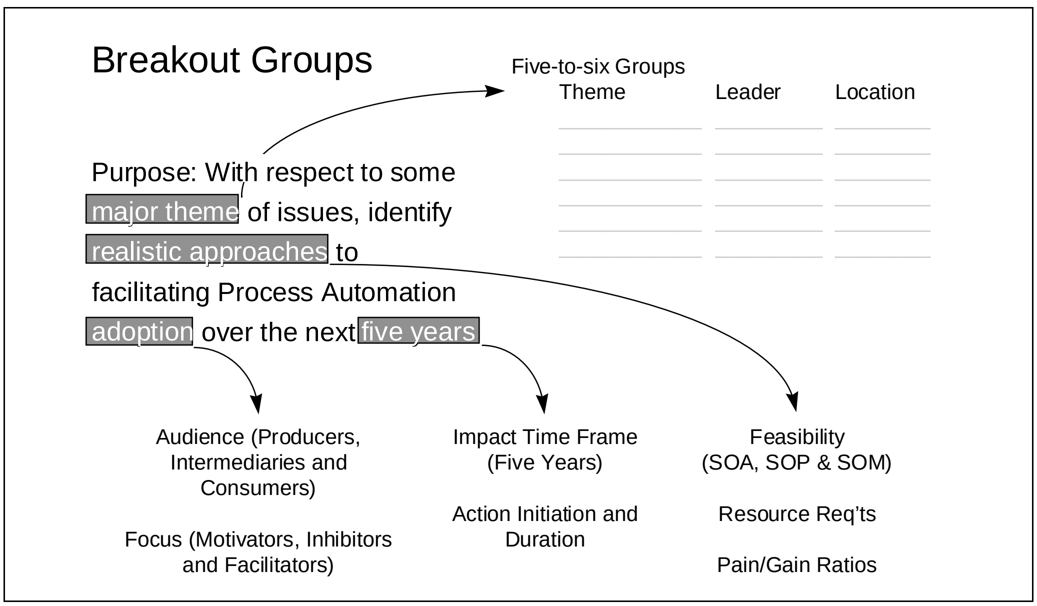

Figure 4-1 Approach to Developing Action Plans - 1

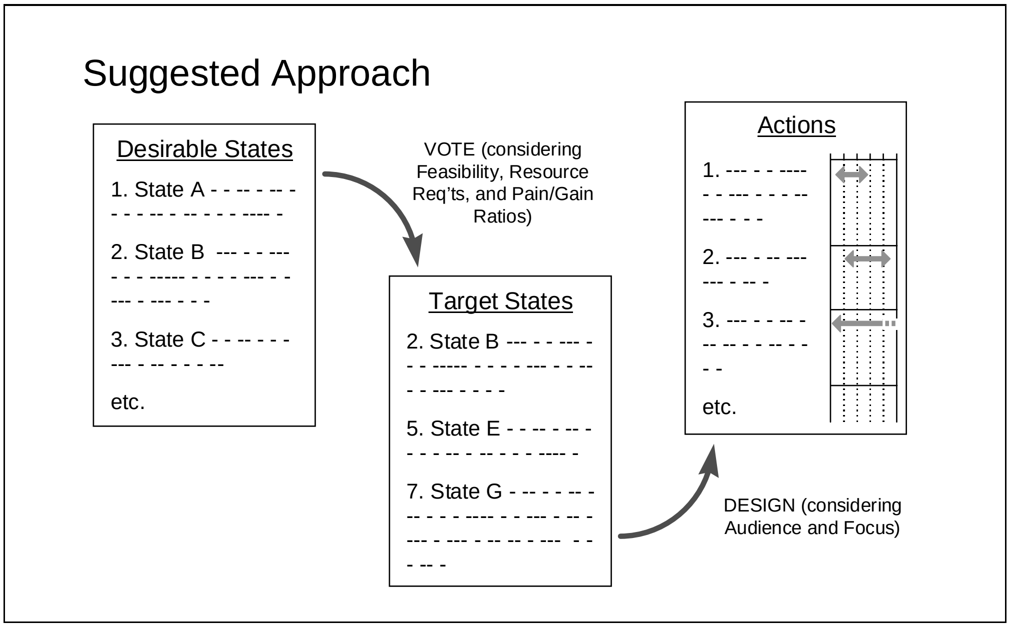

Figure 4-2 Approach to Developing Action Plans - 2

Appendix A The Interview Script

The interview script appears below in its original form.

Question Script for the Software Process Automation Interviews

March 23, 1995

The following identifies a set of topics to facilitate discussions during the in-depth interviews. Each topic is supported by a hypothesis (a statement to be supported or refuted by the gathered evidence) conjecturing a relationship between the topic and its effect on the organization's ability to implement the technology. Suggested questions to probe these relationships are listed for each topic. The topic areas are arranged into three parts.

The in-depth interviews will likely be conducted by different people. It is therefore necessary to have some consistent approach for these interviews, so that comparative analysis of the data can be performed. Given this approach, it seems desirable that the topic areas are used by all teams to structure the interviews. However, note that the questions are only for guidance; it is important that, to some extent, the probing is open-ended.

These site interviews should be augmented by demonstrations of the technology itself. Such demos will be very useful

- to get a feel for the behavior of the automated process
- as a check on what we are told about the system

It would probably be best to get a demo before the interviews begin.

Some of the question groups are relevant to some roles but not to others. The following breakdown of roles is identified:

- Senior managers 1 (SM1) (i.e., those who have financial control over the development of the automated processes
- Senior managers 2 (SM2) (i.e., those who have financial control over the use of the automated processes
- Project managers 1 (PM1) (i.e., those who manage implementation of the automated processes
- Project managers 2 (PM2) (i.e., those who manage the personnel who use the automated processes
- Process developers (PD) (the software engineers who implement the automated processes)
- Adoption support (AS) (those who are responsible for transitioning the automated processes to the end users)
- End-users (EU) (those who are supported by the automated processes)

Each question grouping identifies which of the roles are appropriate to that grouping.

While all organizations should be able to answer the questions in Part 1, some organizations will not have sufficient experience operating automated processes to answer all the Part 2 or Part 3 questions. This is to be expected.

The Question Script

1. Introduction

1. Thank interviewee
2. Introduce team members
3. Purpose of interview
4. Confidentiality/attribution statement
5. Can we tape?
6. What the roles are
7. Review interview topics
8. Length of session, time constraints
9. Ask if there are any questions before we begin

2. Business/Product characteristics (All)

Hypothesis: Business/product environment defines the types of processes and hence the effectiveness of automated processes.

General question: Describe the nature of your business

1. Who are your customers?
2. How large is your business unit and how is it organized?
3. How would you describe your organization's culture?

3. Process maturity (All)

Hypothesis: One must be a process-mature organization to effectively use process automation.

General question: Describe any process improvement efforts in your organization

1. Have you had a process assessment or capability evaluation? - Please describe
2. Do you have a process improvement plan in place?
3. Do things usually run smoothly when developing your products?
4. How do you plan and manage projects?
5. Do you use a CM system to manage your products?
6. Describe project management or product metrics that you track (if any)

4. Application focus (All)

Hypothesis: Some types of processes are more appropriate for automation than others

General question: Describe the process that you are automating

1. Why did you choose this particular process to automate?
2. What benefit do you expect to get from automating the process?
3. Were the processes that were automated typically ad hoc, prior to automation?
4. Describe any metric data you are collecting automatically.

5. Use of tools and technical development (PD)

Hypothesis: A familiarity with technology, prior to the automation project, is a prerequisite to successful automation.

General question: Describe the technical development of the automated environment

General question: Describe what tools and technology you use

1. What tools did you use to construct the automated environment?
2. How did you select the tools (to support both process and applications)?
3. How were integration issues (tool/data/control/process) handled within the environment?
4. How effective were the mechanisms for constructing the automated processes?
5. Does the environment often crash?
6. In which applications, if any, does your organization use CASE tools?
7. Have you used any CASE tools – independent of the automation activities?
8. Has your organization performed any CASE-tool integrations?
9. Are there other technologies that you have used on a trial basis?

6. Team characteristics and experiences (PM1,PD,AS)

Hypothesis: A range of both technical and non-technical competencies is required to implement process automation technology.

General question: Describe the process automation team and their backgrounds

General question: Also tell us about the end-users and their backgrounds

1. Were the end-users involved in defining the automated processes?
2. Tell us about end-user experiences with using the automated process.
3. Was the automated process perceived as being too constraining on the end-users?
4. Did the end-users get training in the automated process?
5. Did the automation team get training in the automation technology?

7. Transition, adoption, and management (PD,AS,PM1,PM1)

Hypothesis: A well thought-out transition/adoption strategy is critical to end-user acceptance.

General question: How are you introducing process automation

1. Who sponsored the automation and how serious was the sponsorship (e.g., funding)?
2. Is anyone perceived as the main driver (champion) of the process automation project?
3. Describe your implementation plan
4. Did the adoption use an all-in-one approach, or an incremental approach?
5. Do you have someone responsible for maintenance of the automation process?

8. Impacts and insights (All)

Hypothesis: Successful use of process automation should correlate with the capabilities identified in the nine areas defined above.

General question: What impact has process automation had in your organization?

General question: Describe your future plans for process automation

1. If you could start from scratch again, what would you do differently?
2. What were the most technically challenging issues in developing the automated process?
3. What were the most socially challenging issues in developing the automated process?

4. Describe tangible benefits of implementing process automation in your organization.
5. With which applications do you think process automation can be most effective?

9. Wrap-up (All)

1. Are there any other things we haven't asked you that you think we should know about?
2. Do you have any questions about the study?
3. OK if we call you for clarification or additional information?
4. Review any action items (e.g., requests for information)
5. Reassure confidentiality/non-attribution
6. Thanks

Appendix B The Survey

The Survey appears on the following pages in its original form.

– An Invitation to Participate in a Study – Identifying Adoption Inhibitors to Process Automation

What is this study about?

Process automation is the use of computer software to support the enactment of a process (such as a document review). While this is a technology with much promise, practical experience with its use is, to date, quite scarce. The aim of this empirical study is thus to document the experience that does exist and to identify what works and what does not. Results of the study will be disseminated in order to help other organizations who are planning to develop, implementing, or using the technology.

What have we done to date?

We have nearly completed the first phase of the study. This has involved conducting a set of in-depth interviews with people who have experience with applying process automation in real world settings. The results of the interviews were reported in the 1995 SEI Symposium session "Software Process Automation: Lessons Learned from the Trenches." From these interviews, we feel we have a better understanding of the issues and the general state of the technology. However, the interviews involved a limited sample of the population. This leads us to the second phase of the study – a questionnaire survey involving a broader population sample – and we invite you to participate. Because we are interested in understanding the evolution of participants' efforts, we are also considering distribution of a second survey about a year after the first.

Who are we looking for?

• End-users of process automation.
• Technical implementers or adoption specialists with experience in process automation.
• Process automation tool vendors. We would like to involve both vendors and their clients in the study.
• Process automation researchers. We would like to involve both researchers and their clients in the study.

Why participate?

• Organizations participating in the study will receive early copies of the reports.
• Vendors and researchers will be provided with a confidential comparison of how their clients are performing in relation to the general process automation population.
• A workshop will be held at the end of the study. Participants will be invited to hear the results of the study, present their experiences, and to interact with others involved in process automation.

Alan Christie
Software Engineering Institute

Instructions for the Survey Questionnaire

We encourage more than one person from an organization to complete the questionnaire. In this way we hope to obtain views of process automation as seen by roles as developers, managers, end-users etc. To this end, feel free to duplicate the questionnaire, or request additional copies from Teresa Belton (see *Support* below).

Confidentiality

Please answer the questions on the following sheets as honestly as you can. Your answers will be strictly non-attributable to you on a personal level, or to your company. Only aggregate figures will be published.

Completing the questionnaire

There are no right or wrong answers to these questions – we are attempting to identify the factors which correlate with the effective use of process-centered environments, not to “score” an organization’s capability.

Important points to note:

• While there are many questions to answer, they are all multiple choice, and we estimate that it will take you about 30 minutes to complete the questionnaire. When you have filled it out, please return it in the pre-addressed envelope provided, or to the product vendor or research organization who distributed it to you.

• If you can’t answer all the questions below, don’t be concerned. We expect this will be the case with many respondents, in part because not everyone will have been involved in all aspects of the automation project, and in part because some automation projects will not have completed all phases. If you feel that you don’t know the answer to a question, or it is not applicable in your situation, check the DK/NA box.

• Sections B and E of the questionnaire focus on development issues – these questions you may wish to ignore if your experience does not include development.

• The questionnaire is written in a manner that assumes you are involved in only one automated process. If you have been involved with more that one, your responses should reflect the automated process with which you have been most recently involved.

• You can expand on any of your answers on the last sheet of the questionnaire.

• Some of the terms in the questionnaire have specific meanings. In order to minimize ambiguities, we have included a section called Terms Used in the Questionnaire.

• Please check the boxes in the questionnaire as unambiguously as possible, as they will be electronically scanned.

Note to Product Vendors and Researchers.

If your organization has developed a process tool that is being used by your clients to build process-centered environments, then we would like to involve these clients in the study. As mentioned on the first page of this survey, if you participate in the study, we will provide you with a confidential comparison of your client base relative to all study participants. You may either administer the questionnaire to your clients yourself (to maintain client confidentiality), or if you supply us with the names with clients who have volunteered, we will administer the questionnaire for you.

Support

If you have any questions regarding the survey or the questionnaire, please send e-mail to Alan Christie at amc@sei.cmu.edu, or Teresa Belton at tbelton@aol.com.

Terms Used in the Questionnaire

There are several terms used in the questionnaire that have specific meaning in the context of the questionnaire. These terms are defined below:

Automation tool *is the software product or language through which the process-centered environment is built and executed.* Thus tools such as ProcessWeaver, SynerVision or InConcert are process automation tools. It may also be possible to build PCEs using, for example, UNIX scripts that are enhanced with process-oriented functions (e.g., to support communications, controls and end-user interface capabilities). Such augmented scripting languages may also be considered process automation tools.

Champion *is a person who is an enthusiastic promoter of a technology and is sufficiently senior to influence management decisions with regard to that technology.*

Development team *is the group of people responsible for implementing and transitioning the process centered environment to the end users of the environment.* Such a group will certainly involve individual with a technical background. It may also involve people who specialize in organizational change or specialize in the social aspects of technology adoption.

End-user *is a person who produces a product by interacting with the automated process.* Thus, for example, if the automated process supports document review, then a person who performs document review is a process end-user.

First-line manager *is a manager who is responsible for a project or business group.* In general a first-line manager will not have other managers reporting to him or her.

Formal (or ***formally***) are sometimes used as qualifiers. Either words implies there is a recognized, documented, and agreed to standard to which the associated concept conforms.

Process is a sequence of interdependent activities whose execution leads to a goal. Often (but not always) a process is initiated by an decision to take action (perhaps by a manager), and is completed when a product is generated.

Process automation *is computer-based support for the flow of work between individual tasks.* Processes (large or small) are said to be automated if manual control of task initiation or sequencing is transferred to the computer. It may be driven by a simple computer-based script or it may be based on a process-centered environment. Such assistance may involve only one person and one computer, or it may involve multiple persons supported by multiple computers terminals. However, for the purposes of this study, an essential component is human communication. Hence the automation shall allow communication between at least two people.

Process-centered environment (PCE) *is an computer-based environment in which multiple people interact under the management of a computer-based process, and in which there are well defined mechanisms for human and machine communications and control.* It is likely to be built using a *process execution tool* that has a process programming language with which to express process execution constructs. A PCE may, for example, enact a bug tracking process, a peer review process, a testing process, or a configuration management process.

Organization *is a set of projects or business groups that share that same basic corporate and technical* *cultures.* They may or may not work in the same product line, but probably share the same values, use similar technologies and have open lines of communication. A project or business group is supervised by a first-line manager.

Senior manager *is a manager who is responsible for a number of projects or business groups and has financial responsibility for and control over these projects or groups*.

A. Business/Product Characteristics

This section deals with the basic characteristics of the business you are in, the products you produce, and your organization's culture.

1. What industries do you support?

☐ *finance* ☐ *health* ☐ *scientific* ☐ *software* ☐ *electronics*

☐ *communications* ☐ *aerospace* ☐ *transportation* ☐ *other (specify):*

2.In which type of organization do you work?

☐ *commercial* ☐ *government* ☐ *academic* ☐ *other (specify):*

3. What is the focus of your products?

☐ *one-of-a kind (conceptually new, may require R&D),* ☐ *customized (tailoring existing product)*

☐ *mass-produced (COTS, assembly line)* ☐ *maintenance (corrective, perfective)*

☐ *other (specify):*

4. How often do you undergo organizational change which affects the work you do?

☐ *every few months* ☐ *yearly* ☐ *every few years* ☐ *never in my experience* ☐ *DK/NA*

5. How would you characterize your organization's culture (in your experience)?

			neutral		
5.1	risk takers	☐	☐	☐	conservative
5.2	formal	☐	☐	☐	informal
5.3	many layers	☐	☐	☐	flat organization
5.4	controlling	☐	☐	☐	hands-off
5.5	static environment	☐	☐	☐	dynamic environment
5.6	complacent	☐	☐	☐	energetic
5.7	closed minded	☐	☐	☐	open minded
5.8	political	☐	☐	☐	non-political
5.9	jobs are routine	☐	☐	☐	jobs are exciting
5.10	stable staff	☐	☐	☐	high turnover

B. Implementation team characteristics

This section deals with the people who were involved in developing the process-centered environment and transitioning the environment into use.

1. How many people are involved in developing the automated process?

☐ *1-5* ☐ *5-10* ☐ *10-20* ☐ *over 20* ☐ *DK/NA*

2. How many years of software development experience does the process automation team leader have?

☐ *0-2* ☐ *2-5* ☐ *5-10* ☐ *10-15* ☐ *over 15* ☐ *DK/NA*

2. How many years of software development experience do you have?

☐ *0-2* ☐ *2-5* ☐ *5-10* ☐ *10-15* ☐ *over 15* ☐ *DK/NA*

3. People with experience in the following categories are part of the development team:

3.1 process definition,	☐ *Yes*	☐ *No*	☐ *DK/NA*
3.2 process-centered environment development,	☐ *Yes*	☐ *No*	☐ *DK/NA*
3.3 tool integration,	☐ *Yes*	☐ *No*	☐ *DK/NA*
3.4 computer networking,	☐ *Yes*	☐ *No*	☐ *DK/NA*
3.6 transition and adoption,	☐ *Yes*	☐ *No*	☐ *DK/NA*
3.7 training.	☐ *Yes*	☐ *No*	☐ *DK/NA*
4. There are representatives from each end-user project on the development team.	☐ *Yes*	☐ *No*	☐ *DK/NA*
5. Some of the expertise is being provided by external consultants.	☐ *Yes*	☐ *No*	☐ *DK/NA*
6. Some of the expertise is being provided by subcontractors.	☐ *Yes*	☐ *No*	☐ *DK/NA*

C. Application focus

This section covers the process that was automated. If you have been involved in more than one automation project answer the questions with respect to that project with which you have greatest familiarity.

1. What general areas does the automated processes address?

☐ *requirements management* ☐ *project planning* ☐ *project tracking & oversight*
☐ *quality assurance* ☐ *configuration management* ☐ *document management*
☐ *document review* ☐ *software development* ☐ *subcontractor management*
☐ *defect/anomaly tracking* ☐ *other (specify):*

2. What elements motivated the management to consider the use of a process automation?

☐ *time-to-market* ☐ *management oversight* ☐ *productivity improvement*
☐ *process improvement* ☐ *quality* ☐ *metrics* ☐ *DK/NA*
☐ *other (specify):*

3.Adequate funding for technical development was supplied.	☐ *Yes*	☐ *No*	☐ *DK/NA*
4. Is the automated process currently being used on a day-to-day basis.	☐ *Yes*	☐ *No*	☐ *DK/NA*

5. How many process-users are (or will be) involved in the automated process?

☐ *1-5* ☐ *5-10* ☐ *10-20* ☐ *over 20* ☐ *DK/NA*

6. Approximately how many times per month is (or will) the automated process be executed?

☐ *less than 1* ☐ *1-9* ☐ *10-100* ☐ *over 100* ☐ *DK/NA*

7. Approximately how many elapsed days does (or will) the automated process take from initiation to completion?

☐ *less than 1* ☐ *1-9* ☐ *10-100* ☐ *over 100* ☐ *DK/NA*

	0	1	2	3	more than 3	DK/NA
8. How many processes are currently being automated?	☐	☐	☐	☐	☐	☐
9. How many automated processes are in operation?	☐	☐	☐	☐	☐	☐

10. To the best of my knowledge, our current automation activities include:

10.1: assessing the technology – no product purchases made, ☐ *Yes* ☐ *No* ☐ *DK/NA*

10.2: organization is evaluating a specific commercial process automation tool, ☐ *Yes* ☐ *No* ☐ *DK/NA*

10.3: defining first process to be automated., ☐ *Yes* ☐ *No* ☐ *DK/NA*

10.4: developing first implementation, ☐ *Yes* ☐ *No* ☐ *DK/NA*

10.5: one implementation running – field trials being performed, ☐ *Yes* ☐ *No* ☐ *DK/NA*

10.6: one implementation successfully deployed. ☐ *Yes* ☐ *No* ☐ *DK/NA*

If the response to question 10.6 is “yes” then:

10.6.1: is automation of any additional process(es) planned, ☐ *Yes* ☐ *No* ☐ *DK/NA*

10.6.2: is development of any additional automated process(es) underway, ☐ *Yes* ☐ *No* ☐ *DK/NA*

10.6.3: are additional automated processes being implemented with end-users, ☐ *Yes* ☐ *No* ☐ *DK/NA*

10.6.4: are additional automated processes successfully deployed? ☐ *Yes* ☐ *No* ☐ *DK/NA*

D. Process characteristics

This section covers issues associated with manually defined process in your organization.

1. A documented process improvement plan is in place. ☐ *Yes* ☐ *No* ☐ *DK/NA*

2. Projects routinely:

2.1 collect metrics on project management data, ☐ *Yes* ☐ *No* ☐ *DK/NA*

2.2 use metrics to support process improvement, ☐ *Yes* ☐ *No* ☐ *DK/NA*

2.3 use documented processes to perform their tasks, ☐Yes ☐No ☐DK/NA

2.4 meet external schedules, ☐Yes ☐No ☐DK/NA

2.5 meet cost estimates, ☐Yes ☐No ☐DK/NA

2.6 provide appropriate training on tools and methods. ☐Yes ☐No ☐DK/NA

3. Do you have any documented processes in manual operation? ☐Yes ☐No ☐DK/NA

3.1 – if 'Yes', in what areas are these processes documented?

☐ *requirements management*	☐ *project planning*	☐ *proj. track & oversight*
☐ *document review*	☐ *software development*	☐ *subcontractor management*
☐ *quality assurance*	☐ *configuration management*	☐ *document management*
☐ *defect/anomaly tracking*	☐ *DK/NA*	☐ *other (specify):*

4. Was a recognized process definition notation used to define the process? ☐Yes ☐No ☐DK/NA

5. If "Yes" please indicate which notation was used:

☐ *IDEF0 /SADT*	☐ *Role Interaction Nets*	☐ *Role Activity Diagrams*
☐ *Rummler-Brache*	☐ *StateMate*	☐ *Process Breakdown Structure*
☐ *ProNet*	☐ *Petri-Net*	☐ *Flow chart*
☐ *ETVX*	☐ *DK/NA*	☐ *other (specify):*

5. The process design is clearly and completely documented. ☐Yes ☐No ☐DK/NA

6. Functional requirements were used to define tools embedded in the process. ☐Yes ☐No ☐DK/NA

7. Metrics requirements are specified for the process. ☐Yes ☐No ☐DK/NA

8. The target process was either (check one):

- a new process (no prior manual operation), ☐
- operated manually prior to the automation initiative, ☐
- don't know / not applicable. ☐

If you checked 'operated manually' then:

8.1 was the manual process documented? ☐Yes ☐No ☐DK/NA

8.2 was the manual process operated in a stable manner? ☐Yes ☐No ☐DK/NA

9. Process definition (for automation) was more challenging than first thought. ☐Yes ☐No ☐DK/NA

E. The development technology.

This section deals with the capabilities of the tool that was used to build the process-centered environments. The section should be completed only by those who have knowledge of the implementation technology

1. With which automation tool(s) are you implementing process automation?

☐ *Continuus/CaseWare*	☐ *LBMS/Process Engineer*	☐ *CRI/ Life*Flow*
☐ *ADM/MATE*	☐ *Cap Gemini/ProcessWeaver*	☐ *ISI/ ProSLCSE*
☐ *ICL/ProcessWise*	☐ *Hewlett-Packard/SynerVision*	☐ *Xerox/InConcert*
☐ *DK/NA*	☐ *other (specify)*	

For questions 2 through 6, please check the category that you feel is most appropriate:

2. The major strengths of the process automation tool I used are:	*strongly agree*	*agree*	*disagree*	*strongly disagree*	*DK/NA*
2.1 the process development environment,	☐	☐	☐	☐	☐
2.2 debugging capabilities,	☐	☐	☐	☐	☐
2.3 ability to integrate application tools,	☐	☐	☐	☐	☐
2.4 ability to design effective end-user interfaces,	☐	☐	☐	☐	☐
2.5 ability to collect metrics,	☐	☐	☐	☐	☐
2.6 performance (speed of response to end-users),	☐	☐	☐	☐	☐
2.7 cross-platform compatibilities,	☐	☐	☐	☐	☐
2.8 customer support,	☐	☐	☐	☐	☐
2.9 availability of training in the tool,	☐	☐	☐	☐	☐
2.10 documentation,	☐	☐	☐	☐	☐
2.11 ease of use of the development environment,	☐	☐	☐	☐	☐
2.12 cost-effectiveness.	☐	☐	☐	☐	☐
3. Defects in the automation tool affected the development effort.	☐	☐	☐	☐	☐
4. System crashes affected the development effort.	☐	☐	☐	☐	☐
5. It is difficult to recover from system crashes.	☐	☐	☐	☐	☐
6. The automation tool supports a good range of hardware platforms.	☐	☐	☐	☐	☐

F. Transition and adoption

This section deals with how the automated process was transitioned into use.

1. How long (in months) has it taken to transition the process to the production environment?

☐ *0-2* ☐ *2-6* ☐ *6-12* ☐ *over 12 (indicate how long)* ☐ *transition not completed* ☐ *DK/NA*

____

2. How long (in months) has the automated process been operating in a production environment (excluding transitioning time)?

☐ *not yet in production* ☐ *0-2* ☐ *2-6* ☐ *6-12* ☐ *12-24* ☐ *over 24 (indicate how long)* ☐ *DK/NA*

____

	strongly agree	*agree*	*disagree*	*strongly disagree*	*DK/NA*
3. Training was provided to support:					
3.1 implementers of the process-centered environment,	☐	☐	☐	☐	☐
3.2 end-users of the automated process.	☐	☐	☐	☐	☐
Statements 4 through 6 deal with end-users' involvement in the development process.					
4. The process design was developed in conjunction with end-users.	☐	☐	☐	☐	☐
5. The process design was reviewed with the end-users.	☐	☐	☐	☐	☐
6. The end-user screens have been evaluated by the end-users.	☐	☐	☐	☐	☐
7. Process simulations have been performed with the end-users.	☐	☐	☐	☐	☐
Statements 8 through 13 deal with your impressions of end-users' operational experience.					
8. The automated process improves the effectiveness of end-users in performing their task(s).	☐	☐	☐	☐	☐
9 The end-users had difficulty in accepting the new process.	☐	☐	☐	☐	☐
10.The end-users feel ownership towards the automated process.	☐	☐	☐	☐	☐
11 End-users make suggestions to improve the automated process.	☐	☐	☐	☐	☐
12. Metrics have been used to improve the automated process.	☐	☐	☐	☐	☐
13. There was resistance to process automation for the following reasons:					
13.1 automation was viewed as externally imposed,	☐	☐	☐	☐	☐
13.2 fear of job loss,	☐	☐	☐	☐	☐
13.3 fear of change,	☐	☐	☐	☐	☐
13.4 the perception that process automation is too controlling,	☐	☐	☐	☐	☐

	strongly agree	agree	disagree	strongly disagree	DK/NA
13.5 end-users feel that they were not consulted sufficiently in process definition,	☐	☐	☐	☐	☐
13.6 fear that metrics would be used in job evaluations.	☐	☐	☐	☐	☐

Statements 14 through 20 deal with management sponsorship.

14. Senior management is supportive of the process automation project.	☐	☐	☐	☐	☐
15. First-line management is supportive of the automation project.	☐	☐	☐	☐	☐
16. An automation business plan was written	☐	☐	☐	☐	☐
17. A development plan was agreed to by management.	☐	☐	☐	☐	☐
18. The design was reviewed with management.	☐	☐	☐	☐	☐
19. The project has received adequate funding for transitioning.	☐	☐	☐	☐	☐
20. The automation project has a champion with designated authority.	☐	☐	☐	☐	☐

21. The automation initiative came from:

☐ *technical staff* ☐ *management* ☐ *a bit of both* ☐ *DK/NA*

Statements 21 through 23 deal with implementation strategy.

22. A documented transition strategy was developed.	☐	☐	☐	☐	☐
23.A prototyping strategy is being used for implementation.	☐	☐	☐	☐	☐

24. The process model is being implemented:

☐ *all at once* ☐ *in multiple incremental phases* ☐ *other (specify):* ☐ *DK/NA*

G. Impacts and Insights

Those automation projects that have progressed far enough will likely have practical insights of considerable value. We wish to capture some of these insights in this section. Respondents who have additional insights, not covered in this section, are encouraged to describe them textually.

	strongly agree	agree	disagree	strongly disagree	DK/NA
1. To date, I consider the process automation project to be a success.	☐	☐	☐	☐	☐

2. Based on my experience, process automation has helped:

2.1 improve end-user productivity.	☐	☐	☐	☐	☐
2.2 improve product quality.	☐	☐	☐	☐	☐

	strongly agree	agree	disagree	strongly disagree	DK/NA
2.3 manage projects more effectively,	☐	☐	☐	☐	☐
2.4 improve communication between end-users,	☐	☐	☐	☐	☐
2.5 improve end-user job satisfaction,	☐	☐	☐	☐	☐
2.6 improve end-user team-building.	☐	☐	☐	☐	☐
3. In the context of my application(s) I feel process automation:					
3.1 helps reduce tedium,	☐	☐	☐	☐	☐
3.2 helps prevent errors,	☐	☐	☐	☐	☐
3.3 supports administrative efforts,	☐	☐	☐	☐	☐
3.4 provides useful process guidance,	☐	☐	☐	☐	☐
3.5 provides timely status information,	☐	☐	☐	☐	☐
3.6 provides useful metric data,	☐	☐	☐	☐	☐
3.7 reduces costs.	☐	☐	☐	☐	☐
4. Automation has helped to enforce defined process.	☐	☐	☐	☐	☐
5. The technical implementation was more challenging than first thought.	☐	☐	☐	☐	☐

6. How well has the actual schedule for automation met the planned schedule?

☐ *significant delays* ☐ *some delays* ☐ *on time* ☐ *ahead of schedule* ☐ *DK/NA*

7. Based on our experience to date, we will automate additional processes. ☐*Yes* ☐*No* ☐*DK/NA*

What is your job title?

☐ *programmer* ☐ *analyst* ☐ *first-line manager* ☐ *external consultant*

☐ *senior manager* ☐ *process end-user* ☐ *other (specify):*

IMPORTANT: The information below is optional. If you would like to remain anonymous, leave the spaces blank

*Name:*____

*Organization:*____

*Address:*____

____

*Business phone:*______________________________ *e-mail address:*______________________________

Please provide additional notes below, to amplify on your responses to the questions. Place the question number (e.g., F.3.1) before each response.

Thank you very much for taking the time to complete the questionnaire.

Appendix C Procedure Used to Compute Measures of Effectiveness

Several of the plots in Section 3 used variables such as “degree of management sponsorship” (Figure 3-22). The values of these variables are computed from primary variables that reflect actual responses. For example, the variable “degree of management sponsorship” is computed using the responses from questions F.14 through F.20 (see Appendix B). For this set of questions, the responses could range from *strongly agree* to *strongly disagree.* These categories are given 1 to 4 points. Thus if a respondent answered *strongly agree* to all the questions, a score of 7*1=7 would result; while if a respondent answered *strongly disagree* to all the questions, a score of 7*4=28 would result. In this case, 7 and 28 represent the minimum and maximum scores. This score provides a composite reading on the degree of end-user involvement for that respondent. The following table defined the basis for scoring associated with each of the appropriate figures.

Table C-1: Measures of Effectiveness

Figure No.	Description	Questions for “degree of...”
Figure 3-9	degree of management effectiveness	D.1, D.2 through 2.6
Figure 3-19	degree of end-user involvement	F.4 through F.7
Figure 3-22	degree of management sponsorship	F.14 through F.20

Appendix D Position Papers for Workshop

The position papers appear below in their original form.

D.1 Defining Processes for Automation

Paul Arnold and Dick Phillips, Software Engineering Institute

Automation of a process is the last step in an effort to collect all relevant information to provide for process enactment. There are a number of issues that must be dealt with during the stages of information gathering to ensure the success of the effort. Automation requires the most complete set of data for the effort to be successful of all the ranges of process work. Key issues for a successful effort include

- defining the audience for, and the ultimate user of, the process
- collecting a complete set of data to build a process model
- layout and organization of data to support completeness and easy change for process improvement
- providing key additional data that supports process enactment
- standard formalisms that support the individuals in the performance of work and don't inhibit individuals
- flexible and dynamic properties in tools used to automate/support the process

These issues together with early end-user involvement to get buy-in are critical to the successful automation of any process. The process end user should be provided with a concise description of the process in the form of a process guide to help the adoption effort as well as training in the use of the tools and the process. Adoption and phase in of the use of the new automated system is dependent upon the complexity of the process being automated. The more complex and critical a process is to an organization, the more important a phased introduction that has been preceded by extensive, end-user familiarization becomes.

D.2 Endeavors: A Process Technology Infrastructure Supporting Incremental Adoption

Gregory Alan Bolcer and Richard N. Taylor, University of California, Irvine

Effective support of day-to-day software development activities is a central goal of many process automation projects. Success or failure of such efforts is at least dependent on how well adoption issues are addressed. Three of the most common complaints about support technologies across projects are 1) lack of personnel training in the support technologies, 2) inability to reuse tools, processes, and objects across projects, and 3) insufficient or underpowered (software) infrastructure to support the actual processes used. Endeavors is an open, distributed, extensible process execution environment designed to address these and other issues. It provides support for incremental adoption, ease of use by multiple stakeholders including both technically and non-technically trained project personnel, and broad customization and reuse.

I. Issues that affect process adoption:

A. Training

1. no incremental adoption policies, technology is pursued as all or nothing solution.
2. difficult to use
3. difficult to learn or train people in:
   - object technologies
   - client/server or distributed technologies
   - programming or process specific languages
4. adoption requires changing work culture:
   - technology is seen as getting in the way
   - people find ways to get around a poorly implemented process
   - use tools they need to accomplish process
   - if can't change or optimize, follow parallel process
5. shortage of talent and skills
6. no support for multiple stakeholders, tools assume only a single user model, limited support for non-technical users

B. Reuse

1. tools are difficult to customize or integrate into a process
2. objects are over-specified and only relevant to particular process or project
   - difficult to develop objects that are generic enough to be reused across an organization
   - special case object behaviors is the norm
3. few departments or projects are willing to pay overhead costs that benefit others down the line or are unable to incorporate global costs into project
4. context customization is difficult

C. Infrastructure

1. diverse machines, protocols, languages, software tools; no cross-platform coordination or standard use
2. performance issues
3. deployment costs, high cost of installing minimum and consistent process tools and technology on every relevant desktop
4. no integration of tools and data through coordinated hyperlinks or processes, i.e., how does this fit?
5. processes may not be tightly connected, mobile or disconnected users difficult to support, a lot of work happens offline

6. messaging limited to email
7. no open APIs, systems in use are closed and difficult to customize
8. lack of development and prototyping tools \

II. The Endeavors System

A. Distribution

Endeavors has customizable distribution and decentralization policies which provide support for transparently distributed people, artifacts, process objects, and execution behavior (handlers). In addition, Endeavors processes, as well as the means to visualize, edit, and execute them are easily downloaded using current and evolving world wide web (WWW) protocols. The system is completely implemented in Java.

B. Integration

Endeavors allows bi-directional communication between its internal objects and external tools, objects, and services through its open interfaces across all levels of the architecture. Implementation of object behaviors in multiple languages is supported, allowing them to be described in whatever programming language is most suitable for integration.

C. Incremental Adoption

Given its Java basis, Endeavors requires low cost and effort to install across all software platforms. All process objects are file (ascii) based allowing greater portability across different machine architectures. Components of the system, including user interfaces, interpreter, and editing tools, may be downloaded as needed, and no explicit system installation is required to view and execute a workflow-style process.

D. Customization and Reuse

Endeavors is implemented as a layered virtual machines architecture, and allows object-oriented extension of the architecture, interfaces, and data formats at each layer. Because processes, objects, tool integrations, and policies can be used across platforms, processes may be adapted or evolved through embedding and composition of process fragments using cutting, copying, and pasting of activity representations.

E. Dynamic Change

Endeavors allows dynamic changing of object fields and methods, the ability to dynamically change the object behaviors at runtime, and late-binding of resources needed to execute a workflow process. Process interpreters are dynamically created as needed.

D.3 Discovery and Validation – Aiding the Deployment of Process Automation

Jonathan E. Cook and Alexander L. Wolf, University of Colorado

Process automation has yet to make a significant impact in real-world application for several reasons. First, making a single step from no process support to a fully automated process is too large; second, process automation systems are as yet not flexible enough in allowing exceptions to the model driving the process; and third, there is not enough evidence of benefit for organizations to implement such a heavy-weight solution.

The first step to support is that of creating the process model. We have developed methods for “process discovery” that automatically generate (partial) models of an executing process from data collected from that process. This helps lower the barrier of initially developing a formal process model.

The second step to support is that of ensuring that the process follows the model or, equally, that the model indeed reflects reality. It is this guidance that process automation has focussed on, by forcing the process to follow the model. With this, steps in the process that do not need human input are automatically done, but the problem of exceptions to the model remain.

We have developed a complementary framework for process guidance that measures how closely the process, as seen through collected data, corresponds to what the model prescribes. We call this “process validation.” Our framework assumes that the model cannot represent 100% of the real process and, therefore, that the process must deviate to some extent from the model. However, it is also assumed that the model does capture important aspects of a good process, and it is desirable for a process to agree largely with what the model prescribes.

Process validation offers an alternative control model than automation, while not precluding allowing portions of the process to be automated.

We undertook an industrial case study in which the benefits of process validation techniques were shown. In our study, we applied the techniques to a set of process executions from a repetitive change-request process, and showed that closer correspondence of the processes to the prescribed model correlated significantly with the quality of the product produced by the process.

In summary, process discovery offers assistance in the first step of creating a process model, and process validation offers an alternative control model than process automation to using a model to guide a process. These techniques have provided evidence of the benefit of formal models in a case study, and can thus pave the way for further deployment of all formal model technologies, including process automation.

D.4 Introducing Process Technology – An Analogy with the CASE-Tool Industry, the Numbers Game, and Why Things Can Get Better Quickly

Anthony Earl, Software Engineering Institute

In this note I wish to argue that, although it is currently very easy to point to failures in effectively applying process technology and to reasons that there are difficult problems to overcome, there are many reasons to believe that the near-future holds some promise for seeing substantial improvements. Before discussing some of those reasons, I would like to begin by comparing some aspects of the CASE-tool industry with the process technology industry to contrast their histories and states of progress. This will provide some basis for my later claims that hope lies around the corner.

A. Lessons from CASE-Tool History

I believe that the current state of the CASE-tool industry reflects two major aspects of its history. The first being the progressive sets of ideas in design approaches from structured design and analysis to the latest use- and pattern-based object-oriented design techniques. Each of these generations has changed some of the requirements upon the facilities to be supported by CASE tools. Each step has also found its followers and dissenters, thus dispersing the champions and expertise for each approach. The economic aspect of CASE-tool history compounds the tool manufacturers' problems brought about by the evolution of ideas. CASE-tool companies have been tiny compared to the giants of the software industry. Their resources have always been under pressure, and no runner has gained a substantial financial or technical lead over the pack. Of course, some have fallen by the wayside, only to be replaced by optimistic new-comers. Justifiably fluctuating consumer confidence has pressured the industry in combination with rapidly changing hardware and software platforms.

Some vendors have fought those pressures by creating meta-tool technology. But this is more complex to build and support in many ways. Resources to create the meta-facilities are consumed at the expense of providing the specific support for a user's favorite design method. And user-customization, if not beyond consumer capabilities, is more likely than not to consume far too much of their available design-time to be worthwhile.

In many ways, the history of the CASE-tool industry can be seen repeating itself in the early stages of the Process Technology (PT) industry. The most-primitive graphical process-design approach, flowcharts, are still the most widely used and supported. The next wave of process design books arrived last year and support for them is beginning to appear in the process tools marketplace. But are there enough champions to take these better approaches into real-life process improvement projects and cause them to succeed? The process community lacks anyone with the design-guru status often found in the CASE community. Will the process technology industry repeat the mistakes and suffer the misfortune of the CASE community?

B. The Numbers

I think they will make many of the same mistakes and face many of the same problems. They are similar in many respects. However there are some key differences. I think it is those differences that will enable the process technology industry to create a more successful marketplace. And offer consumers a demonstrably useful set of facilities.

There are some obvious differences between the CASE and process communities, although they are also similar in some ways. Process problems were around since before the age of software. Before software was being designed, world economics had seen the impact of focusing on process improvement inspired by the quality movement. But it seems a relatively recent development to take a computing infrastructure and use it to model, support, and guide processes in an effort to make gains over methods of process improvement “by hand.”

This is not the place to fully compare and contrast the history of processes and CASE. There are many interesting relationships and interactions that can be identified. But I think there is a single difference that will easily overshadow all others. Indeed, there is evidence that it already has. It is the numbers involved. In the following paragraphs I invite the reader to use her or his own most reasonable numbers. Precision is not important. The critical factor is the scale of magnitude of the differences.

Think of all the software being created in the world. Now estimate what percentage of that is being designed in any real way. Now reduce that percentage to the amount being designed in any relatively formal way. At this point, I suggest that many such designs are being done with pencil and paper diagrams. Some may be presented better than others with the aid of some word-processors and basic diagramming tools. How many do you think are being supported by CASE tools? I suggest very, very few. The reasoning is that few organizations can justify the purchase of software from small producers that requires well-trained individuals in the techniques and the tools. This is especially true when such software has to meet requirements such as supporting their chosen method, running on their chosen development platforms, using version-controlled work-products, and producing configurable output that meets the constraints of their customer commitments. The effective marketplace for CASE tools is thus very small. It may be a viable industry, but it is unlikely to make the headlines.

Now perform a similar reduction of the process technology marketplace. The one major difference is that you start with not just all the software producers in the world, you start with all the organizations in the world. You still make similar reductions based on analogous constraints, but I suggest that the resulting marketplace size for process technology is orders of magnitude greater than for CASE technology.

C. Substantial Progress is Evident

So far, I've argued that there are reasons to believe that we should see somewhat better process technology because the numbers suggest it is a far more attractive place in which to make progress than the CASE industry. But is there any concrete evidence to suggest that this is anything more than wishful thinking? There follow some reasons that make me believe that evidence is present.

They say that doctors make the worst patients. Give a software engineer a piece of software with which to improve their performance, and they may spend more time criticizing and abusing that software than attempting to use it for its intended purpose. This is despite the fact that they are the best equipped, both in infrastructure and training, to take advantages of the technology. The CASE industry suffers from this syndrome. Process technology can be used effectively by a wide range of communities. Benefits are being reported when process technology is used for its intended purposes. Once some users see the benefits, others are liable to follow without too much questioning of the underlying implementations.

Until recently, the platform of computing infrastructure required to support process technology has been beyond the reach of many industries. Now those platforms are cheaper and more powerful than ever before. People now expect fast response times and connection to networks even if they are not working in the corporations of the computer industry. This means that substantial designs of real processes, along with their simulation and enactment become easily possible on machines costing less than two thousand dollars. And prices are still heading downwards.

The tools with which to accomplish the tasks referred to above have passed the very early adopter stage. Until recently, investing in process technology required being at the bleeding edge. Now the first true generation of process technology is available in a growing marketplace. Some tools are gaining good reputations in their partition of the market. Indeed, the common partitioning of the market is a clue that progress is being made.

Although the process-based quality movement has been around for many decades, often being overshadowed by the “latest management fads,” the basic message of the importance of process in quality and productivity has rarely been seen to reach the critical mass of awareness as it seems to have reached today. It is easy to find articles in the mass media that discuss the importance of process in the industries of today and tomorrow. The importance of this awareness is that the producers do not have to spend all of their sales resources educating the customer-base. They can use it more effectively to explain the particular features and benefits of their own technology offerings.

Another recent technological development has occurred that will enable process enactment to be more efficiently and naturally implemented. Through mechanisms such as CORBA and COM, tool vendors are able to make their tools more integrable. Process enactment technology is able to take advantage of these standards without investing much effort in finding subtle techniques (a.k.a. “hacks”) to enable pre-existing tools to work naturally within the semi-automated environment.

Again from the technological angle, there are clearly improvements to process technology available in today's marketplace that were previously unseen except in research projects. For example, several tools offer multiple, editable views of the same design that are kept synchronized. The graphical support for non-experts is now very good (although it can vary widely from tool to tool), some performing real-time checking as changes are made by the users. Animated and/or annotated simulations can be run in real-time on cheap, desktop machines or laptops.

There is still a long way to go. Process technology that covers more than one aspect of the process life-cycle is typically quite weak in some areas. While tools that are good in one area are still designed as though they are the center of the world, making it difficult to integrate them into an overall solution.

D. Conclusion

This has been a short note with the intent to provoke some thoughts from a particular viewpoint and to raise some questions for discussion. I think there are useful lessons to be learned from both technological and economic perspectives by comparing CASE technology with process technology. The CASE community has clearly not found all the answers to their challenges. I think that the greater resources available to the process community will result in more progress.

I think that research and theory in the area of process is a long way ahead of the practice. In fact, it may be too far ahead in some respects. We are only now seeing the first real wave of process technology in the general marketplace. We have yet to understand the drawbacks and limitations of early implementations. We have yet to understand how people can make profitable use of the technology. And we have yet to see what improvements need to be made to the technology to make it more effective. It is true that we can add many more features and techniques from the research communities, but which of these will provide the most usable, acceptable, and profitable benefits to our customers?

D.5 Focal Points for Successful Process Automation

Ed Guy and Carol Klingler, Lockheed Martin Tactical Defense Systems

While it may be fair to say that the process automation community has not achieved the goals we set for itself, it is also true that the attempt has advanced the state of practice in software engineering. We have not introduced breakthrough technologies that have dramatically changed the way software is developed, but we have identified some existing technologies that can be applied to significant advantage. We have not fostered wide-spread development of software engineering environments that embody an organization’s development processes, but we have developed techniques for building such environments from available components. We have not convinced tool vendors to build tightly integrated, interoperable tool sets, but we have learned how to make effective use of the capabilities they provide. We have not caused end users to think about their jobs in terms of the process being performed, but we have learned a lot about how our end users think about their jobs. We have not succeeded in fully automating development processes, but we have learned how to provide automated process support to the people who develop software. We have not failed, we just haven't learned to recognize our successes.

A. Focus on automating the exchange of process control and work products among process performers, instead of on controlling the activities of one performer.

The technology exists to achieve any level of process automation desired. Commercial products are immature, but given a sufficiently detailed process description, an open tool set, expertise in several programming languages, lots of time and money, we have been able to develop programs that automate every aspect of a particular development activity. Unfortunately, that's not what the users need. Commercial tools provide capabilities that can guide, control, measure, restrict, or otherwise automate performance of individual process steps, when what users really want is help in managing their interactions with other users, their interactions with tools, and interactions between tools. They know how to do their part of the job; they want help handling the interface between their job and someone else's.

B. Focus on using metaphors that reflect the users' mental models.

The technology exists to build adequate process-centered environments. No such environment may ever be purchased as an off-the-shelf product because no outside vendor can know enough about how his potential customers do business to support them all. Various commercial products can be used to build process-centered environments that reflect task-driven, product-oriented, tool-oriented, and role-based process models. Unfortunately, the process presentations used in most of the available tools reflect the way process engineers think about processes, not the way users think about software development. We try to make users think about their jobs in terms of processes, when we should be thinking about processes in terms of their jobs.

C. Focus on effective integration of tools with the user's processes, instead of integration of the tools, themselves.

The technology exists to achieve effective levels of tool/data integration, but it has been assumed that such integration must be done at an infrastructural level to be effective. While integration within the environment infrastructure could solve a great many problems, the degree of cooperation required of tool developers, or effort required of environment builders is prohibitive. Effective integration of disparate tools and data can be achieved to a degree that will support the most urgent process support needs of an organization.

D. Focus limited resources on critical processes whose automation can benefit multiple organizations.

Cost-effective process automation depends greatly on identification of processes or fragments whose automation will significantly benefit the development organization. The resources required to fully automate a process make identification of a suitable target critical to the effort. Initially, process automation resources should be concentrated on critical process needs with broad organizational impact. More detailed support can be added incrementally for successively smaller process fragments and more specialized needs.

E. Focus on minimizing tedium and maximizing opportunities for creative work.

Our end-users know enough about what we do to avoid becoming the victims of our mistakes. They are justifiably reticent about embracing process automation, because we have not done a good job of understanding their needs. What the user wants us to do is eliminate the tedious, non-productive, repetitive tasks so he can concentrate on the creative, challenging parts of the job.

F. Focus on solving real user problems by providing automated process support, rather than automating an abstract process.

We often speak of process automation as if processes had some inherent need to be automated. Automation has no intrinsic value. It is only valuable if it solves a problem or otherwise removes an obstacle to effective development.

Process automation is not an end in itself, it is a means to an end. Our goal is to improve the effectiveness of our development processes by providing automated support to the developers. Process engineering principles and process automation techniques, while invaluable to us, should not be imposed on unsuspecting users. Our challenge is to use process automation to support users in performing their tasks more effectively without getting in their way.

D.6 Some Process Automation Approaches Before Their Time...

Hal Hart, TRW

As with the advent of other recent software technologies (e.g., CASE, AI/smart systems, Ada, IPSEs, perhaps even OO), process automation research and insertion efforts have thus far fallen short of the early hopes and promises. The following two “less-than-successful” phenomena of early process-automation activities are identified, and then compared and contrasted with analogous endeavors from earlier software innovations. From this we can attempt to extrapolate lessons-learned from those other software technology domains to process automation activities.

(1) Full INTEGRATED life cycle process support automation all at once, & (2) INDEPENDENT monolithic process-supportive environment frameworks (or, at least, in-control “process managers”).

The first is a natural extension of a goal identified in the 1970's (which consumed a large proportion of software engineering research resources in the 80's) for project support environments. These provided automation on a common platform for software project activities across all life cycle phases (at least the “technical” ones). Emphasis was on tailorable modeling of each specific project's data/information needs, seamless transitions and conversions of technical artifacts between life cycle phases, and user access to the environment in styles natural to project personnel and their domains of discourse (not low-level cryptic commands). Over-ambition, failure to match up well to the most vexing problems encountered by practitioners, and insufficient enabling technology products are possible contributors to the fact that this goals is far from achieved in most software production organizations today.

The predecessor of (2) above was thought to be one of those enabling technologies – the tool/operating system independent environment “framework”. It was hoped that this framework would facilitate project modeling and into which tools from multiple vendors could be inserted easily, hence expeditiously achieving portability and interoperability. The framework was thought to be key to platform-independence, commonality, and tailorability at the user-interface level, and for information integration between tools and activities. Only if those capabilities were implemented at the framework level (instead of in individual tools) could the needed uniformity be guaranteed and efficiencies implemented. Alas, environment framework specifiers and builders mis-read the tool vendor community's willingness to buy into this strategy, and instead we see vendors each with expanding breadths of life cycle coverage (i.e., each trying to provide the entire environment, but with a much more constrained notion of project support than the practitioners' needs); and, early framework implementations exhibited the opposite of hoped-for efficiencies. Hence, real software development projects still realize minimum prospects of productivity-enhancing integration between tools from different vendors, and no one even considers procuring an environment framework any more.

The talk will identify selected specific projects representing both the cited process-automation “false starts” and the analogous predecessors upon which the observations and lessons-learned are based. As an alternative, a list of separate, pragmatic, real-user process-related activities that are poorly automated (and not addressed much by this community) will be posed.

D.7 What is Impeding Process Automation?

James King, The Boeing Company

A. COST: Long-Term Support

Major companies that utilize software but are not necessarily considered as software companies have concluded that it is not economical to develop and support unique system and software development tools such as operating systems, compilers, process engines, and process automation tools. The trend is toward selecting “Open System” tools that provide essential functionality that is maintained by a supplier. Attempts to develop and support “in-house” functionality have consistently failed. In some sense this is because the “in-house” solution represents a single point of view while the industry is providing a vast array of solutions. As a result, the “in-house” support is only provided for a short period of time and ultimately abandoned because it could not provide sufficient capability with the modest support provided and rapidly developing global technology. Organizations do not want to support complex software tools that are not directly related to the products that the organization produces and markets.

B. ADOPTION: End User Reaction

The end user must perceive value in the use of automated processes. The ultimate user of process automation tends to view the situation as being “yet-another-tool-to-learn.” The user finds it hard to see any benefit from process automation since it is viewed as restricting the user's freedom to be creative. This reaction also applies to organizations in a large company. A large company has many different organizations that provide solutions for specific problems organized around large projects. These projects are managed from the top of the organization and have little interaction among themselves. Each organization provides its own unique approach for each project. These organizations react in much the same way as individuals to restrictions on their freedom of choice. A complicating problem is that the organizations may have been in existence for a long period of time and as a result have institutionalized procedures and approaches for solving their own unique problems, therefore becoming very resistant to change. This resistance is often rooted in the cost necessary to convert to an entirely new and unproven technology.

The word “automation” implies considerably more than “guidance” to the end user. In general, the end user sees process automation as a threat, not as an assistant or aid. Software processes are difficult to define when many possible exceptions are considered. The end user views an automated process as a “Theory X” approach to restricting their job and their ability to react to exceptions. Developers of automated processes interact organization to organization, largely with management of other projects but seldom with the real end user. This interaction exacerbates the end user's impression of having management doing another thing to the end user resulting in “no control” and “mandated from above” feelings. End users view process definitions and information as heuristics, not something that must be absolutely followed.

C. IMPLEMENTATION: Process Technology

Process automation technology often is provided by tools that have idiosyncrasies that are hard to learn and not intuitive. “If things are fun (like the Web), they will be adopted.” However simplicity is important. Most people can build HTML home pages and information, few develop Java. The major key to acceptability may be whether adaptability of process definitions and automation is relatively easy to use and, to some extent, under the control of the end user.

D.8 Identifying Success Strategies for Software Process Automation

S.J. Leadabrand, Lockheed Martin Vaught Systems

Summary: The present and future demands for software with ever increasing complexity and scope necessitates sophisticated means for its development and maintenance. Technology advances in language and design methodologies are rapidly approaching their limits in return on investment. The next, and potentially last, high-return frontier is process automation. Current approaches to this automation are based on stove-pipe solutions, and not on a well-defined set of requirements accompanied by rigorous design based on a thorough understanding of the total problem. And, to make matters worse, large amounts of capital investment are being poured into these ad-hoc approaches diverting correct solutions to the general problem. But, there is hope since the more general requirements and approaches are beginning to be understood. The question is, “Can we solve the general problem in time to prevent disaster?”

Point 1: Unless automation of process significantly reduces life-cycle costs, improves schedules (time-to-market) or results in product quality increases, there is no good business case for doing it. Current approaches are management intensive. They require extensive training and maintenance of skill levels by the everyday users. The extent of these problems is so great that the currently deficient automation tools are sometimes forced into use, only to be later abandoned when they cannot support the schedule required for delivering the product(s).

Point 2: Tool vendors jeopardize their existence in undertaking to develop software process automation given the currently deficient set of requirements. This is presently a risky business area with many probable failures.

Point 3: Process automation specification and design is similar to that needed for development of a quality software product. Automation of an application within a domain necessitates both a depth of understanding of the domain and of software implementation engineering. In order to automate the process of development and maintenance of software, it is essential that we both understand the nature of process itself and be capable of engineering its implementation. As a community, we presently can do neither to the extent that we must.

Point 4: Because of the similarity between software development and implementing its automation, the lessons learned through software development should be extended into process automation. The following examples illustrate how software-development lessons learned may be extended into the process automation domain.

A. Avoid Large Units

Software-Development Lesson: Large units should generally be avoided.

Process-Automation Extension: Large process steps should generally be avoided.

Solution: Define a “Quantum Process Step (QPS)” for the process, that is, the smallest piece of a process step that we wish to consider. Add the requirement that a QPS must be made stable in the Statistical Process Control sense. Usually, a QPS will produce a single output product and frequently will require only a single tool and only one person for its production. In the typical development of a software unit of reasonably high quality, about 30 QPSs will be required. For a medium-sized product of 50K SLOC, assuming 100 SLOC per unit, there will be 500 units requiring the execution of (50,000/100)*30 or 15,000 QPSs. This illustrates the true complexity of software product development and why no one can do it very efficiently or reliably without having automation (in combination with effective organization and defined processes).

A complete set of QPSs for implementation of a specific process can then be used to model the process. This should provide a picture of the resultant expectations in each of the cost, schedule and quality domains. With process automation correctly specified and implemented, the system can automatically collect the cost, duration and quality data for each QPS. From these, statistical process characteristics can be derived.

B. Minimize Coupling

Software-Development Lesson: Internal coupling and other dependencies between units should be minimized.

Process-Automation Extension: Internal coupling and other dependencies between QPS should be minimized.

Solution: Design QPSs for parallel implementation. Use parallel processing concepts for process automation. In general, do not couple one QPS to another by embedding the necessity for completion of a previous QPS to the start-up criteria of another. Instead, enable dynamic process flow-control via externally defining start-up criteria in terms of the necessary states of its inputs. This will enable the QPSs within a total specific process to be easily changed.

C. Decouple the Tools

Software-Development Lesson: Software development tools should not be coupled across the development process, but should work with products and artifacts produced, or to be produced by different tools from different vendors.

Process-Automation Extension: Process automation implementation tools should not be coupled across the process, but should work with a variety of process steps dynamically adapted as specific-process requirements may change throughout the project.

Solution: The process engine, work-product management, tool management, personnel management functions should be decoupled. This process should not be embedded within the configuration management tool, personnel assignments should not be embedded into the tool management function, etc. The total system should appear seamlessly integrated to its users, but should internally consist of totally decoupled parts. We need process-automation tool integration standards before we progress any further toward ad hoc solutions. We need to define the requirements for the process engine, and other parts of the integrated system in order to make it possible for vendors to specialize in a piece of the system and thereby survive. For now, each piece is sufficiently risky for any one vendor. Biting off the whole at the start almost ensures failure at this point. Further, development tools applied directly to the products (e.g. compilers, design, test, analyzers, etc.) should also be decoupled from the process, but built to work within a process. Again, we need to develop some standards.

D. Understand and Apply the Process Domain

Software-Development Lesson: Successful development of software products requires someone who understands the application domain sufficiently to formally communicate the software-product requirements to the designers. The designers must have the capability to engineer the product. The technologists must be capable and sufficiently trained for its implementation.

Process-Automation Extension: Successful process automation requires someone who understands the process domain sufficiently to formally communicate the process-automation requirements to the designers. The designers must have the capability to engineer the process. The technologists must be capable and sufficiently trained for its implementation.

Solution: The process domain is mathematical in nature. Mathematics modelers who are knowledgeable in statistical methods and familiar with the development of software products are needed to quantify the nature of process. (Such individuals are rare.) Engineers capable of interpreting the models need to translate the conceptual nature of process into implementable constructs for software and other product development applications. Software engineers need to apply the specific engineering results to the development of software process automation implementations. We're not there, yet. Instead of allowing ourselves to be pressed into ad hoc solutions and implementations due to “schedule constraints” (typically resulting in low quality software with inherently high maintenance costs; similarly for process automation), let's do the job right!

D.9 Identifying Success Strategies for Software Process Automation

Steve Sorensen, Lockheed Martin Astronautics

I have been involved with several research projects within the last several years dealing with software processes and process automation. There are several reasons why software process automation has not taken off further than it has within our company.

A. Immaturity of software process tools in being able to communicate with each other.

Our concept of initial software process automation requires process definition and representation, project planning, and work-flow control. We have found no tool that does all of these functions to the extent needed. Therefore, individual tools are employed for each function. To facilitate automation, communication of process elements between these tools is highly desirable. Last year we found that most of the tools do not facilitate this communication. Some tools were beginning to incorporate translators from their tool to another tool performing a different function, however these were not widely used, readily available or cost-effective. Vendors had little motivation to pursue this.

This research was done in late 1994-early 1995, and I am assuming that tool communication maturity has improved within the year. I would be anxious to find out about the state-of-the-art in process tool communication now.

B. Low interest and priority placed on software process automation within upper management.

I used to believe that software process issues could be pushed from the grass-roots level of a company to effect change. I still believe that research can and should be done at this level, but for a corporation built on traditional ways of doing business, a software process automation initiative must be emphasized from upper management. It is difficult for employees to make a change to something new unless they are motivated to do so. This motivation can come from mandates, or from a display of importance by one's supervisors. In either case, management must be on board. Priorities must be set such that research, development and implementation of a software process automation system can proceed without interruptions of funds or tasks. In all those places that I have seen progress in software process automation, management commitment has been strong.

To sell management, one must make a business case emphasizing potential cost savings, productivity increases, and a better view into the software development schedule. This case is best made showing actual results done on a pilot project. I believe pilot projects are critical in moving automated process environments from experimentation to the implementation stage.

D.10 Identifying Success Strategies for Software Process Automation

Jordan Vause, SEI Resident Affiliate

Software process automation will not work in a community that is only now coming around to the idea of software process itself.

Any effort to implement an initiative as important or complicated as software process automation in a large company must be predicated by a significant attempt to educate those who will be expected to use its products. In particular, these “end-users” must be told what the technology means to them, how it will affect their work, how they can improve their productivity, how they can increase their skills, and so on. Furthermore, these users must first understand something of process theory itself, or else they will have no basis for understanding its automation. Any such effort undertaken without this close attention to the end-user community is doomed to failure.

Several years ago our company (which shall remain nameless) was swept away on the wave of CASE technology. Large amounts of time, resources, and money, were invested in the design and implementation of a CASE system which would be used throughout the corporation. Regrettably the effort failed, and in retrospect it is not hard to see why. A small cadre of developers and “innovators” had indeed become excited about CASE, and they produced a very good product, but their progress within the company went almost unnoticed by the vast majority of what was to have been the “end-user” community. This is because nobody took the time to explain why CASE was such a good idea or what it could do for the people who actually wrote the code and made the money. It seems unnecessary to observe that the system built at such a cost is not now in use - it died of apathy.

Now, with the evaluation of a tool called IDEF0, our company has begun the first steps towards implementing software process automation. I fear that it will all be for naught, however, since the engineers on the floor haven’t got a clue about what software process automation means, and in fact have only recently begun to understand the ideas and principles behind the software processes they are now using manually. Such a mistake should not be duplicated at the industry level.

Appendix E Output from the Workshop

This appendix provides the detailed output that was generated by the workshop participants. The participants were divided into four groups that addressed the issues: performer concerns, organizational dynamics, system functionality, and process articulation. A fifth group (system realization) had few volunteers, so people in this category were merged in with the system functionality group. The following is a breakdown of the issues covered and where they can be found.

Group/Item	See	Page
Performer Concerns		
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Performer Concerns
Issues

Allaying Fears of "Something New"

- Reluctance, Resistance, Fears of obsolescence, etc.

Addressing Feelings of Constraint

- Stifling of creativity and innovation, Failure to support individual differences, etc.

Handling Fears that System Will Be Intrusive

- Disruptive attention to detail, Micro-management, Excessive management oversight, etc.

Addressing Rejection of "Outside Help"

- Pride in experience-based abilities, Suspicion of "expert opinion," etc.

Generating Feelings of Ownership

Figure E-1 Issues—Performer Concerns

Theme: Performer Concerns
Desirable States

	Votes
[1] Respect: Process automation supports and fosters mutual respect within the the organization's workforce	1
[2] Benefit: Personnel are motivated to use process automation and generally report a benefit	4
[3] Creativity: Process preserves individuality and does not stifle creativity	1
[4] Intrusion: Personnel feel that process automation is non-intrusive	1
[5] Ownership: Personnel feel they have been involved in defining the nature and extent of process automation	3

continued ...

Figure E-2 Desirable States—Performer Concerns - 1

Theme: Performer Concerns
Desirable States

(continued)

[6]	Management: Management actively and firmly sponsors efforts to improve the organization’s workforce	2
[7]	Appreciation: Efforts to improve the level and scope of process automation are recognized and rewarded	0
[8]	Measurement: Process automation supports and fosters appropriate measurement of personnel capability and productivity	0

Figure E-3 Desirable States—Performer Concerns - 2

Theme: Performer Concerns
Target States

[2] Benefit: 80% of the users in the organization say that process automation helps them do their job

[5] Ownership: 85% of the users feel their contribution affected the success of process automation

[6] Management: The organization is at CMM Level 2

Figure E-4 Target States—Performer Concerns

Theme: Performer Concerns
Actions

[1] Establish a reward system with specific criteria for work in process automation

[2] Demonstrate quantifiable benefits with productivity statistics and other data

[3] Establish a process improvement process with feedback to originators of suggested improvements

[4] Achieve CMM Level 2 throughout the organization

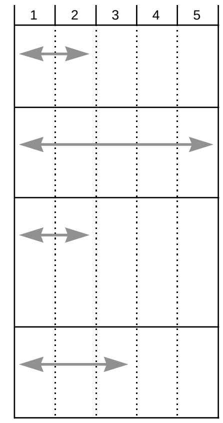


Figure E-5 Action—Performer Concerns

Organizational Dynamics
Issues

Gaining & Maintaining Sponsor Commitment

Managing Cultural Change

Predicting, Demonstrating and Assessing Value

Mitigating Risk

Defining Migration Paths and Piloting

Defining Success Criteria

Figure E-6 Issues—Organizational Dynamics

Theme: Organizational Dynamics
Desirable States

	Votes
[1] Strategic Planning and Success Criteria: The organization has a strategic plan for process automation that includes success criteria	16
[2] Technology Transfer: New technology is systematically acquired or developed and propagated throughout the organization	7
[3] Cultural Change and Trust: The organization is one in which change is accepted through trust in the organization's proven processes	6

continued ...

Figure E-7 Desirable States—Organizational Dynamics - 1

Theme: Organizational Dynamics
Desirable States (continued)

[4] Marketing and Funding: Organizational change and improvement is actively promoted and well supported throughout the organization	5
[5] Sponsorship: All levels of management actively promote and support organizational change and improvement	5

Figure E-8 Desirable States—Organizational Dynamics - 2

Theme: Organizational Dynamics
Target States

[1] Strategic Planning and Success Criteria: The organization has a strategic plan for process automation and reflects: a business case for process automation and its alignment with the organization’s goals, 2) process automation success criteria, 3) the organization’s readiness for process automation, 4) reasons to automate, and 5) what to automate

[2] Technology Transfer: New technology is systematically acquired or developed and propagated throughout the organization

[3] Cultural Change and Trust: The organization is one in which change is accepted through trust in the organization’s proven processes

Figure E-9 Target States—Organizational Dynamics

Theme: Organizational Dynamics
Actions — “Strategic ...” Target State

[1] Develop a template to allow personnel to easily provide process automation-related information

[2] Develop and refine the strategy at offsite planning sessions attended by sponsors and process engineers

[3] Gather feedback on current versions of the strategy from throughout the organization

1	2	3	4	5

continued ...

Figure E-10 Actions—Organizational Dynamics - 1

Theme: Organizational Dynamics
Actions — “Strategic ...” Target State

(continued)

[4] Develop a phased approach to introducing process automation

[5] Articulate the rationale for a process-automation strategic plan that gains management support for the effort

1	2	3	4	5

Figure E-11 Actions—Organizational Dynamics - 2

Theme: Organizational Dynamics
Actions — “Technology ...” Target State

[1] Establish a technology transfer process for selecting appropriate technology and getting it used throughout the organization

[2] Form an organization-wide group, and a supportive infrastructure, to administer the technology transfer process

[3] Establish external relationships to provide channels for exchanging information [Software Process Improvement Network (SPIN), vendors, Web connection, user groups, Software Engineering Institute, etc.]

1	2	3	4	5

Figure E-12 Actions—Organizational Dynamics - 3

Theme: Organizational Dynamics
Actions — “Cultural ...” Target State

	1	2	3	4	5
[1] Arrange for participation by respected people in the organization’s Software Process Improvement (SPI) groups and Software Process Engineering Groups (SEPGs)					
[2] Enroll those who do not have a high degree of trust in process improvement actions					
[3] Identify and enroll middle management personnel who must promote and support improvement efforts					
[4] Collect historical data					

continued ...

Figure E-13 Actions—Organizational Dynamics - 4

Theme: Organizational Dynamics
Actions — “Cultural ...” Target State

(continued)

	1	2	3	4	5
[5] Arrange for a powerful, well-respected sponsor to champion improvement plans					
[6] Initially work with (and through) personnel who have relatively high degrees of trust that process change will be beneficial					
[7] Establish and maintain high levels of consistency and integrity with respect to organizing and institutionalizing process changes					

continued ...

Figure E-14 Actions—Organizational Dynamics - 5

Theme: Organizational Dynamics
Actions — “Cultural ...” Target State

(continued)

	1	2	3	4	5
[8] Build a strong, believable track record of success					
[9] Reduce activities to common practice through appropriate corporate policy					

Figure E-15 Actions—Organizational Dynamics - 6

System Functionality
Issues

Sharing Information and Facilitating Communication

Orienting and Guiding Performance

Enforcing Policies and Regulations

Training and Educating the Work Force

Reusing Processes Across Projects and Organizational Units

Maintaining Organizational Capability

Incrementally and Radically Improving Organizational Capability

Integrating Organization-wide Processes

Collecting and Interpreting Quality/Performance Data

Facilitating Team-based Approaches

continued ...

Figure E-16 Issues—System Functionality - 1

System Functionality
Issues

(continued)

Managing Organization's Infrastructure (People, Resources, etc.)

Providing Differing Views for Various Stakeholders

Providing Decision Support Assistance

Developing Appropriate User Interface

Integrating with Organization's Management Information System

Supporting Relationships Among Processes

Figure E-17 Issues—System Functionality - 2

Theme: System Functionality
Desirable States

	Votes
[1] Analysis*: Process measurement and analysis — in particular through simulation — are routine	7
[2] Marketplace: Process "parts" and fragments are readily available and they can be used in a "plug & play" fashion	7
[3] Marketplace, Adoption: Process-centered environments can be installed incrementally; they can also be used incrementally, i.e., simple features can be used in isolation at first, and more complex features can be learned and employed as needed	7/6

* Titles indicate a grouping of Desirable States used to rank order them. Desirable States falling into more than one group have multiple ranks, one for each group into which they fall.

continued ...

Figure E-18 Desirable States—System Functionality - 1

Theme: System Functionality
Desirable States

(continued)

[4]	Marketplace: A "product line" of adaptable, tailorable processes is commercially available	7
[5]	Marketplace, Integration: Separate process steps are independently supported by decoupled facilities	7/0
[6]	Usability: Process definition tools support describing coordination among groups	4
[7]	Analysis: Estimation capabilities are an integral part of process-centered environments	7
[8]	Analysis: Collection of process and product data capabilities are an integral part of process-centered environments	7

continued ...

Figure E-19 Desirable States—System Functionality - 2

Theme: System Functionality
Desirable States

(continued)

[9]	Marketplace: Process automation facilities support domain engineering in general and architecture-driven processes and product line product development in particular	7
[10]	Analysis: Resource expenditure data collection capabilities are an integral part of process-centered environments	7
[11]	Evolution: Process automation fosters a synergy between processes and products; for example, usage processes can be embedded in products and processes can be defined in terms of the products they produce	3

continued ...

Figure E-20 Desirable States—System Functionality - 3

Theme: System Functionality
Desirable States

(continued)

[12]	Evolution: Process-centered environments elegantly support handling exceptions during process performance	3
[13]	Evolution: Process-centered environments elegantly support dynamic process modification (i.e., modification during process performance)	3
[14.1]	Usability, Integration: When a user chooses to work on a process step, pertinent tools, artifacts, standards, procedures are automatically made available	4/0

continued ...

Figure E-21 Desirable States—System Functionality - 4

Theme: System Functionality
Desirable States

(continued)

[14.2]	Usability, Integration: Configuration management tasks and tools, management tasks, and even the process itself are transparent and unobtrusive	4/0
[15]	Marketplace: Automated support for CMM key practices (e.g., peer reviews) is available in the marketplace	7
[16]	Analysis: Metrics and an econometric model are used to quantify and justify both processes and process-centered environments	7

continued ...

Figure E-22 Desirable States—System Functionality - 5

Theme: System Functionality
Desirable States

(continued)

[17]	Marketplace: There is a widely-used and well-understood reference model for process-centered environments (i.e., the situation is similar to the current situation for operating systems)	7
[18]	Analysis: Processes are reflexive and self-optimizing (i.e., they contain steps that concern process change and improvement)	7
[19]	Marketplace, Integration: Process-centered environments are “open,” allowing, among other things, inquiries about status and invocation of functions by other systems	7/0

continued ...

Figure E-23 Desirable States—System Functionality - 6

Theme: System Functionality
Desirable States

(continued)

[20]	Integration: Collaboration among process-centered environments is possible through the use of well-defined interaction protocols	0
[21.1]	Adoption, Evolution: Processes have architectures that can be used to obtain a “top-down” understanding of their primitive steps	6/3
[21.2]	Adoption, Evolution: A process’ architecture can be inferred from considering the process-centered environment reference architecture and any refinements made to support the process	6/3

continued ...

Figure E-24 Desirable States—System Functionality - 7

Theme: System Functionality
Desirable States

(continued)

[22]	Analysis: Quality quantification, specification and tracking are an integral part of a process (similar to the current situation for cost and schedule)	7
[23]	Analysis: Process-centered environments make process verification information visible and provide automated support for process verification	7

Figure E-25 Desirable States—System Functionality - 8

Theme: System Functionality
Target States — The Top Three

		Votes
[1,7,8,10,16,18,22,23]	Analysis: Process measurement and analysis capabilities	7
[2,3,4,5,9,15,17,19]	Marketplace: Viable, active, commercial marketplace for process descriptions and process-centered environments	7
[3,21]	Adoption: Incremental adoption of process-centered environments	6

Figure E-26 Target States—System Functionality - 1

Theme: System Functionality
Target States — The Other Three

		Votes
[6,14]	Usability: Facilities supporting individuals and groups	4
[11,12,13,21]	Evolution: Support for evolving processes over time	3
[5,14,19,20]	Integration: Support for integrating tools within a process-centered environment and process-centered environments themselves	0

Figure E-27 Target States—System Functionality - 2

Theme: System Functionality
Actions — "Analysis" Target State

[1] Establish well-integrated size-estimation capabilities

[2] Develop econometric model to quantify and justify process automation

[3] Integrate process, product and resource data collection (effort, schedule and defect)

[4] Develop capability to analyze and model using measurements to verify (static), validate (dynamic) and optimize

[5] Automate KPA verification activities for SQA

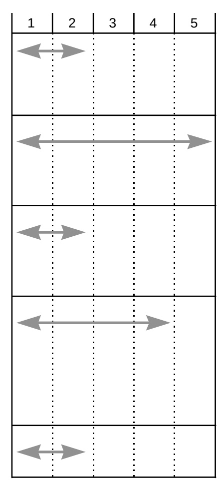


Figure E-28 Actions—System Functionality - 1

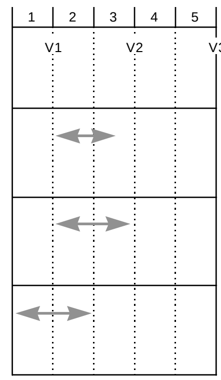
Theme: System Functionality
Actions — “Marketplace” Target State

[1] (State 14) Develop process-centered environment reference model

[2] (State 19) Create “open” process-centered environments

[3] (State 4) Establish an adaptable, tailorable product line of processes

[4] (State 9) Provide support for domain engineering in general



continued ...

Figure E-29 Actions—System Functionality - 2

Theme: System Functionality
Actions — “Marketplace” Target State

(continued)

[5] (State 9) Support for architecture-driven processes

[6] (State 15) Provide automated support for CMM KPAs

[7] (State 5) Develop ability to independently support process steps in a decoupled fashion

[8] (State 3) Develop ability to incrementally install process-centered environments

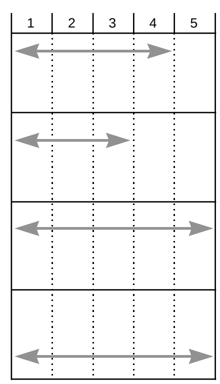


Figure E-30 Actions—System Functionality - 3

Theme: System Functionality
Actions — “Adoption” Target State

[1] Provide product and process measurement support for use during manual process enactment (without automation)

[2] Support deployment, integration, automation and evolution of partial process models

[3] Support automation of generic processes that are detailed and evolved during process enactment

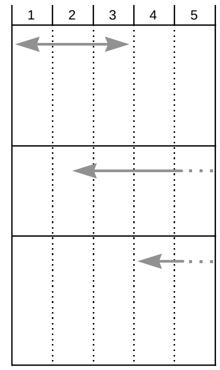


Figure E-31 Actions—System Functionality - 4

Process Articulation
Issues

Obtaining Consensus on Details

Allowing Variation, Tailoring and “Shortcuts”

Clarifying Boundaries Between Major Organizational Processes

Reducing Apparent/Real Complexity

Defining Assumptions and Boundaries of Applicability

Flagging Assumption Violations

Fostering and Facilitating Rework, Work-ahead and Opportunistic Activities

Fostering and Facilitating End-user Involvement in Design and Implementation (e.g., GUI Design)

continued ...

Figure E-32 Issues—Process Articulation - 1

Process Articulation
Issues

(continued)

Balancing Flexibility with Encouragement and Enforcement

Supporting Process Evaluation

Supporting User Involvement in Modeling

Allowing Process Inference

Describing Relationships Across Process Boundaries

Figure E-33 Issues—Process Articulation - 2

Theme: Process Articulation
Desirable States

	Votes
[1] Tailorability: Generic organizational processes easily tailored to specific project settings within six weeks	5
[2] Flexibility: Experts can modify, or even ignore, the official process	0
[3] Enforcement: Personnel will be punished for not following the “official” process	1
[4] Selection: Guidelines exist for selecting processes to define and automate	1
[5] Granularity: Guidelines exist for determining appropriate level of detail in process descriptions	1

continued ...

Figure E-34 Desirable States—Process Articulation - 1

Theme: Process Articulation
Desirable States

(continued)

[6]	Architecture: Capability exists to describe process architectures, in particular, the relationships among processes	0
[7]	Reuse: Reuse of process components and composition of processes from components are supported, common practices [not feasible with the next five years]	1
[8]	Notations: “Next generation” notations are in common use and well-supported with tools; IDEF is not commonly used; notations allow clear, unambiguous process descriptions	5

continued ...

Figure E-35 Desirable States—Process Articulation - 2

Theme: Process Articulation
Desirable States

(continued)

[9]	Complexity: Capabilities exist to manage process description complexity (e.g., role-oriented, editable views; multiple notations are available; notations can be used in tandem; etc.) [the cost of achieving this state is high]	0
[10]	Work Ahead and Rework: Notations (and automation) can easily accommodate work ahead, rework, conditionality, etc.	1
[11]	Integrated Management: Project management activities are an integrated part of an overall process description	4

continued ...

Figure E-36 Desirable States—Process Articulation - 3

Theme: Process Articulation
Desirable States

(continued)

4

[12] Evaluation: Managers commonly make process-related decisions based on business goals and quantitative information obtained, in part, through simulation

Figure E-37 Desirable States—Process Articulation - 4

Theme: Process Articulation
Target States

[1] Tailorability: Generic organizational processes easily tailored to specific project settings within six weeks

[8] Notations: “Next generation” notations are in common use and well-supported with tools; IDEF is not commonly used; notations allow clear, unambiguous process descriptions

[11] Integrated Management: Project management activities are an integrated part of an overall process description

[12] Evaluation: Managers commonly make process-related decisions based on business goals and quantitative information obtained, in part, through simulation

Figure E-38 Target States—Process Articulation

Theme: Process Articulation
Actions — “Tailorability” Target State

Action	1	2	3	4	5
[1] Pilot trial versions of process tailoring capabilities					
[2] Provide ability to find and inspect example process descriptions along with information about the context in which they have been used					
[3] Create a Process Control Board and a cyclic process for its operation					
[4] Develop a reward system for suggestions about improving processes through tailoring					

Figure E-39 Actions—Process Articulation - 1

Theme: Process Articulation
Actions — “Notations” Target State

Action	1	2	3	4	5
[1] Determine requirements for the next generation of process description notations					
[2] Identify factors affecting the understandability of process descriptions					
[3] Sensitize process engineers to the variety of alternative notations					
[4] Develop standards for process descriptions and process description notations					
[5] Develop ability to tailor meta-tools to specific process description notations					

Figure E-40 Actions—Process Articulation - 2

Theme: Process Articulation
Actions — “Integrated Management” Target State

	1	2	3	4	5
[1] Educate project managers about the necessary and appropriate relationships between management tasks and the tasks in a managed process					
[2] Educate process engineers about including project management-oriented tasks in all process descriptions					
[3] Integrate process technology and project management technology					

Figure E-41 Actions—Process Articulation - 3

Theme: Process Articulation
Actions — “Evaluation” Target State

	1	2	3	4	5
[1] Develop guidance for managing process change					
[2] Conduct piloting and case studies to generate value-demonstrating examples					
[3] Reward managers who routinely manage their projects’ process based on data (and punish those who don’t)					
[4] Develop a repository of appropriate data					
[5] Foster use of simulation-based systems for learning how to quantitatively manage software projects					

Figure E-42 Actions—Process Articulation - 4

System Realization
Issues

Integrating Tools and Data

Using COTS Technology

Prototyping

Balancing Control Flow and Information Flow Approaches

Predicting and Improving System Performance

Incorporating Locally-developed and Commercial Legacy Tools

WAN and LAN Networking

Assuring Security

Handling Intellectual-property Constraints

Capturing State and Re-establishing State after Interruption

continued ...

Figure E-43 Issues—System Realization - 1

System Realization
Issues (continued)

Managing Artifacts

Supporting Process Inspection and Navigation

Supporting Collaboration Among Multiple Performers, Including Both Individuals and Teams

Figure E-44 Issues—System Realization - 2

Appendix F Workshop Participants

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13. **ABSTRACT** (maximum 200 words)

This report describes the results of a two-year study of experiences with the adoption and use of software process automation. The work was motivated by a desire to provide insights and guidelines to those planning to implement this technology. The focus of the study was primarily, but not exclusively, on end-user organizations. The study was conducted in three stages: First, in-depth interviews were conducted to assess the state of the practice. Second, a survey questionnaire was distributed to a wider number of organizations to obtain more quantitative data. The populations in these two groups turned out to be quite different—a fact that we believe enriches the content of this report. Finally, a one-day workshop was held, the objective of which was to explore with practitioners why the gap between the theory and practice of software process automation is as large as it is. A previous report by Alan Christie, et al. [Christie 96] documented the results of the in-depth interviews in detail. This report now summarizes the results of the interviews, and describes in more detail the questionnaire survey and the workshop. It also provides both insight for process automation tool developers and guidelines for adoption to process-automation end users.

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interviews, process automation, questionnaire, technology adoption, workshop

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