Addressing the People Issues when Developing and Implementing Engineering Processes

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ABSTRACT

This paper describes the approach used by a defense contractor to address the people issues raised when developing and implementing engineering processes. First, a brief description of the context is presented, then organizational mechanisms to better manage changes are described finally, sixteen lessons learned are presented.

BACKGROUND

The organization is a systems integrator of an air defense missile system. Over 120 systems and software engineers are involved in the development and maintenance of the system.

The organization had been ISO 9001 certified since 1993. In 1997 the organization had been certified as CMM (Paulk 1993) level 2 by independent assessors certified by the Software Engineering Institute. In addition to satisfying level 2 goals, the organization met 8 of the 17 level 3 goals.

In 1995, it was decided that a formal systems engineering process had to be developed and implemented in order to seamlessly integrate disciplines associated with systems engineering. The process and its application in the organization have been presented at previous INCOSE symposia (Laporte 1997, 1998).

The organization felt that it would also benefit from a standardized project management process. In 1996 a working group selected the Guide to the Project Management Body of Knowledge, developed by the Project Management Institute (PMI 1996), as the framework for the organizational process.

THE MANAGEMENT OF CHANGE

Since the management of change is a key element of a successful process improvement program, a series of mechanisms were put in place in order to facilitate the development, the implementation and the adoption of processes, methods and tools.

Process Action and Coordination Team

In early 1997, it was felt that the implementation of these processes would need organizational coordination and direction. It was decided to establish a steering committee called the Process Action and Coordination Team (PACT). The PACT is composed of vice-presidents, the manager responsible for quality assurance and the coordinator for process performance improvement. The functions of the PACT are:

- Establish time-to-market, quality, costs and product performance objectives to be supported by organizational processes
- Set priority in accordance with company vision and yearly objectives
- Liaise with executive committee
- Establish consensus among different groups
- Provide support for process performance improvement:
  - Review results of assessments and audits
  - Charter technical area working groups
  - Budget for resources for process groups
  - Monitor process performance

Process Ownership

A process owner is responsible for the effectiveness and the efficiency of the process, methods and tools. As an example, each year the process owner develops a Process Improvement Plan (PIP). Process owners had also been delegated the responsibility to review the tailoring of the process before a project is approved. Knowing that a project manager and a process owner may, occasionally, have conflicting views about the tailoring of a process, a policy was written to handle such conflicts. In the event of a deadlock

between a project manager and the process owner, both would present a risk analysis to a vice-president for the final approval of the tailored process.

Awareness Activities
As an example, to build the sponsorship level, the President of the organization attended an executive seminar on process improvement and two directors attended a three-day seminar discussing process, process assessment and improvement. Moreover, the coordinator for process improvement attended process improvement courses and conferences. Briefing sessions were held and articles were written in each company's newsletter to explain the why, what and how of process assessment and improvement and describing the progress made.

Meeting Guidelines
In order to facilitate the conduct of working group activities, a certain number of meeting guidelines were proposed (Scholtes 1996), by the facilitators, to the members of working groups during the kick-off meeting their group (figure 1). The facilitator read each proposed rule and asked participants if they agree with the rule. Once the discussion was over, the facilitator reminded the participants that in the future, he will be facilitating each meeting using the set of rules selected. After a few meetings, the facilitator invited participants to become secondary facilitators, i.e. when a participant observed a behavior which violated one of the meeting guidelines, he raised the issue with the offender. Eventually, a group can manage the "soft issues" by itself without the help of an outside facilitator. During meetings, a process owner focused on the content of a specific process while the facilitator focused on the process of developing a specific engineering process.

Decision Making
It was also decided that consensus decision making was the preferred decision-making option. We defined consensus, according with the definition found in the Team Handbook (Scholtes 1996): consensus is not unanimity, consensus is based on the assumption that solutions are more likely to succeed if all of the key participants are "comfortable enough" with the outcome to move forward. From time to time "thumb voting" procedure (Popick 1996) were used to make decision by consensus. Thumb voting allows the following three alternatives: first, if the proposition is favored, the thumb is up; second, if someone can live with the decision, the thumb is to the side; third, if someone cannot live with the decision, the thumb is down. In the later case, the members of the working group had to take time to understand the issues at stake and proposed an alternative that everyone can live with.

Team Evaluation
From time to time, members of the working groups had to evaluate the effectiveness of their group. A survey (Alexander 1991) was distributed at the end of a meeting. Individually, members completed the survey and sent it to the facilitator of their group. The survey addresses the following issues: goals and objectives, utilization of resources, trust and conflict resolution, leadership, control and procedures, interpersonal communications, problem solving, experimentation and creativity. Issues that were surfaced by members were discussed in order to generate suggestions for improvement.

Team Charter
Each working group was managed like a project: it had a charter. The charter listed a budget, a schedule objectives, key players, roles and responsibilities, deliverables, risk issues and expected schedule.

LESSONS LEARNED

Certain lessons likely to be used by other organisations in the future are discussed below.

Lesson 1: Set Realistic Expectations for Senior Management
Appropriate expectations must be set prior to embarking on a process development journey. The trap, especially for a low maturity level organisation, consists in communicating to management the idea that a process improvement initiative will be easy, fast and inexpensive, has to be avoided at all costs.

A typical scenario looks like this: senior management hears about the benefits that attaining a maturity level could represent for his organisation's competitiveness. Then, a project manager or an external consultant states, in order not to upset senior management, that such objectives are easily attainable. Then senior management mandate middle managers to attain this objective in a very short lapse of time. If a formal process assessment is performed, a string of countless findings are surfaced up to senior management. Findings that had been known by developers for a long time but remained ignored by middle managers due to the mode of management that consists in dealing continuously with the problems created (i.e. fighting fires), in a clumsy way at time. Then, senior management, that had already publicly announced their objectives realise suddenly that it will take a lot more time and resources than what had been estimated initially.

One conversation at a time.
In the meeting or out, but not both (i.e. participants should make a commitment to participate to the meeting for the full duration).
100-mile rule (i.e. no interruptions: e.g. telephone messages are not allowed unless urgent)
How decision will be made (e.g. by consensus, majority or minority rule, autocracy, unanimity).
Once a decision is made, participants support it inside and outside the meeting.
Be as open as possible.
We listen, with respect, to others and do not interrupt them.
Silence is consent.
Few recreational stories.
Differences are respected.
Avoid blaming individuals.
We come prepared to meetings.
We publish minutes and action items at each meeting.

Figure 1. Proposed Meeting Guidelines

At that time, three reactions are possible. Senior management may accept the findings and confirm that they will continue to support the objectives announced. Or, they may announce discreetly that objectives will be lowered. Finally, they can deny the findings of the assessment and renounce to implement an action plan to correct the deficiencies highlighted by the assessment. This decision could have a destructive effect on developers, since they know that the deficiencies they had been deploring for a long time will remain ignored for a long time.

The lesson to be remembered is to prepare a short action plan -- some sort of a brief appraisal of the situation -- preferably by someone who is not involved in the sector targeted and to assess the time and resources necessary to performing a formal assessment, preparing and implementing an action plan. Moreover, it is better not to proceed to an assessment if it is not intended to deal with the findings. As a matter of fact, once the problems are identified and publicised within the organisation, if the management decides not to act, it then sends a very bad message to practitioners.

Lesson 2: Secure Management Support

A second lesson for low maturity level organisations consists in realising that most of the assessment findings target the deficiencies of project management processes. It is necessary to create an environment where the management is ready to invest in the implementation of processes rather than blame its managers; in other words "where the management is ready to fix the process, not the people". This is one of the reasons why it is necessary to also keep informed senior management so that they can show understanding and full commitment when these findings are publicised within the organisation.

Beside senior management buy-in, it is essential that middle management and first line managers become strong supporters of the process improvement program. The strongest signal sent by managers is their day-to-day activities, because "what a manager does talks louder than what a manager says". The developers must receive clear signals announcing that the changes announced will be implemented and they will have to adopt new practices.

Lesson 3: Identify Management Needs, Expectations and Understanding of the Problem

The involvement of process owners or managers is largely related to their understanding of the current situation (i.e. strengths and weaknesses). Once convinced that the current situation is undesirable, they will provide the leadership (e.g. direction and momentum) to implement solutions. They can also keep a working group focused on solving the right problems. Since, it is very easy, after a few meetings, for members of a working group to start solving what they perceived to be the problems.

Lesson 4: Establish a Process Improvement Working Group before an Assessment

It would be better that a small process group becomes active in process activities a couple of months before the on-site assessment. The process group should take this time to familiarise itself with the models, such as the EIA 731 (EIA 1998) and associated process improvement methods and tools. Ideally there should be one full-time person on the process group while the other members could be assigned on a part-time basis. Beside their technical competencies, the members of the process group should be selected based on their enthusiasm for improvement and the respect they have within the organisation.

Lesson 5: Start Improvement Activities Soon after an Assessment

With regards to the development of the action plan, the organisation should capitalise on the momentum gained during the assessment period. The organisation does not have to wait for a

completed action plan to start process improvement activities. Some improvement activities can begin soon after the completion of the on-site assessment. The implementation of certain improvements is an important motivation factor for all members of the organisation.

Lesson 6: Collect Data to Document Improvements

Before and during the assessment, it is recommended to collect both quantitative and qualitative data which will be used later to measure the progress realised. One could obtain project data such as budgets and schedules, or measure the degree of satisfaction of the customers regarding product quality level. Since senior management will have made investments, it is important to be able to demonstrate that these investments have been profitable.

Lesson 7: Train all Users of the Processes, Methods and Tools

Once processes are defined, it is essential to train all users. Otherwise, process documents will end up getting dusty on shelves. It is illusory to think that developers will study, by themselves, new processes in addition to their work load. Training sessions also serve as a message that the organisation is going ahead and will require that its developers use these practices. During the training sessions, it is necessary to indicate that, however everybody's good will, errors are bound to happen while using new practices. This will help reducing developers' level of stress when using these new practices. It would be a good thing that a resource-person be available to help developers (i.e. hot-line) when they face obstacles while implementing new practices.

Lesson 8 : Manage the Human Dimension of the Process Improvement Effort

The authors wish to make the reader aware of the importance of the human dimension in a process improvement program. The people responsible for these changes are often extremely talented engineering practitioners, however not too well equipped in change management skills. The reason for this is simple: their academic training focused on the technical dimension and not on the human aspect. However, the major difficulty of an improvement program is precisely the human dimension.

While preparing the technical part of the improvement action plan, the change management elements have to be planned. This implies, among other things, a knowledge of (1) the organisation's history with regards to any similar efforts, successful or not, made formerly; (2) the company's culture; (3) the motivation factors; (4) the degree of emergency perceived and communicated by (a) the management, (b) the organisation's vision, and (c) the management's real support. The authors are convinced that the success or the failure of an improvement program has more to do with managing the human aspect than managing the technical aspect.

Lesson 9: Process Improvement Requires Additional "People Skills"

In an organisation that truly wants to make substantial gain in productivity and quality, a cultural shift will have to be managed. Such a cultural shift requires a special set of "people" skills. The profile of the ideal process facilitator is someone with a major in social work and a minor in engineering. The implementation of processes implies that both management and employees will have to change their behaviour. With the implementation of processes, management will need to change from a "command and control" mode to a more "hands-off" or participative mode. As an example, if the organisation truly wants to improve its processes, a prime source of ideas should come from those who are working, on a daily basis, with the processes. This implies that management will need to encourage and listen to new ideas. This also implies that the decision making process may have to change from the autocratic style, e.g. " do what you are told" to a participative style, e.g. "let us talk about this idea". Such a change requires support and coaching from someone outside the functional authority of the manager who has to change its behaviour. Similarly, employees' behaviour should change from being the technical "heroes" that can solve any problem to team members that can generate and listen to others' ideas.

Also, the first few months of the introduction of a new process, a new practice or a new tool, both management and employees must acknowledge that mistakes will be made. Unless a clear signal has been sent by management and a "safety net" has been deployed to recognise this situation, employees may "hide" their mistakes. The result is that not only the organisation will not learn from them but other employees will make the same mistakes again. As an example, the main objective of a formal inspection process is to detect and correct errors as soon as possible in the project lifecycle. Management has to accept that in order to increase the errors detection rate, results from individual inspections will not be made public, only composite results from many inspections (e.g. at least ten inspections from different projects) will be made public. When this rule is accepted by management, employees will feel safe to identify mistakes in front of their peers instead of hiding them. The added benefit to correcting errors is that

those who participated to an inspection will learn how to avoid these errors in their own work.

Facilitating behaviour changes requires skills that are not taught in technical courses. It is highly recommended that the people responsible for facilitating change be given appropriate training. The authors recommend two books that may facilitate the management of change: the first one (Block 1981) gives advises to anybody acting as internal consultant; the second one (Bridges 1991) gives the steps to be followed for writing and implementing a change management plan.

Lesson 10: Select Pilot Projects Carefully

It is also very important to carefully select pilot projects and participants to the pilots since these projects will foster adoption of new practices throughout the organization. Also, first time users of a new process will make mistakes. It is therefore mandatory to properly coach the participants and provide them with a "safety net". If participants sense that mistakes will be used to learn and make improvements to the process instead of "pointing fingers", the level of anxiety will be reduced and they will bring forward suggestions instead of "hiding" mistakes.

Managing the human dimension of the process engineering initiative is the component, which not only fosters the adoption of change but also creates an environment where changes could be introduced at an increasingly greater rate. Members of the engineering organization now realize that managing the "soft stuff" is as important as managing the "hard stuff".

The utilization of models and standards such as the Capability Maturity Model (CMM) for software and EIA-731 for systems engineering is slowly changing the culture of the organization from the "Not Invented Here" (NIH) to the "Not Reinvented Here" (NRH) mindset. Practitioners see the benefits of reusing someone else's work. They also see that the organization encourages them to look for existing solutions instead of constantly reinventing the wheel. Engineers are now intensively using the Internet to look for practices developed by other organizations and adapting these practices to the environment of their own organization. Practitioners attend conferences sponsored by organizations such as the Software Engineering Institute and INCOSE to identify best practices for their utilization in day-to-day activities.

Lesson 11: Conduct Process Audits

Process audits should be conducted on a regular basis for two main reasons: first, to ensure that practioners are using the process, and second, to discover errors, omissions, or misunderstandings in the application of the process. Process audits help to assess the degree of utilization and understanding of the practioners. As an example, a documentation management process was released and practioners were asked to produce and update documents using this new process. It is widely known that engineers are not very prone at documenting their work.

An audit was launched to measure process compliance. As expected, see table 1, results of the first audit were not exhilarating. The engineering manager kindly reminded engineers, in writing, to use the process. He also informed them that a second audit would be performed in the future. As shown in the table, the results of the second audits are substantially better than the first audit. Also, the auditor gathered feedback from engineers, this information will be used by the process owner to improve the process.

Activity	Results from First Audit	Results from Second Audit
Comments made by reviewers	38 %	78%
Approval matrix completed	24%	67%
Effort log completed	18%	33%
Review checklist completed	5%	44%
Configuration management checklist completed	5%	27%
Distribution list completed	38%	39%
Document formally approved	100%	100%

Table 1. Results of Audits performed on the Documentation Management Process

Lesson 12: Conduct Team Effectiveness Surveys

Such tools (Alexander 1991) may promote open discussion with members of a group besides improving the performance. Usually, people are not very prone to raise “soft” issues. Also, such tools provide the facilitators with information that help

them probe delicate issues. As an example, if the majority of a working group reports that interpersonal communications are weak, the facilitator can probe the members and invite them to propose solutions. After a few meetings, the results of a new survey will show if the solutions really helped the team improve their communications.

Lesson 13 : Start a Process Initiative from the Top Level Process

The process improvement initiative was a bottom up exercise, i.e. first software process was developed, then systems engineering, then project management where each additional process "sits" on top of the other. Historically, this was the selected strategy because, in 1992, only the software CMM was available; then, came the systems engineering CMM and after, the Body of Knowledge in project management. If an organization had to start, today, a process initiative, it would be easier and more efficient to start from the top by developing the project management process, then the systems engineering process and finally the software process. It would also be possible to develop these process in parallel once the requirements for the top level process are well stabilized.

Lesson 14: Get Support from Organizational Change Experts

As mentioned above, surveys were conducted in order to "measure" issues such as culture, implementation history, team effectiveness. Once the surveys were compiled, we had some indications of organizational strengths and weaknesses. The difficult part was to decide what to do next. As an example, one issue on the survey is risk taking. If the survey showed that people resent to take risks, one possible cause for such behavior was that people did not want to be blamed for an error. Having found this cause was not too helpful since we would have to find the cause for this behavior, and so on. It would have been very helpful to have access to someone with expertise in organizational change. This would have saved a lot of long discussions and many wrong answers.

Lesson 15: Tie Process Improvement Activities to Business Objectives

It was observed that software and systems engineering process improvement really picked up momentum when a common focal point was created between management, engineers and customers. Understanding that the real benefit of process improvement lies in improving product quality, reducing time-to-market and cost. Consequently, improving the ability of the organization to better compete. Additionally, a multi-year Process Improvement Plan (PIP) was a very important tool to illustrate the links between business objectives, project requirements and process development or improvement. Essentially the PIP illustrated that the engineering of processes was not a paper exercise but an important infrastructure for the successful accomplishment of projects. Being a multi-year plan, the PIP also showed to practitioners the long-term commitment of management to process improvement activities.

Lesson 16. Adopt a Common Vocabulary

To succeed in any project endeavor, a common vocabulary is a basic requirement. As we developed the processes, we realized that different players had different meaning for the same word, or the same word had different meanings, and some words were not well known to some individuals. We therefore mandated one team member as the "glossary keeper". His role was to collect a vocabulary, propose some "clean-up" in the terminology, and to gradually build a common glossary for all processes.

CONCLUSION

The organization had made substantial investments toward the definition implementation and integration of engineering processes, methods and tools. Improvements required significant investments. The definition of technical and management activities will allow complex projects to be developed in a disciplined environment. Engineers and managers will be able to perform their activities more effectively and efficiently. The organization is moving from the "not invented here" to the "not reinvented here" culture where practitioners are constantly looking for practices to be pilot tested and integrated to the process asset library of the organization.

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BIOGRAPHY

Claude Y. Laporte obtained in 1973 a Bachelor in Science from le Collège Militaire Royal de Saint-Jean. In 1980, he obtained an MS in physics at Université de Montréal, and in 1986, an MS in Applied Sciences from the Department of Electrical and Computer Engineering at École Polytechnique de Montréal. He was an officer in the Canadian Armed Forces during 25 years and a professor for over 10 years. From 1988 to 1992, he was involved in the implementation of the Applied Software Engineering Center. He left the Canadian Forces in 1992 at the rank of major. Since then, he has joined Oerlikon Aerospace where he coordinates the development and implementation of software engineering, systems engineering and projects management processes, methods and tools. In 1999 he left Oerlikon Aerospace to launch consultation services as a partner of Yortar Technologies. He is the president of the Montréal Software Process Improvement Network (Montréal SPIN). He is also involved in the establishment of a chapter of INCOSE (International Council on Systems Engineering) in Montréal.

Sylvie Trudel obtained in 1986 a Bachelor degree in Computer Science from Laval University in Québec. She worked in for more than 10 years in development and implementation of management information systems. She joined Oerlikon Aerospace in 1996 as the process control analyst for the software engineering department. She is a full-time member of the organizations Process Action and Coordination Team. She played a major role in the introduction of formal inspections. She was a team member and site coordinator of the formal software engineering process assessment.