Managing the Software Process in the Middle of Rapid Growth: A Metrics Based Experiment Report from Nokia

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Abstract. Software Process Improvement is a well known approach in software organisations these days. Process assessments or audits have been experienced in one form or another by 'almost everybody' in the business. What are the benefits that have been reached through these efforts? An assessment or an audit is often planned and carried out by people who are outsiders in the organisation and the result of these approaches is normally an improvement plan or a set of process improvement ideas. What happens after an assessment? Who takes the responsibility to take care that the improvement plan is really implemented in an organisation? More and more organisations take this challenge seriously and have allocated a remarkable amount of resources to develop their process improvement a continuous activity. This paper presents one approach for organising process management activity in an organisation and also practical experiences collected in using the approach.

1 Introduction

Process management and improvement are concepts that have become to everybody's consciousness in software business during the past decade. The aim of these approaches is to teach organisations to carry out their daily routines in a correct and careful way. The quality must not be sacrificed even under the threat of tight deadlines. In an ideal situation the software projects can be planned in a way that resource usage and schedules are in balance and at the same time the quality of the products is on satisfying level. This provides good facilities for keeping the customer satisfaction high. All these observations are often heard as arguments when process improvement is offered as a mean of increasing the overall effectiveness and quality in an organisation. Do these ideas work in practice then? Certainly, if you manage to to implement them successfully in an organisation.

Several process improvement methods use assessments as their main source of information in collecting data of a target organisation: ISO/IEC 9000 standards [5, 6], CMM [2, 3, 4, 11], Bootstrap [1], ISO/IEC 15504 [7], etc. However, in order to make an improvement approach a continuous and fundamental activity in an organisation

there is a need to create a capable process management activity. In a large organisation this normally means a separate process management organisation with several full-time process developers belonging to it. How to build this type of sub-organisation then? How to plan its activities? How to create effective communication mechanism between the process management activity and the rest of the organisation? These are just few of the questions that need to be solved in an organisation that aims to make a severe attempt to start a process management activity as a part of its daily routines.

Fixed Switching Research & Development (FSG R&D) unit of Nokia produces software for the DX200-product line of phone switches. As a separate Nokia unit its history started in the year 1995 and today it has approximately 600 employees. The volume of production has together with the number of employees grown rapidly in FSG R&D ever since the beginning. All these attributes make FSG R&D an interesting environment from the point of view of Software Process Improvement. This paper presents the experiences got in FSG R&D in developing a process management activity in it a systematic way.

2 FSG R&D

FSG R&D (Fixed Switching Research and Development) unit of Nokia produces software for the DX200-product line of phone switches. DX200 development was started in early 70's as a research project and the first customer delivery took place in 1980. Currently the third generation of DX200 is in production and the applications of it cover all the main areas of switching business. There are over 15 million source lines of code in the DX200 program library and more than 2000 engineers are committed to carry out the DX200 development work. Unofficially DX200 is the largest software project in Finland. FSG R&D produces Fixed Applications on DX200 System Platform, presented in figure 1.

Another important type of applications being developed on DX200 platform is the GSM applications. The phone switches applications typically have common core part on the top of which a customer specific part is built for building the separate customer deliveries.

From the point of view of FSG R&D the DX200 environment means the following challenges to cope with:

- large and complex software,
- large and growing software and
- a multisite environment.

Ever since year 1995 the number of customer deliveries and projects has strongly grown each year in FSG. Figure 2. presents the trend of increase in the number of projects in FSG R&D from year 1996 to year 1999. Today the number of customer delivery projects is four times as big as it was in year 1996. This fact, together with the increased number of employees, have led FSG R&D to a situation where it has had to develop a high standard Process Management activity to be able to cope with

the increased demands. High standard processes make it possible on the one hand to create capable facilities for the new employees to be trained to their tasks and on the other hand to coordinate increased numbers of people and projects – without sacrificing the quality.

Fig. 1. DX200 Applications and System Platform [9]

Fig. 2. The relative trend of the number of FSG R&D customer delivery projects in comparison to year -96 level.

3
Process Management Activity of FSG R&D

In front of the challenges presented in the previous chapter FSG R&D has already from the beginning clearly realised that high standard processes and efficient process improvement have a vital role in the organisation. FSG R&D allocates remarkable effort on reaching these goals, i.e. there are fourteen full-time process developers in

the organisation and more than 60 part time process developers on the different organisational levels. The common objective of all these process developers is taking care of continuous improvement of FSG R&D processes, methods and tools.

The process improvement activity of FSG R&D, illustrated in figure 3, is steered by the FSG R&D Management Team. The processes of FSG R&D have been divided to five separate process areas: *Release-, Design-, Testing-, Maintenance- and Quality Assurance Processes*. All these process areas are managed by the Process Teams each of which are responsible of one specific area. Each process team is headed by a Process Development Manager who is a full-time process developer. The rest members of the teams are part-time process developers, i.e. their primary role in FSG R&D is sw development, testing, etc. The Management Team defines the long-term process improvement Road Maps and Action Plans and also accepts and gives resource commitment to the process improvement projects proposed by the Process

Fig. 3. The Steering Structure of FSG R&D Process Improvement Activity [9]

Teams. All process improvement projects are carried out the same way like the software projects in FSG R&D and their progress and resource usage are followed and compared to the project plan. FSG was originally separated from another Nokia unit to a unit of its own in year 1995. It inherited the key process models for itself partly from its Nokia mother unit and partly from the general process models of Nokia. The inherited models were based on ISO 9000 standard and the general project milestone model of Nokia and offered a firm base for starting productive work in FSG. However, it was obvious already in the beginning that the business of FSG will grow rapidly during the following years. The need for tailoring and improving the process models further to satisfy the FSG specific needs became urgent. The most important process improvement activities carried out in FSG R&D from year 1996 to 1999, illustrated in figure 4, are:

Fig. 4. History of FSG R&D Process Management Development: the highlights from year 1996 to 1999 [9].

1. In year 1996, the Process Management activity and model for continuous process improvement were established in FSG R&D. It was also started to build a Metrics Programme [10, 12] for FSG R&D needs and the first FSG R&D wide Metrics Programme concentrating on the Product Process metrics was started at the end of year 1996.
2. During year 1997 two CMM based self assessments were carried out for the first time in FSG R&D, and the first long term Master Improvement Plans for Process Management process were defined and implemented in the organisation. The two first main aims in FSG R&D from the point of view of Process Management were reorganising and redefining the Release Management and the Testing processes. Also the development of Innovation process was started during year 1997.
3. In year 1998 the effects of as well the renewed process models as the organised and continuous Process Management activity started to become clearly visible as practical results. A visible proof of this was got in a full scale CMM assessment held at the end of year 1998 in which FSG R&D reached a high maturity level. The most important process improvement approaches started in FSG R&D during 1998 were the redefinitions of the SQA-, Review- and Project-management processes. The renewed SQA included capable facilities for the use of metrics throughout the organisation.
4. Finally, during year 1999, the most important process improvement approaches have been the implementation of a company wide Quality Management system and renewals of as well the Design- and the Product-processes.

Overall conclusion of the status of the FSG R&D software process is that it is educated, well-organised and effectively established through the organisation. However, FSG R&D has gone through a challenging path during the past four years. Despite the fact that the whole Process Management approach seems to have turned to a success story in FSG R&D, there has also been many difficulties that have been encountered

and that have had to be overcome before reaching the recent status. The next section will present some metrics based findings and analyse the details of the effect of systematic Process Management improvement of FSG R&D from the beginning of year 1996 to the end of year 1999.

4 Metrics Based Findings from FSG R&D

The aim of the first Metrics Programme of FSG R&D (see the previous section) was defined to measure the status of the Product Process. The programme was based on a set of metrics each of which were followed four times a year. The programme has been going on for four years now and some trends that show progress of the FSG processes can be seen. Earlier in this paper, in figure 2, the remarkable increase in the number of customer delivery projects in FSG R&D was presented. This number shows strongly increasing trend from year 1996 to 1999. In the middle of this type of rapid growth any organisation has to allocate remarkable amount of resources for developing its processes in order to prevent the accuracy of the projects and the quality of the products to decrease. In the following presentation the progress of four metrics included to the Product Process metrics programme of FSG R&D are presented as trend curves from year 1996 to 1999 (the Measuring Period).

Figure 5. shows the relative trend curve of the delayed projects in FSG R&D during the Measuring Period. This chart is based on the *Release Accuracy* metric of FSG R&D. *Release Accuracy* metric measures the absolute number of days of delay in the projects. A project is classified to be delayed if the delay exceeds the predefined number of days when checked against the original schedule. The trend of the number of delayed customer delivery projects shows slightly decreasing trend during the

Fig. 5. Relative trend curve of delayed projects in FSG R&D from 1996 to 1999.

Measuring Period. This finding shows that keeping of the project schedules is today on a slightly better level than it was in year 1996. During this period the number of customer delivery projects has grown 400 % in FSG R&D.

Figure 6. shows the relative trend curve of the number of faults in FSG R&D during the Measuring Period. This chart is based on the *Release Maturity* metric of FSG R&D. *Release Maturity* metric measures the sum of internally found and customer found faults at major milestones of a project. FSG R&D uses several severity classes for the faults. The faults of the two most severe fault classes, the critical and the important, are counted in to the *Release Maturity* metric value. The curve in figure 6. shows a relative trend of the one year averages of the absolute numbers of faults in FSG R&D projects during the Measuring Period. The trend of the number of faults is showing a remarkable decrease. This finding implies that the average number of faults in FSG R&D projects has strongly decreased during the Measuring Period. The most important factors that have made it possible to reach this result in the middle of the growth have been the renewed Testing and Review processes (mentioned in section 3 of this paper).

Figure 7. shows the relative trend curve of the *Fault Fixing Coverage* metrics in FSG R&D during the Measuring Period. Fault Fixing Coverage measures the ratio of the fixed faults in comparison to the total number of faults in a project. The curve in figure 7. shows a relative trend of the one year averages of the fault fixing coverage percentages in FSG R&D projects during the Measuring Period. The trend of the fault fixing coverage is showing slight decrease from year 1996 to 1997. From year 1997 to 1999 the trend is showing steady increase. It can be concluded that at the same time when the number of faults has decreased in average the effectiveness of fixing the faults has increased. These two findings together show that the quality of software and handling of the faults have improved greatly during the Measurement Period in FSG R&D.

Fig. 6. Relative trend curve of number of fault in FSG R&D from 1996 to 1999.

Fig. 7. Relative trend curve of fault fixing coverage in FSG R&D from 1996 to 1999.

Fig. 8. Relative trend curve of Resource Estimation Accuracy in FSG R&D from 1996 to 1999.

Figure 8. shows the relative trend curve of the *Resource Estimation Accuracy* metrics in FSG R&D during the Measuring Period. The *Resource Estimation Accuracy* metric measures the deviation between the planned use of resources in a project in comparison to the realised amount of resources. The metric value shows the corresponding coverage percentage. The curve of figure 8. shows a relative trend of the one year averages of the Resource Estimation Accuracy percentages in FSG R&D projects during the Measuring Period. The trend of the Resource Estimation Accuracy

is showing steady decrease during the Measuring Period. This type of result has to be considered as an alarming finding that needs to be analysed and taken care somehow. Is it the 'price' of rapidly grown numbers of personnel and projects?

5 Process Improvement Recommendations for a Rapidly Growing Software Organisation

The recommendations presented in this section are experiment based findings made in FSG R&D. The worth of these findings have been validated in two CMM self-assessments, one full-scale CMM assessment and an organisation wide Metrics Programme presented in section 4. The recommendations presented here are especially directed for large and rapidly growing software organisations. However, they are also worth for looking through for small organisations while well managed Project Improvement should be based on certain basic elements in all organisations. Management Commitment is not mentioned as a separate bullet in the list while this subject is an underlying requirement for any Process Improvement Programme – there is no process improvement without active and continuous Management Commitment. The other recommendations are as follows:

1. *Allocate full time process developers in charge.* These days large organisations do a severe mistake if they decide to rely only on part-time process developers in managing their processes. If anybody in an organisation does not have full-time responsibility of the processes the process development activity will definitely not be continuous. Continuous development is the only way to get any real improvement to take place and actually even the only way to keep the previous level of process maturity. Among 600 employees of FSG R&D there are 14 full-time process developers.
2. *Use part-time process developers for assisting roles.* Part-time process developers are necessary in an organisation for supporting and assisting the full-time process developers. Their role is to provide facilities for collecting and transferring information to both directions, i.e. from software development organisation to process management organisation and vice versa. In addition to their role as part-time process developers these people also have defined roles as part of normal processes of the organisation. This type of people are in an excellent position to show example to the rest of the people in starting to use new models, tools, etc. FSG R&D has approximately 60 part-time process developers who participate process management monthly.
3. *Plan process improvement approaches as projects.* Project improvement approaches should be planned and followed as projects, i.e. they should be treated the same way like the product development projects. This is the only way to ensure that they get the resources they need and that they are fulfilled in the defined schedule. Process improvement is not something that somebody does on his/her 'own' time.

4. *Get resource commitment of all the necessary groups in organisation.* Process improvement activities can not be implemented by 'external forces' alone in an organisation. Unavoidably these approaches bind also a certain extent of product or software development resources. In practice this means that people who are expected to follow the processes are also required to participate in planning of them. The commitment for allocating these resources for process improvement projects should be given by the organisation resource owners the same way it is given for product development or software projects. Otherwise it is likely that the planned resources will not be available.
5. *Define clear milestones for process improvement projects.* Process improvement projects need the same type of follow up as the 'normal' projects. Plans, resource allocations, schedules, etc. are all necessary also in process improvement projects. Clear milestones with defined set of exit criteria are vital part of the follow-up.
6. *Test new models and ideas by piloting.* Costs of spreading a new process or a practice to a large organisation are normally high. Number of people need to be trained, number of installations need to be done, and so on. A good idea is to select a part of organisation for piloting the new practice there at first. By this way the errors found must be fixed only for the people in the scope of the pilot. The rest of the organisation then get the fixed delivery of the practice already at the first hand.
7. *Plan the roll out of new processes and practices carefully[8].* A new process model or a practice will probably not be popular in an organisation if the roll-out of it is not planned carefully. Things to be noticed in planning the roll-out are for example: target group, technical questions, technical support, training channel, training events, training material, usage support, information for interest groups, etc.
8. *Use metrics for follow-up and planning of continuous improvement.* Comparable and valid long-term follow-up results can not be collected without proper set of metrics. Definition of the metrics is a wide task that is recomendable to carry out as a Metrics Programme. In FSG R&D there are several Metrics Programmes going on continuously.

6 Conclusions

A well planned and carefully implemented Process Management Organisation is a vital part of any large software organisation these days. The existing Process Maturity models and assessments based on them offer a good base to get started in arranging an effective Process Management activity in an organisation. However, a process assessment is only a start – the practical process improvement efforts need to be planned and carried out after it. In many organisations these days it is not realised clearly enough that reaching good results in process improvement requires capable resources. This is understandable while the pressure of product development and software projects is hard and demands often 'all possible resources'. However, re-

sources spent on process improvement efforts will bring the money spent on them back if the efforts are planned well.

A long term plan for process improvement is required in order on the one hand to coordinate and fit together the separate process improvement activities in an organisation and on the other hand to evaluate the progress made through years. Learning from the history is a vital part of process improvement. It is also important to regard the process improvement approaches as 'normal projects' with proper follow up, clear milestones and capable resource allocations. Otherwise there will not be any remarkable results. Also things like piloting the big improvement approaches first in smaller groups and careful planning of the roll-out of new models and tools are worthwhile to notice. Finally, the definition and implementation of well focused metrics give a firm base for evaluating the quality of the processes and the products and offer an effective way to inform the employees of the strategical goals.

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