Addressing People Issues when Developing and Implementing Engineering Processes

Claude Y. Laporte
Yortar Technologies
Sylvie Trudel
Oerlikon Aerospace

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, and finally 16 lessons learned are presented.

Background

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

The organization had been ISO 9001 certified since 1993. In 1997 the organization had been certified as CMM® [1] Level 2 by independent assessors certified by the Software Engineering Institute. In addition to satisfying Level 2 goals, the organization met eight of the 17 Level 3 goals.

It was decided in 1995 that a formal systems engineering process had to be developed and implemented in order to seamlessly integrate disciplines associated with systems engineering. For an in-depth description of the process and its application in the organization, the reader is referred to other papers that have been published [2,3].

The organization thought that it also would benefit from a standardized project management process. In 1996 a working group selected *A Guide to the Project Management Body of Knowledge©*, developed by the Project Management Institute [4], 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, implementation, and adoption of processes, methods, and tools.

Organizational Process Coordination

In early 1997, the thought was that implementing these processes would need organizational coordination and direction. A steering committee, the Process Action and Coordination Team (PACT), was established. The PACT is made up of vice presidents, the manager responsible for quality assurance, and the coordinator for process performance improvement. The functions of the PACT are to:

- establish time-to-market, quality, costs, and product performance objectives to be supported by organizational processes
- set priorities in accordance with company vision and yearly objectives
- work as a liaison 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 processes' effectiveness and efficiency, methods, and tools. As an example, each year the process owner develops a process improvement plan (PIP). Process owners have also been delegated to review the tailoring of the process before a project is approved. Knowing that a project manager and a process owner may 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

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. The coordinator for process improvement attended process improvement courses and conferences. There were briefing sessions and articles 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, the facilitators proposed a certain number of meeting guidelines to the members of working groups during their group's kick-off meeting [5] (Table 1). The facilitator read each proposed rule and asked participants if they agreed with the rule. Once the discussion ended, the facilitator reminded the participants that in the future, he would facilitate each meeting using the set of rules selected. After a few meetings, the facilitator invited participants to become

---

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

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

Table 1. *Proposed meeting guidelines.*

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" without 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 option. We defined consensus, according to the definition found in *The Team Handbook* [5]: 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" procedures [6] were used to make decision by consensus. This allows the following three alternatives: if the proposition is favored, the thumb is up; if someone can live with the decision, the thumb is to the side; and 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 could live with.

Team Evaluation

From time to time, members of the working groups had to evaluate their group's effectiveness. A survey [7] was distributed at the end of a meeting. Individually, members completed the survey and sent it to their group facilitator. 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 members brought up were discussed to generate suggestions for improvement.

Team Charter

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

Lessons Learned

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

Lesson 1: Set Realistic Expectations for Senior Management

Appropriate expectations must be set prior to embarking on process development. The trap, especially for a low maturity level organization, consists of 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 the organization's competitiveness. A project manager or an external consultant states, in order not to upset senior management, that such objectives are easily attainable. Senior management mandates middle managers to attain this objective in a short amount of time. If a formal process assessment is performed, a string of countless findings are surfaced to senior management. These are findings that developers had known about for a long time but which middle managers ignored due to the management mode of dealing continuously with the problems created (i.e. fighting fires). Then, senior management that had publicly announced its objectives suddenly realizes that it will take a lot more time and resources than initially estimated.

Three reactions are possible. Senior management may accept the findings and confirm that it will continue to support the objectives announced. Or senior management may announce discreetly that objectives will be lowered. Finally, it cannot accept the assessment findings and not put in place an action plan to correct the deficiencies highlighted by the assessment. This decision could have a destructive effect on the morale of the developers, since they know that the deficiencies they had been long deplored will continue to be ignored.

The lesson 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 targeted sector. Estimate the time and resources necessary to perform a formal assessment, prepare and implement an action plan. It is better not to proceed to an assessment if it is not intended to deal with the findings. Once the problems are identified and publicized within the organization, if the management decides not to act, it sends a very bad message to practitioners.

Lesson 2: Secure Management Support

A second lesson for low maturity level organizations consists in realizing that

most of the assessment findings target the deficiencies of management processes. It is necessary to create an environment where the organization is ready to invest in implementing 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 it is necessary to keep senior management informed so it can show understanding and full commitment when these findings are publicized within the organization.

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 managers send is their day-to-day activities, because what a manager does talks louder than what a manager says. The developers must receive clear signals that the changes announced will be implemented and new practices will be enforced.

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 situation i.e. strengths and weaknesses of management and process. Once convinced that the current situation is undesirable, they will provide the leadership, direction, and momentum to implement solutions. They can also keep working groups focused on solving the right problems since it is very easy, after a few meetings, for a working group to start solving what it perceives to be the problems.

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

It is best if a small process group becomes active in process activities several months before the on-site assessment. The process group should take this time to familiarize itself with the models, such as the Capability Maturity Model (CMM) or the Electronics Industries Association (EIA)731 [8] and associated process improvement methods and tools. Ideally there should be one full-time person in the process group, while the other mem-

bers could be assigned on a part-time basis. Beyond 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 organization.

Lesson 5: Start Improvement Activities soon after an Assessment

With regard to the development of the action plan, the organization should capitalize on the momentum gained during the assessment period. The organization does not have to wait for a completed action plan to begin process improvement activities. The implementation of certain improvements is an important motivation factor for all members of the organization.

Lesson 6: Collect Data to Document Improvements

Before and during the assessment, it is recommended that quantitative and qualitative data be collected. It will be used later to measure progress. One could obtain project data such as budgets and schedules, or measure the degree of customer satisfaction 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 collecting dust on shelves. It is illusory to think that in addition to their workload, developers will study new processes by themselves. Training sessions also serve as a message that the organization is moving ahead and will require that its developers use these practices. During the training sessions, it is necessary to indicate that errors are bound to occur while using new practices. This will help reduce developers' level of stress when using these new practices. It would be wise if a resource person (i.e. a hotline) is available to help developers 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: (1) a knowledge of the organization's history with regards to any similar efforts, successful or not; (2) the company's culture; (3) the motivation factors; (4) the degree of emergency perceived and communicated by (a) the management, (b) the organization's vision, and (c) the management's real support. The authors are convinced that the success or 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 organization that truly wants to make substantial gains in productivity and quality, a cultural shift will have to be managed. This 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 behavior.

With the implementation of processes, management will need to change from a "command and control" mode to a more "hands-on" or participatory mode. As an example, if the organization 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 manage-

ment 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 participatory 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 his/her behavior. Similarly, employees' behavior should change from being the technical heroes who can solve any problem, to team members that can collaborate and listen to others' ideas.

During the first few months of the introduction of a new process, a new practice, or a new tool, 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 recognize this situation, employees may hide their mistakes. The result is that not only the organization will not learn from those mistakes but other employees will make the same mistakes. As an example, the main objective of a formal inspection process is to detect and correct errors as soon as possible in the project life cycle. Management has to accept that in order to increase the error's detection rate, results from individual inspections will not be made public, only composite results from many inspections (e.g. at least 10 inspections from different projects) will be made public. When management accepts this rule, employees should feel safe to identify mistakes in front of their peers instead of hiding them. The added benefit to correcting errors is that those who participate in an inspection will learn how to avoid these errors in their own work.

Facilitating behavior 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 [9] gives advice to anybody acting as an internal consultant; the second one [10] gives the steps for developing and implementing a change management plan.

Lesson 10: Select Pilot Projects Carefully

It also is important to carefully select pilot projects and participants to the pilots, since these projects will foster adoption of new practices throughout the organization. As stated before, first-time users of a new process will make mistakes. 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."

Lesson 11: Conduct Process Audits

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

An audit was launched to measure process compliance. As expected, 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. The results of the second audit are substantially better than the first audit (Table 2). The auditor gathered feedback and suggestions from engineers; this information would be used by the process owner to improve the process.

Lesson 12: Conduct Team Effectiveness Surveys

Usually people are not very likely to raise "soft" issues. Such tools [7] may promote open discussion with members of a group in order to improve its performance and provide the facilitators with information that helps them probe delicate issues. As an example, if the majority of a 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). Historically, this was the selected strategy because, in 1992, only the software CMM was available; then came the systems engineering CMM and after that, the Project Management Body of Knowledge. If an organization had to start a process initiative today, it would simplify process integration to start from

Table 2. *Results of audits performed on the documentation management 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%

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 engineering processes in parallel once the requirements for the top level process are well stabilized.

Lesson 14: Get Support from Change Experts

As mentioned above, surveys were conducted in order to "measure" issues such as culture, implementation history, and 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 was risk taking (i.e. people resent taking risks). One possible cause for such behavior could be that people did not want to be blamed for an error. Next 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 among management, engineers, and customers. Understanding that process improvement's real benefit lies in improving product quality and reducing time-to-market and cost, leads to improving the organization's ability to better compete. Additionally, a multi-year 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 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

We have shown that the development and deployment of engineering and management processes entail technical and management competencies. Five elements are necessary for a successful implementation of organizational changes:

- Management sets a direction and process objectives are linked to business objectives. Without a clear direction, confusion may mislead people from reaching the desired change.
- People are trained to perform new tasks. Without the proper training, anxiety among the organization's staff is likely to slow down the occurrence of change.
- Incentives are provided to facilitate the adoption of changes.
- Resources are estimated and provided. Otherwise, frustration may put an end to the organization's willingness to change.
- An action plan is developed and implemented to avoid false starts.

These years of process improvement activities have demonstrated that constant attention to the people issues is critical to the success of technological changes. We suggest to manage those people issues as risk items and to track them throughout the improvement effort.

Finally, as stated by J. Pfeffer in his book *The Human Equation*, "It is almost impossible to earn above-normal, exceptional economic returns by doing what everyone else is doing ... it is also impossible to achieve some lasting competitive advantage simply by making purchases in the open market — something that anyone can do" [11]. ◆

About the Authors

Claude Y. Laporte obtained a bachelor of science degree in 1973 from le Collège Militaire Royal de Saint-Jean. In 1980, he obtained a master of science degree in physics at Université de Montréal, and in 1986, a master's degree 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 for 25 years and a professor for more than 10 years. From 1988-92, he was involved in the implementation of the Applied Software Engineering Center. He left the Canadian Forces in 1992 at the rank of major. He joined Oerlikon Aerospace, where he coordinated 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.

Yortar Technologies
481 Bissett
Saint-Jean-sur-Richelieu
Québec, Canada J3A 1W6
Voice: 450-349-4088
Fax: 450-349-4620
E-mail: claporte@yortar.com

Sylvie Trudel obtained a bachelor's degree in computer science in 1986 from Laval University in Québec. She worked 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 organization's 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 engi-

neering process assessment.

Oerlikon Aerospace
225 Seminaire sud
Saint-Jean-sur-Richelieu
Québec, Canada J3B 8E9

E-mail: strudel@oerlikon.ca

References

1. Paulk, M. et al, Capability Maturity Model for Software, Software Engineering Institute, SEI/CMU-93-TR-24, 1993.
2. Laporte, C., Papiccio, N., "Development and Integration of Engineering Processes at Oerlikon Aerospace," Proceedings of the Seventh International Symposium of the International Council on Systems Engineering, August 3-7, Los Angeles, Calif., 1997.
3. Laporte, C., A. Guay, J. Tousignant, "The Application of a Systems Engineering Process to the Re-Engineering of an Air Defense System," Proceedings of the 8th International Symposium of the International Council on Systems Engineering, July 26-30, Vancouver, Canada, 1998.
4. *A Guide to the Project Management Body of Knowledge*, Project Management Institute, 1996.
5. Scholtes, P., *The Team Handbook*, Joiner Associates Inc, 1996.
6. Popick, P.R., S.A. Shear, "Ten Lessons Learned from Implementing Integrated Product Teams," Proceedings, International Council on Systems Engineering 6th Annual International Symposium, Boston, July 7-11, 1996.
7. Alexander, M., *The Encyclopedia of Team-Development Activities*, edited by J. William Pfeiffer, University Associates, San Diego, Calif., 1991.
8. EIA 731, Electronic Industry Association, Systems Engineering Capability, EIA Standard EIA/IS 731 Part 1: Model, 1998.
9. Block, P., *Flawless Consulting*, Pfeiffer & Co., 1981.
10. Bridges, W., *Managing Transitions*, Addison Wesley, 1991.
11. Pfeffer, J., *The Human Equation: Building Profits by Putting People First*, Harvard Business School Press, 1998.