Software Process Engineering Activities in Québec

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Claude Y. Laporte obtained in 1973 a first degree diploma in physics and mathematics at Collège militaire royal de Saint-Jean. He was also sponsored by the Department of National Defense to pursue graduate studies in science. In 1980, he obtained a master in physics at Université de Montréal, then, in 1986, a master 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 and a professor for over 10 years at Collège militaire royal de Saint-Jean. From 1988 to 1992, he was involved in the feasibility study that led to the implementation of the Applied Software Engineering Centre. He left the Canadian Forces in 1992 at the rank of major. Since then, he has joined Oerlikon Aerospace where he co-ordinates software and systems process engineering activities. He is the president of the Montreal Software Process Improvement Network (SPIN).

Abstract

This paper is divided in three parts. The first part will present the Applied Software Engineering Centre, its history, its mission, and the services offered. The second part will present a brief profile of organisations that have undertaken to improve software processes utilising mainly the Capability Maturity Model developed by the Carnegie Mellon University Software Engineering Institute. The third part will present lessons learned in process improvement. This paper is an update of a presentation given on the occasion of a workshop held at GMD, a German software research centre. (Laporte 1993, 1995, 1996a).

Key Words

Software Engineering, Applied Software Engineering Centre, Capability Maturity Model, Software Engineering Institute, Trillium, Management of Changes. Software Process Improvement Network, Camélia.

1   Introduction.

We often hear of problems in software intensive systems. Typically the problems are: systems that do not meet customer's requirements, unreliable operation, costly development and maintenance and unmet development schedule and budget. The U.S. Department of Defence reports (DoD 1987) that after two decades of unfulfilled promises about productivity and quality gains from applying new software methodologies and technologies (e.g. tools), industry and government organisations are realising that their fundamental problem is the inability to manage the software process. In this paper we will present software process improvement initiatives undertaken by private and public organisations of Québec.

2   The Applied Software Engineering Centre.

The Applied Software Engineering Centre (ASEC) was created as a result of an agreement between the Computer Research Institute of Montréal (CRIM) and six Canadian corporations committed active in the development and maintenance of software for critical applications: Bombardier, CAE Electronics, Keops Informatique, Lockheed Martin, Oerlikon Aerospace and Spar Aerospace.

An action had been undertaken in 1988 in the form of a feasibility study financed by 13 companies and the federal and Québec governments, with the participation of the Collège militaire de Saint Jean, which confirmed the role and importance of software engineering in improving the productivity and competitiveness of Canada's industry.

Encouraged by these results, the study's sponsors decided in 1990 to draw up a business plan aimed at creating a software engineering centre, the mission of which would be to assume a leadership role the technological level and to assist industry, where such an expertise is required, to improve their competencies in software engineering. In 1991, the Applied Software Engineering Centre became a division of CRIM.

ASEC was created to respond to an urgent need expressed by the industry in Canada, which is facing a challenge the outcome of which will be decisive. Although information technologies have become an overriding factor of productivity and innovation in all sectors of activity and although demand for more and more complex software has increased in a spectacular way, the lags in terms of software development as well as the lack of qualified personnel are seriously hampering our industry's progression. In this matter, cost overruns, schedule slips, lack of

product friability and system failure due to software bugs are innumerable. Even worse, in certain critical applications, these problems can have serious repercussions on public security or result in significant financial or social losses.

The mission entrusted to the Applied Software Engineering Centre is to provide access to and training in the best software engineering managerial and technical solutions. Its target clients comprises companies and agencies that rely on information technology to improve the productivity and quality of their services and products. ASEC offers four main categories of services: services related to software engineering process such as software process assessment, auditing of suppliers' competencies and advising, training, awareness to new technologies by means of appropriate activities, as well as implementation of and relevant support to specific interest groups. ASEC is also part of a network of similar centres subsidised by the federal government.

ASEC signed in December 1995 a co-operation and research agreement with the Software Engineering Institute (SEI) of Carnegie Mellon University. In accordance with this first SEI's international agreement, ASEC is not only able to utilise the SEI's assessment methods to assess the maturity of the software process engineering, but also transfer to industry in a more efficiently way methods and techniques permitting to improve software development and maintenance practices.

Until now, the "Capability Maturity Model" (CMM) has only existed in English, which limited considerably its usage for the French-speaking community. Fortified by its strategic agreement with the SEI, ASEC jointly with organisations from France (CEGELEC, Dassault Électronique, the French Department of Defence, Snecma Elecma and Thomson-CSF) and other from Quebec (Bombardier and Hydro-Québec) as well as the federal and Quebec governments (respectively Industry Canada and ministère de l'Industrie, du Commerce, de la Science et de la Technologie) the translation into French of the Capability Maturity Model developed by the SEI. ASEC also participates in the creation of software Web site in French. This Web site will comprise not only French translations but also information conceived and circulated in French through all French-speaking communities.

3   Software Capability Models developed in Québec.

Since 1982 (Coallier 1995), Bell Canada has also been developing a Software Capability Maturity Model to assess the processes of its telecommunication systems suppliers in view of

reducing risks. Trillium is now part of the management program of Bell Canada's suppliers. Trillium insists on the self-improvement of software manufacturing processes as an approach allowing to improve the quality and reliability of telecommunication systems and reduce their operation and maintenance costs. This is critical when considering that Bell Canada's telecommunication network depends on more than fifty million lines of code.

Trillium was developed by Bell Canada, Nortel and Bell Northern Research. Although strongly inspired by the CMM Model, several requirements were drawn from the ISO, Bellcore, IEEE standards as well as from the criteria related to the Malcom Baldrige National Quality Award. A major difference between the CMM and Trillium is that the latter contains key process areas which vary on a five-level scale (road map) contrarily to CMM where each key process area lies at one capability level only. The Trillium model also comprises practices that are not covered in the CMM.

A France-Québec project, started in 1992, deals with the adaptation of the Trillium model and with the creation of an evaluation method based on the CBA-IPI method for use, namely, in the information software sector. The project comprises mainly the translation in French of the Trillium model, the addition of practices related to the information systems sector, and the change of terms in order to be compatible as much as possible with the ISO 12207 Software Life Cycle Process standard. The result is named the Trillium-Camélia model. Some domains, road maps, and practices have been added to cover more extensively the development, maintenance and operation of information systems. They are: business process re-engineering, architectures, financial life-cycle analysis, data management, product re-engineering, and operations. An evaluation method was created and embedded in a 3 to 5 day course. The method is named Camélia. Within this method, a questionnaire of more than 100 questions, based on the trillium-Camélia model, has been created as a tool to have a first overview of the maturity of the organisation evaluated. The Trillium-Camélia model was tested both in Québec and in France, in 1995 and in 1996. It should be published soon.

4   First Experiments with the Maturity Model

A first exposure to the software process assessment methodology developed by the Software Engineering Institute (SEI) was done in Montréal in the summer of 1989. Two members of the technical staff of the SEI conducted a one-day workshop at École Polytechnique, Montreal. The workshop was attended by 50 persons. The participants came mainly from defence,

aerospace and finance organisations, of both the private and public sectors. During the workshop, the participants answered the SEI questionnaire, that was used to conduct formal assessments (Humphrey 1987). The questionnaires were compiled, and the results were that 93% of the participants to this workshop worked for organisations at the initial maturity level (level 1) and the remaining 7% were at the repeatable level (level 2) of the maturity scale. Although the assessment of organisations according to the SEI's approach would have been far more stringent, these results remain nevertheless indicative of the situation prevailing at that time.

As a comparison, the United States conducted similar workshops and gathered data from 113 projects (Humphrey 1989). The assessment workshop results as of January 15, 1989, indicate that the majority (86%) of the participants reported projects at the initial level (level 1). Fourteen per cent (14%) of the participants reported projects at the repeatable level (level 2) and one per cent (1%) reported projects at the defined level (level 3).

Following the tutorial held at École Polytechnique, some organisations decided to conduct software process assessments and improvement activities. The following section will present organisations that have performed software process assessments and improvement activities.

5   Some Software Process Improvement Experiences in Québec

The data published here have been supplied by the organisations themselves and not by ASEC, since the latter has to respect the confidentiality of the assessments done by the organisations. Moreover, we will only be discussing the organisations that have undertaken the improvement of their processes utilising either the CMM, a model, or an assessment method associated to the software capability maturity model such as Trillium. Because of space limitations, process improvement activities related to the ISO 9000 standard will not be discussed.

5.1   CAE Electronics - Fighter Aircraft Maintenance Group

In 1990, CAE Electronics, in collaboration with Bombardier, decided to go ahead in performing a Software Process Assessment using the SEI's assessment method. A group of CAE Electronics is responsible for the maintenance of the software of the Canadian Armed Force's fighter aircraft CF-18 fleet. For this assessment, it was decided that the assessment team would be composed of representatives from the customer's organisation as well as representatives from the assessed organisation. The on-site assessment was performed in

February of 1991 and the action plan was published in September. The costs of process assessment and improvement activities (Lambert 1992) are summarised below (Table 1). This division has also performed, in collaboration with ASEC staff, in the summer of 1994, an assessment using the new method developed by the SEI. This method is called CBA IPI (Capability Maturity Model - Based Appraisal Internal Process Improvement). We know that the group responsible for the maintenance of the fighter aircrafts was assessed at maturity level 2, hence mastering all objectives of the 6 key sectors of the CMM. The assessment has also showed that several objectives of level 3 were reached.

Assessment training and consulting cost:		Cdn$40,000
Labour:		
	Training	160 hours
	On-site assessment	240 hours
	Action plan elaboration	500 hours
	Action plan implementation	2,500 hours

Table 1: Assessment and Improvement Costs

5.2 Lockheed Martin Canada

In 1991, Lockheed Martin Canada, formerly known as Paramax Systems Canada, decided to perform an SEI assessment. Lockheed Martin Canada is an organisation mainly responsible for the development of the Canadian patrol frigate's computer system. The 2 million source lines of code software were developed by a large team of over 200 engineers, geographically dispersed in Canada and in the United States. Since 1991 Lockheed Martin Canada has been improving its processes using the SEl's CMM, TQM (Total Quality Management) and ISO 9000 principles.

5.3 Hydro-Québec - Automatisation Group

In 1993, four organisations performed SEI assessments. The first organisation is the province of Québec's electricity supplier: Hydro-Québec. Its automatisation department conducted an in-house assessment using the SEI questionnaire (Humphrey 1987). This department, staffed with

17 people at that time, is mainly responsible for the development and maintenance of real-time embedded software that controls the Quebec's electrical network.

5.4   Oerlikon Aerospace

The second organisation that conducted an assessment in 1993 is Oerlikon Aerospace (Laporte 1996b). This organisation is responsible for the production of an air-defence anti-tank system. The software engineering department, staffed with over 25 people, is responsible for the maintenance of the weapon's software; the command control and communication system's software; simulation software and instrumentation software. The on-site assessment was done in collaboration with the customer and the Applied Software Engineering Centre, in the spring of 1993. The action plan was completed in December 1993 and the process improvement activities were initiated in January 1994. The action plan aims at implementing within Oerlikon Aerospace level 2 and 3 practices in compliance with the SEI's model. The organisation is planning a re-assessment, in collaboration with the Applied Software Engineering Centre, in 1996.

Oerlikon Aerospace has also undertaken, in 1995, a systems engineering improvement program. The effort was started by performing an internal assessment using the Systems Engineering Capability Maturity Model (SE-CMM) (Bate et al., 1995) and the SE-CMM Appraisal Method (SAM). A beta version of the systems engineering process has been defined, and pilot projects are being conducted. As pilot projects are using the new process, practices are identified and incorporated into the process description. A parallel effort is also conducted to integrate the systems engineering process to the in-use software engineering process.

5.5   Montréal Trust (Scotia Bank)

The third organisation that performed an assessment is the Montréal Trust. Montreal Trust has been, since then, acquired by the Scotia Bank. Montreal Trust used to offer a range of financial and trust services. It administered assets of $64 billion. The on-site assessment was done in spring of 1993 and the recommendations were presented to management in fall of 1993. Montréal Trust was assessed as a strong level 2 and was expected to reach level 3 by the end of 1994.

5.6 CAE Electronics - Energy Control Department

CAE Electronics is the fourth organisation that performed an assessment in 1993. CAE Electronics mainly develops and manufactures a wide range of military and civilian simulators. In September, the Energy Control System Department, staffed with 90 software engineers, performed an assessment of its processes in collaboration with a customer. CAE uses the ISO 9000 standard as an objective and the CMM as a guide to implement practices compliant to the ISO standard.

5.7 Hydro-Québec - Research Institute

The management responsible for the Network Technologies (DTR) of Hydro-Quebec's research institute (IREQ) has undertaken to improve its processes in 1993 (Lafleur-Tighe 1996). This initiative follows the basics of several development models, particularly the CMM. At IREQ's, the improvement is done by establishing methodological guides, such as definition of the requirements, the development plan and the typical mandate, related to software engineering and system engineering fields. By the end of 1996, the DTR should ensure a repeatable development process and be able to supply process descriptions and/or documentary standards for each step of development, as well as umbrella activities in planning and project-tracking, configuration management and quality-assurance support. It is also foreseen to perform an assessment of the processes in 1996 and a follow-through assessment in 1998. The DTR's objective is having a defined process, i.e. a level 3 according to the CMM, by 1999.

5.8 IST Group

In 1994, the IST Group started a process improvement initiative using the S:PRIME assessment method (this method is described further in this text). This initiative began by a training session in 1994, followed by a series of assessments in 1995 in Toronto, Quebec and Montreal. An action plan was approved in May 1995. The initiative permitted to identify the best practices, to complete their descriptions and transfer them in other sectors. Each sector could customise the practice to its own requirements. One of the objectives aims at obtaining the ISO certification in 1996.

5.9   Ericsson's Total Business Improvement Program

In 1994, the company Ericsson undertook an improvement program (Modafferi 1996). The ISO certifications had been obtained in 1993. The initiative followed a reflection on the challenges to be faced by companies world-wide. Following this reflection, it was decided that the software capabilities were among the company's major objectives. In May 1995, an assessment was realised in Montreal by a team of experts belonging to the mother company. It is interesting to underscore here that Ericsson conducted over twenty assessments on its various sites. The assessment method used was very similar to CBA IPI. Elements were added to it, from the assessment method called "European Quality Award" in order to add practices that were not covered by the method CBA IPI. The company foresees to conduct a second CBA IPI assessment in 1997, it will be using the S:PRIME method to assess the progress made between two major assessments.

5.10 Canadian Marconi Company

Canadian Marconi Company (CMC) has a wide range of domains and applications, and the domains are organised in business units distributed over a number of sites in Canada and in the United States (Sayegh 1996). The objectives of the software process effort are: to address the needs of all business units; to ensure buy-in from all entities; and to optimise cost effectiveness. At CMC, software process improvement is managed as a project and a management steering group provides oversight and verifies the progress of the effort. A process improvement project is started by performing a CBA IPI assessment with accredited SEI assessors and establishing a software engineering process group. A software process has been defined with a minimum set of requirements addressing the needs of the business units. Each business unit tailors the process by adding practices as required. CMC terminology, instead of CMM's terminology, has been used such that processes are easy to use and unambiguous.

In 1994, Canadian Marconi Company initiated its process improvement program. A first CBA IPI assessment was performed, at the Montréal site, by the Applied Software Engineering Centre. An improvement plan was developed and approved in April 1995.

5.11 Régie de l'assurance -maladie du Québec

In 1996, the Management Information System (MIS) department internal to the Régie de l'assurance-maladie du Québec (RAMQ) decided to initiate an improvement program by using the result of the Camélia project. The effort started by performing an assessment (Bistodeau 1996). Two assessments were conducted under the supervision of ASEC and the Treasury Board of the Québec government: one for the development and the maintenance processes of the information systems, and one for the operation processes. The first assessment evaluated about 300 practices related to development and maintenance while the second evaluated about 150 practices related to the operations of information systems. The action plan based on these two assessments should be completed by the end of October 1996. This action plan will be inserted in the overall enhancement plan inside the MIS department.

5.12 Bombardier - Mass Transit Division

In previous train systems, sub-systems were controlled through electro-mechanical devices. They were developed and tested individually and then integrated on the railway car. Today, not only sub-systems are more complex, but they are controlled by software and they often communicate between each other. Moreover, once defined, requirements are often modified. This has led the mass transit division to define a software development process (Bélanger 1996). In addition, since many components are acquired through suppliers, subcontracting management practices were defined. An assessment was also performed using the S:PRIME method.

6   Process Related Activities

6.1   Montréal SPIN

Montréal is the host of a SPIN (Software Process Improvement Network). Essentially, a SPIN is an interest group composed of software professionals from industry, government, academia, professional organisations, and consulting agencies. The SPIN provides a forum for the free and open exchange of information on software process improvement. The SEI provides some support to the SPIN (Marchok). In fact, the SPIN in Montréal is part of an international network of interest groups called "SPIN for Software Process Improvement Network". The 1996 SPIN directory listed 42 U.S. and 29 international SPIN organisations. The Montréal SPIN was founded in 1993. Its mission is to facilitate the understanding, the adoption and the

deployment of proven or innovation solutions for software process improvement. Each year, the SPIN organises events such as tutorials, workshops and round tables. The SPIN is affiliated to the Applied Software Engineering Centre; the meetings are generally held at ASEC facilities. In addition, the SPIN benefits from the administrative services offered by ASEC (e.g. mailing, reservation, accounting).

The co-operation between the Montreal-SPIN, ASEC, the SEI and the International Council on Systems Engineering (INCOSE) gave rise to an international symposium on systems and software process improvement, entitled Vision96, was held in Montreal in October 1996. This symposium was aimed at gathering managers, professionals and contributors intervening in the continuous implementation and improvement of systems and software processes. It represented a unique opportunity to perfect participants' knowledge and enrich their vision by sharing their experience and concerns on subjects such as investing, stakes, risks, profits and international trends in process improvement. Over 238 persons from 10 countries attended the symposium.

6.2   Software Engineering Standards Interest Group

ASEC also hosts an interest group that focuses on software engineering standards (GINIGL). More specifically, this group is very active in the ISO-SPICE project (lnternational Standards Organisation: Software Process lmprovement and Capability Determination (Paulk 1994b). In collaboration with the interest group, ASEC participated to the first field trials of this forthcoming ISO standard, in 1995. More than 35 international organisations participated in these field trials, of which one took place in Quebec. Hydro-Québec's Automatisation Department, i.e. 35 people, participated to the field trials. An action plan was developed following the assessment: it integrates both the concepts of the SPICE model and those of the SE-CMM model (Systems Engineering CMM). The second SPICE field of trials will begin in May 1996 and will last 12 months. Again, the GINIGL and ASEC will play a major role in the co-ordination of the field of trials in Canada, Central America and South America.

6.3   S:PRIME Assessment Method

Since there is close to 500 small or medium businesses that develop software in Québec, it was felt that these organisations could not afford the resources of performing a CBA IPI assessment and still be able to set aside resources needed to address the findings of the assessment. A CBA IPI typically requires around 1500 person-hours on the part of the assessed organisation. Also, an organisation that do not have in-house assessors must add the cost of a certified assessor

who will spend at least ten days in the preparation and the conduct of the assessment. Therefore ASEC, in collaboration with industrial partners, developed a risk evaluation method based essentially on the CMM key process areas. The method is called Software: Process Risk Identification Mapping and Evaluation (S:PRIME). The result of S:PRIME assessment consists in an identification of the risks the organisation or the project are faced with, as well as in an identification of the CMM practices that should be improved or introduced in the organisation or project in order to prevent these risks (Poulin 1996). The method typically takes 100 staff-hours to perform the assessment of an organisation. Once an organisation has been trained, it can perform by itself follow-up S:PRIME assessments in order to track action plan progression or identify other areas of priority.

The method consists in administering two questionnaires. A first questionnaire is answered by managers in order to identify their perception of the level of risk in their project(s). Seven risk categories are addressed. They are risks related to: requirements, design and production, the development environment, the development process, management, personnel, and external constraints. The taxonomy of these risks constitutes the result of the work performed by the SEI these past years. A second questionnaire is answered by practitioners assigned to the assessed project(s). This questionnaire addresses level 2 and 3 key process areas of the CMM augmented with two practices: customer service and organisation culture. An algorithm computes the expected value of the risk level for each risk category and each practice area. Figure 1 illustrates graphical results generated by the software tool.
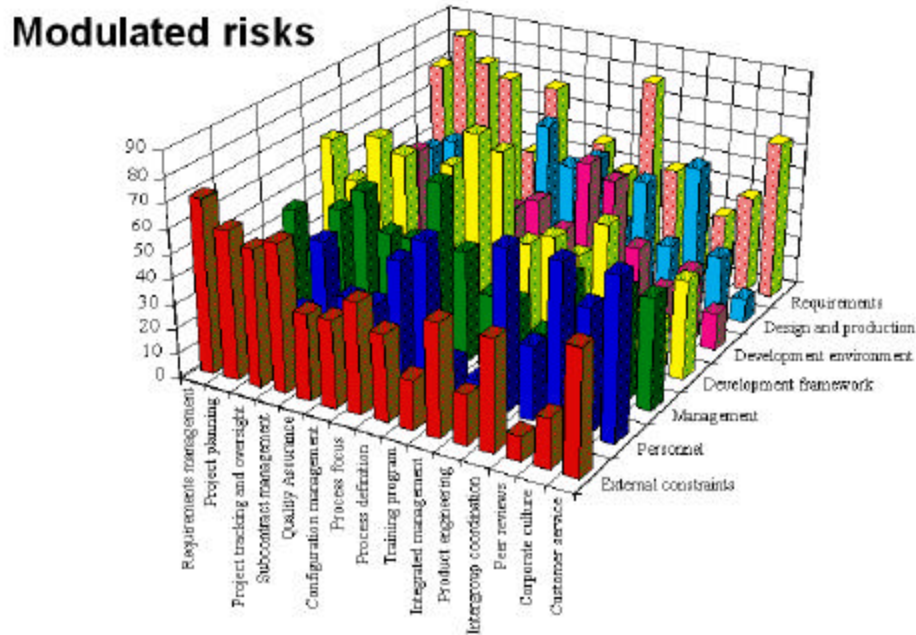
Figure 1. Typical results of a S:PRIME assessment

So far, twenty two S:PRIME assessments have been performed of which two in Chile and one in France. The method has also been translated into French and Spanish. The method is supported by a software tool in order to facilitate the capture, the analysis and the presentation of the date gathered during an assessment. An action planning approach also complements the S:PRIME assessment.

6.4   Personal Software Process

The Personal Software Process (PSP) is a framework for doing disciplined software engineering. The PSP was developed under the direction of Watts Humphrey (HUMPHREY 1994, 1996) of the SEI. The PSP consists in activities similar to several key sectors of the CMM. Essentially, PSP shows professionals how to use measurements and statistical methods to plan and control their work. It also helps them to make accurate plans, to estimate the accuracy of these plans, and to track their performance. They learn to define, evaluate and

improve a software process that is tailored to their own evolving personal needs. This helps them to evaluate and progressively improve their own performance. CAE Electronics, in collaboration with McGill University, undertook a pilot study to see if the PSP could be adapted to their organisation (Shostak 1996). Twenty eight volunteers participated in the study. The approach was to provide the PSP lectures and then allow the volunteers to apply the techniques in their job.

6.5   Risk Assessment for Investment Decisions

An organisation, Telsoft Ventures Inc., with a software venture capital of $78.2 million uses a process maturity assessment as one indicator of risk level before making substantial investments in organisations (Mayrand 1996). Other issues evaluated are: financial health, technology created, market, technology and product maturity, and management maturity. A first process maturity is performed before a decision is made to invest in the target organisation. Then, once the investment is made a detailed process assessment is conducted, and an improvement plan is defined and executed. A joint assessment, based on Trillium, is performed. One of the goals, in performing a joint assessment, is to train the employees of the organisation. The improvement plan usually starts by documenting actual processes. Then, support and requirement processes and customer interfaces are defined. Finally, the development process is formalised and formal reviews are introduced. Re-assessments are conducted initially at 6-month intervals.

Table 2 lists organisations known by the author, that are actively involved in software process engineering activities. So far, most assessments were performed by large organisations, using the SEl's approach. ASEC performed at least five SEI assessments since April 1994 and expects to conduct another five in 1996-97. Since in Québec the number of small and medium organisations outnumbers the number of large organisations, we expect a growing use of S:PRIME method. Finally, since it is expected that SPICE will become and ISO standard in 1998, it is possible that organisations choose to wait two or three years before deciding whether to adopt this type of assessment or stay with the SEI's approach. It is also possible that the SEI decides to map its maturity model to the SPICE framework. It is worth mentioning that the SEI is collaborating to the development of a System Engineering Capability Maturity Model (SE-CMM). This CMM is using a framework nearly identical to the SPICE framework for the mapping of maturity levels (Bate et al., 1995).

Organisation	Sector	Year	Activity
CAE Electronics and Bombardier	Defence	1991	SEI - SPA (1)
Lockheed Martin Canada	Defence	1991	SEI - SPA (1)
Hydro-Québec	Utility	1993	Internal assessment using CMM
Oerlikon Aerospace	Defence	1993	SEI - SPA (1)
Scotia Bank (Montréal-Trust)	Finance	1993	SEI - SPA (1)
CAE Electronics	Energy Management	1993	SEI - SPA (1)
Hydro-Québec- IREQ	Utility - Research	1994	Internal assessment using CMM
Ericsson	Telecommuni-cations	1994	SEI - CBA IPI (3)
CAE Electronics and Bombardier	Defence	1994	SEI - CBA IPI (4)
Canadian Marconi Company	Defence	1994	SEI - CBA IPI (4)
M3i	Network Management	1994	S:PRIME (5)
Hydro-Québec	Utility Automatism	1995	SPICE
IST Group	Information Systems	1995	S:PRIME
Bombardier-Mass Transit Division	Transport	1995	S:PRIME
CRIM	Research & Development	1995	S:PRIME
RAMQ	Information Systems	1996	Camélia (6)

Table 2: Software Process Activities in Québec

Note:
1. SEI - SPA: Software Engineering Institute Software Process Assessment with third party.
2. Internal assessment using CMM conducted without participation of third party.
3. SEI - CBA IPI: SEI - CMM based-assessment: Internal Process Improvement with third party together with additional practices.
4. SEI - CBA IPI: SEI - CMM based-assessment: Internal Process Improvement with third party.
5. S:PRIME: Software Process Risks Identification, Mapping and Evaluation
6. Camélia: Based on Trillium with practices for Management Information Systems

6.5 Software Engineering Management Research Laboratory

This laboratory is located at l'Université du Québec à Montréal and directed by professor Alain Abran. Its mission is to develop, for our software engineering community, the analytical models and measurements instruments to enable them to improve their decision-making processes in order to meet their business objectives. The laboratory is funded partly by Bell Canada and the National Research Council of Canada. One field of research is the development of an evaluation and improvement model for software maintenance processes (Zitouni 1996). The model is largely inspired by the CMM for software. Since the CMM is heavily development-oriented, it does not necessarily apply to maintenance. The project will identify, describe, structure and model the components of the proposed model and insert them in a CMM-like structure. The present version of the model is composed of 21 key process areas, 63 goals and 312 practices spread from level 2 to level 5. It also includes a glossary of 112 words specific to the maintenance domain.

7   Lessons Learned

These assessments enable us to learn certain lessons likely to be used by other organisations or companies in the future.

Lesson 1: Set Realistic Expectations for Senior Management

Appropriate expectations must be set prior to embarking on a process improvement journey. The trap consisting in communicating to management the idea that the initiative will be easy, fast and inexpensive has to be avoided at all costs. As a first step, a top management member realises the benefit that attaining a maturity level can represent for his organisation's competitiveness. As second step, a project manager or an external consultant states, in order not to upset the top management, that this objective is easily attainable. As a third step, top management gives managers the mandate to attain this objective in a very short lapse of time. During the assessment, the managers face countless a string of findings. Findings that had been known by developers for a long time, but remained ignored due to the mode of management that consists in dealing continuously with the problems created (i.e. fighting fires), in a clumsy way at times, by managers. Top management, that had maybe already announced its objective to its peers from other organisations, realises suddenly that this objective will take a lot more time and resources than what had been estimated. At that time, three reactions are possible. Top management may accept the findings and confirm that it will continue to support the

objectives announced. It may announce discreetly that it will be lowering its objectives. Finally, it can deny everything 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 for a fact that the deficiencies they had been deploring for a long time are now known by everybody and will remain ignored for a long time.

The lesson to be remembered is to prepare a first action plan -- some sort of a brief appraisal of the situation status -- preferably by someone who is not involved in the sector targeted and to assess the time and resources necessary to assessing and, writing and implementing the action plan. One has to remember top management does not like bad surprises. 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 CMM level 1 organisations consists in realising that 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 representatives 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 champions of the process improvement program. The developers must receive very clear signals announcing that the changes advertised will be implemented and that they themselves will have to adopt new practices.

Lesson 3: Establish a Software Process Engineering Group

The Software Capability Maturity Model suggests the formation of a Software Engineering Process Group (SEPG) for any organisation heading toward level 3 (Fowler, 1990). Even for a level 1 organisation, it would be better that a small number of persons becomes active in process activities a couple of months before the on-site assessment. The SEPG should take this time to familiarise itself with the Capability Maturity Model and associated process improvement methods and tools. Ideally, in a large organisation, there should be one full-time

person on the SEPG while the other members could be assigned on a part-time basis. Beside their technical competencies, the members of the SEPG should be selected based on their enthusiasm for improvement and the respect they have within the organisation.

Lesson 4 : 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.

During the assessment, it is recommended to collect both quantitative and qualitative data (i.e. indicators) which will be used later to measure the progression realised. One could obtain data on non respected 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 very appropriate to be able to demonstrate that these investments have been profitable.

Lesson 5 : Train all Users of the Processes Methods and Tools

Once the processes defined, it is essential to train all users. Otherwise, all related 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 anxiety in their using these new practices. It would be a good thing that a resource-person be available to help developers when the latter face obstacles while implementing new practices.

Lesson 6 : Manage the Human Dimension of the Process Improvement Effort

The author also wishes 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 software engineering practitioners, however not too well equipped in change management skills. The reason for this is simple. During their training, they focused on the technical dimension and not on the human aspect. However, the major difficulty in the whole

improvement program is precisely the human dimension. Also while preparing the technical part of the action plan, the change management elements have to be planned (Laporte 1994). 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 author is 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 7 : Process Improvement Requires Additional "People Skills"

In an organisation that truly wants to make substantial gain in productivity and quality, a major cultural shift will have to be managed. Such a cultural shift requires a special set of "people" skills. The profile of the ideal software process facilitator is someone with a major in social work and a minor in software engineering. The implementation of processes implies that both management and employees will have to change their behaviours. With the implementation of processes, management will need to change from a "command and control" mode to a more 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, i.e. the employees. 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 bug, from being passive and unheard in management issues to work in teams and generate and listen to others' ideas to make improvement.

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 will "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 the inspection process is to detect and correct errors as soon as possible in the software process. 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) 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 early in the process is that those who participated to an inspection will learn how to avoid these errors in their own work.

Facilitating such a change in behaviours 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 author recommends a course given by the SEI, the title of which is "Managing Technological Change". For lack of such a course, the author recommends to read 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.

8   Conclusion

The Software Engineering Institute's Capability Maturity Model as well as Trillium and SPICE models have been used successfully by some organisations in Québec to conduct assessment and to put in place process improvement programs. As more organisations perform similar activities, we should be in position to verify if these activities will have an impact on software productivity and on organisations' profitability. Finally, let's remember that any improvement process includes a human dimension which, at times, has a bigger impact than the technological dimension, should it be neglected during the improvement phase.

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For more information, please get in touch with the following electronic addresses:

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Applied Software Engineering Centre - http://www.crim.ca/cgla/
IREQ - http://www.ireq.ca/degel
Trillium model - http://ricis.cl.uh.edu/Trillium/
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