

Software Process Improvement

5.1 Software Process Improvement (SPI) is a set of activities that will lead to a better software process, and thus higher quality software delivered in a more timely manner Abstract. Many organizations wish to improve the quality of software they develop, the predict- ability of developing it, and the productivity of the people developing it. One approach for doing this is to improve software development processes. Most process models identify purely technical approaches to improve software processes and seldom consider organizational or cultural issues. This paper, on the other hand, identifies ten steps for managing change that address these issues. Four of these steps are critical, that if not done, will almost guarantee failure. This ten-step program emphasizes the alignment of business goals, change process goals, and the work performed by the employees of an organization.

Ten Steps to Successful Software Process Improvement

1. Introduction

In the early 1970s, software engineering teams seldom produced applications on time or within budget. When completed, applications often did not meet system requirements or the expectations of their customers. The situation did not change much, if at all, during the 1980s and 1990s. Today, software systems are still delivered late, cost more than planned, and contain numerous defects. Software Engineering Notes, for instance, publishes tens or hundreds of such accounts in every issue, which demonstrates how widespread this phenomenon is.

To overcome these deficiencies, the software industry has adopted many software process standards, such as the CMM [26] and ISO 900. Each of these standards advises organizations what they should do to develop reliable software.

Unfortunately, these standards address software process improvement simply as a technical problem, although the organizational and cultural aspects have greater effect on the success of a change effort. Simply stated, organizational and cultural banners can significantly hinder or prevent a process improvement program from succeeding. To overcome these barriers, this paper introduces a ten-step program that address organizational and cultural issues that improve the likelihood of instituting successful software process change.

Step 1. Define an organizational vision. To gain commitment from its employees, an organization must define a vision and simply and clearly communicate it to them. A vision statement should reflect the organization's uniqueness and set high standards for productivity and quality that will guide future work [18]. A vision statement must identify what leadership wants an organization to be, do, and

create. A vision statement must identify the financial, human, and product values of an organization; that is, what it cherishes.

An organization must define a core strategy based on achieving operational excellence, product leadership, or customer intimacy [11]. An organization that achieves operational excellence will produce standard products at the best price with the least customer inconvenience. An organization that achieves product leadership does so by continually innovating a type of product. An organization that achieves customer intimacy focuses on giving customers exactly what they want. The selection of a core strategy should shape every plan and decision an organization makes.

Once an organization commits to a core strategy, based on its vision and values, it can create strategic plans, operating plans, and quantitative, realistic, and clearly stated objectives that identify what it wants to do and how to effectively do it. From these plans and objectives, an organization can derive a software process improvement plan and objectives that is consistent with the organizational vision. Usually, software process improvement efforts try to justify their worth based on changes in productivity and quality metrics. However, those metrics may not be easily mapped to the business plans and objectives of the entire organization. Instead, benefits of software process improvement must be explained in terms of the measured business metrics.

If such measures are based on productivity and quality, an organization can estimate a sustainable improvement rate based on two other organizations. During the 1990s, the productivity of the software organization of CSC, which has been assessed as a CMM Level 5 organization, improved by six percent per annum.' Similarly, the IBM organization that developed the Space Shuttle Onboard Software, which is another CMM Level 5 organization, appears to have improved productivity by about eight percent per year over about fifteen years [26]. In addition, both of these organizations reduced software defects between six and nine percent per year for these same periods.

Step 2. Articulate a compelling need for change. Compelling needs usually must support business needs and goals. One way to make a case for a compelling need is to compare an organization against its competitors and other best-of-breed organizations. Another way of establishing a compelling need is to identify business threats and opportunities [10]. An organization should use only the most compelling threats and opportunities to convey an understanding of the reasons for change to its employees. Often, the survival of an organization is the compel-

ling need for change. Compelling needs should be expressed in terms important to the people that commit resources to a change effort [18] and are affected by it [10]. Finally, the greater the gap between the current and desired states, the more important the identification of a compelling need [5]. Without a compelling need, change rarely occurs.

Step 3. Define a change effort and vision. A change effort should address the most promising improvement activities. To identify them, an organization should perform four tasks. First, the organization should identify projects that can most benefit from change. Thus, an organization should focus a change effort on new projects since it is more difficult to change processes of existing projects than for new ones [9]. Alternatively, an organization could focus on projects vital to the organization. Second, it should identify what the customer values most and determine what processes, policies, or strategies it could change or improve to add customer value. Third, it should identify those strategic, internal processes that it can improve. These processes define the basic purpose of an organization or directly and significantly affect everyday performance. Fourth, it should analyze global inefficiencies caused by redundancies performed within activities of the overall business process that usually result from bureaucratic rules and regulations. By removing redundancies and eliminating absurd rules and regulations, the organization will improve morale and gain acceptance of a proposed change.

For each process the organization decides to change, it must develop and document a vision for it. Each process vision must describe the new capabilities of the process and identify realistic performance and quality improvement expectations [24]. Further, it must identify how the organization will support the changed processes, respond to customer needs, and respond to competition. The new vision must include measurable objectives for each new process that illustrate dramatic improvement, and fact-based analysis must drive the new vision. By creating a vision for each process undergoing change, the organization provides its employees with a sense of how they will perform work in the future. This will lower resistance to change by allaying fears that arise when people are uncertain about their futures. When changing multiple processes, an organization must take a gradual approach. Consequently, it should introduce changes in three to four month time frames and change no more than three processes at any given time [5]. When an organization attempts to change more than three processes, personnel often become confused about the goals and objectives of the effort. In addition, personnel have an emotional limit to the amount of change they can handle at any given time. By limiting the amount of concurrent change, an organization will

improve its ability to change [26]. Over time, a gradual approach will permit an organization to achieve massive change [20].

Step 4. Obtain management sponsorship and commitment. The readiness of an organization to change is dependent on several variables, including the strength of the corporate culture and the number of prior change efforts [21].

To obtain a commitment to change within an organization, a proposed change should be consistent with past changes and employees must see that management is committed to the change. That is, they should not feel that managers will abandon a change when another fad comes along. Consequently, if there have been several recent change efforts, acceptance of a new change will be extremely challenging.

Achieving a commitment to change requires one or more key individuals to sponsor it and gain the commitment of organizational managers and leaders [23]. A change sponsor must have the authority to legitimize a change, provide adequate resources to it, and ensure that it becomes an organizational goal. Change sponsors must understand and communicate what the change is, why it must occur, and the effect it will have on the organization. In addition, they must have a personal stake in making the change succeed and openly demonstrate a commitment to it by demonstrating behavior consistent with the change.

No major change is possible without a committed sponsor commanding authority. When an organization-wide change is attempted, the primary sponsors must be the head of the organization and some of the top management, which are direct reports to the organizational leader. As the change effort progresses in a breadth-first fashion, each successive lower-level manager must become a sponsor too. More specifically, the support of management personnel at multiple levels of an organization is critical to the success of a change effort. This is because their positions give them the ability to motivate others to adopt change, through various mechanisms, and lead their staff in accepting change.

Step 5. Adopt a change approach. Organizations adopt a range of approaches to implementing change. What distinguishes each approach is how leaders manage the change. At one extreme is a complete focus on logistical or project management issues, on getting the job done while neglecting human and organizational issues. At the other extreme is a balance of a commitment to addressing human and organizational issues, as well as a focus on project management issues.

The autocratic approach involves three major steps: (1) top leadership determines what needs to change; (2) leadership enforces their expectations with compliance mechanisms; and (3) leadership waits for the achievement of the results. The autocratic approach does not address human and organizational issues. It assumes individual and organizational behavior will change over time although the affected personnel had no input into the change. These managers are either unaware of the impact of human and organizational issues in implementing change, or they believe that the change will cause such minimal disruption to the organization that it does not require attention to human and organizational issues. Unfortunately, most organizational changes do require an organization to focus on these issues; the choice simply is whether it plans for them or not.

The common approach involves three major steps: (1) top leadership determines what needs to change; (2) a select group of people develop key strategies to align the organization; and (3) change leaders apply the strategies to gain commitment from the people and develop new mindsets and behavior in the organization. While more effective than the autocratic approach, the common approach often falls short of achieving desired results. This top-down approach relies primarily on the wisdom and skills of a small number of strategic-thinking and influential people. This process also depends on the responsiveness and cooperation of the people affected by the change. When people do not commit to and adapt to the change, management uses bureaucracy to control behavior, resulting in a very slow and, often, painful implementation process.

The enlightened approach involves four major steps: (1) change leaders involve stakeholders in developing a shared understanding of what needs to change and why; (2) stakeholders affected by the change develop transition strategies; (3) change leaders model the new behavior; and (4) strategies are applied to bring about the desired behavior throughout the organization. This approach requires more people to define the solutions or strategies so that a larger group of individuals owns them, which is important in achieving success change. This approach requires more time during planning to create a shared view, but requires much less effort to sell it at the end of the process. In sum, the enlightened approach capitalizes on the wisdom of senior leadership as well as other people throughout the organization, which results in a greater probability of success than the other approaches. Hence, a change effort should use the enlightened approach of implementing change.

Step 6. Identify and mitigate risks. Technical and cultural risks always exist when an organization attempts to change. Technical risks occur when a change does not work as expected or when an implemented process disrupts ongoing business to such an extent that it harms its relationships with important customers. Cultural risks, on the other hand, are many. First, some employees believe that what they do not know is not worth knowing. Second, some employees believe their situation is so unique that others do not have the knowledge or ability to help them. Third, employees often fear losing something they value [22]. For example, people may perceive a change effort as a threat to job security, social status, or power. Fourth, people may not understand the change or do not trust the organization. Fifth, people may assess the situation differently than the change team and feel that the change will not have a net gain [22]. Finally, some people simply may be intolerant of change because they are unable to develop new skills or behavior, or have no desire to change.

An organization can mitigate these risks in several ways. One way is to thoroughly, effectively, and truthfully communicate the change effort to the members of the organization. Another way is to implement change through successful pilot efforts. A third way is for an organization to identify how the work patterns of employees need to change and then manage those changes. However, the most effective way to get people to accept change is to involve them in negotiating and defining a change. That is, an organization cannot ignore the know-how or common sense of the practitioners that will be affected by a change.

Step 7. Align the training program with the change effort. Employee competence should be a part of any strategic plan. Core competencies include belief systems and motives, whereas specific job skills and knowledge are surface reflections of competence. Thus, organizations should be less interested in improving specific, transient skills and more interested in improving core, enduring skills. By teaching employees the why of things as well as the how of things, it can build organization capacity. This approach will also lessen resistance to new ideas and permit the organization to adapt to an ever-changing world. By developing the analytical capabilities of its personnel, an organization also helps them to better identify, understand, and solve problems in a variety of situations. Even though an organization needs a training curriculum that emphasizes analytical thinking, it should provide its personnel with a training program emphasizing the latest tools and methods. If an organization does not provide such a training program, old practices will render new organizational changes meaningless and a business's operating units will not function as desired.

Step 8. Align the reward and recognition program with the change effort. Typically, organizations reward individuals based on their ability to successfully complete activities. Instead, an organization must define recognition and reward systems based on tangible value to an organization, as defined by the vision statement [11]. In addition, since it is imperative that an organization maximize value and most efforts involve teams then it should assess individuals based on team performance in addition to individual performance. Thus, using a system that ranks individuals against one another is counter-productive. Further, an organization must use objective and public criteria for merit increases and promotions that is fair and equitable and substantially differentiates pay between top, middle, and low performers.

During a change effort, an organization must examine its reward and recognition program to ensure that it is consistent with a change effort. If not, the organization must change the program to recognize and reward employees that adopt the desired behaviors. In addition, the organization must clearly communicate to its employees the required behavioral changes that it will reward.

Step 9. Communicate often and effectively. Communication is one of the most effective tools an organization can use to obtain acceptance of a change. Such communication should be face-to-face since passive participation (e.g., written memos) typically does not demonstrate the necessary commitment [20]. Communication must also occur frequently and an organization should encourage its executives and middle-level managers to initiate it. In addition, such messages should first explain the shortcomings of a change, followed by its benefits. A message that should continually be reinforced is that practitioners must tailor change efforts to best meet their needs and that they need to provide feedback to the organization about changes.

Following are some communication actions an organization can perform to foster positive change. First, an organization should tell employees how the change effort will affect them. Second, an organization should inform its employees of a change honestly, simply, and straightforwardly. Third, an organization should periodically communicate the result of a change to its affected personnel. Fourth, an organization should tailor messages to target audiences. All these efforts help build trust, and management providing regular feedback enhances this trust. In sum, effective communication will help the workforce understand what the change is, the motivation for the change, and how it affects them [25], which will help the workforce to accept change.

When tailoring a message, an organization must be mindful of the motivators for key groups [1]. Practitioners and project managers are all motivated to change when they see visible success of change initiatives, both generally and within their own development environments, and the provision of adequate resources, which demonstrates upper-level management commitment. However, each group also is motivated by other factors too. For example, practitioners are influenced by changes that peers initiate. Project managers, on the other hand, are motivated by owning the software development process. Finally, senior managers are motivated by the visible benefits of a change effort and the increased ability of projects to meet schedules.

Step 10. Measure personnel productivity and product quality. An organization must use metrics to measure its progress in transitioning to a desired state. Measurement, in general, permits an organization to compare the rate of actual change against its planned change and allocate resources based on the gaps between actual and expected progress. When necessary, an organization should discard old metrics and replace them with newer ones that measure the desired behaviors. Such metrics should measure the effectiveness and efficiency of each process, as well as the acceptance of the new or changed processes. Furthermore, metrics should focus on measuring product quality. Thus, an organization must institute a balanced set of predictive measures focusing on both products and processes. These measurements should form a hierarchy, such that the higher-level measurements relate directly to organizational goals and the lowest level goals relate to detailed individual measurements, such as total labor hours per developed line of code. In addition, an organization must link the measures so that higher-level ones relate to lower-level ones. Thus, the movement of lower-level indicators will predict movement of the higher-level indicators. Finally, the organization should monitor each measure over time to identify developing trends.

Summary

This paper has identified a ten-step program to improve the acceptance of software process changes by practitioners. Of these, four steps are critical. Failing to successfully perform any of them will cause the change effort to fail. The first critical step is constructing the vision of the new organization, as well as for the individual changed processes. Unfortunately, this is seldom addressed by software process improvement plans nor discussed by software process improvement professionals. This is somewhat strange considering that modern software development processes usually specify the development of a concept of operations, which essentially outlines the vision of a proposed software development system. So why is it that software process improvement professionals think that they can

create a new system - a software process - without doing what they themselves advocate to software practitioners? Thus, a software process improvement program must develop an operational concept and support it with several operational scenarios. Besides explaining what the future will look like, operational scenarios may also help to identify who will resist change [20]. The second critical step is to obtain executive-level commitment. Without executive-level commitment, the commitment of others most likely will not be forthcoming. To obtain executive-level commitment, a change effort must support the organizational strategy and business needs and provide a demonstrable and beneficial return on investment.

The third critical practice is to involve practitioners in the development of the change effort, or software process improvement initiative. Such involvement should include ten to twenty-five percent of the workforce, depending on the size of the organization. Without such involvement an organization will not be able to gain acceptance of a change effort because practitioners will resist what they did not help to create. Even if mandated, they will not necessarily follow the process. If they do follow the new processes, it will be done simply to satisfy a mandate, which will not provide the desired benefits.

The fourth critical practice is communicating the change effort - the vision, its benefits, its differences, and so on - to the entire workforce. An organization will have to develop a different message for its executives, middle-level managers, and practitioners. For high-level executives, the message will concentrate on the alignment of the change effort with the business goals and needs of the organization and the financial return on investment. For practitioners, the message will emphasize the difference between how they do work today and how they will work in the future.

The organization should emphasize the personal benefits of the change, and emphasize the tedious operations that will be automated. Finally, the change team should motivate middle-level managers by emphasizing the benefits in terms of improved product quality, reduced schedules, and greater predictability of schedules. That is, the organization should emphasize that managing projects will be easier in the new state than in the prior one.

In conclusion, this paper has identified numerous practices for changing an organization. Organizations should adopt these practices to improve their change efforts. To promote success, an organization must address the four identified critical processes - creating a vision of the future organization, achieving executive

commitment, involving practitioners in change definition, and communicating that vision to the organization. In addition, a select group of people, having the necessary skills and personal characteristics, should lead process improvement efforts. References