Introduction of Software Process Improvement within Philips Medical Systems

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This article gives an impression of the work environment of an OOTI-graduate at a software development department of Philips Medical Systems and the characteristics of the software development process within that department. A description is given of the introduction of a Software Process Improvement programme within this department and which lessons have been learned over several years of working with SPI.

Philips Medical Systems

Philips Medical Systems (PMS), a part of Philips Electronics, is competing in the world market for medical diagnostic imaging systems. PMS serves the hospitals mainly in the field of radiology, cardiology, surgery, and oncology. The PMS product range consists among others of computed tomography, magnetic resonance, ultra sound, and mammography, but PMS has a leadership position in the field of X-ray systems. For our products, image quality is one of the most important characteristics. There are, besides image quality, other aspects that gain importance. This is caused by the efficiency drive due to the cost savings in the medical care. Examples of these aspects are teleradiology and archiving systems.

The department *Cardiovascular Systems* of PMS

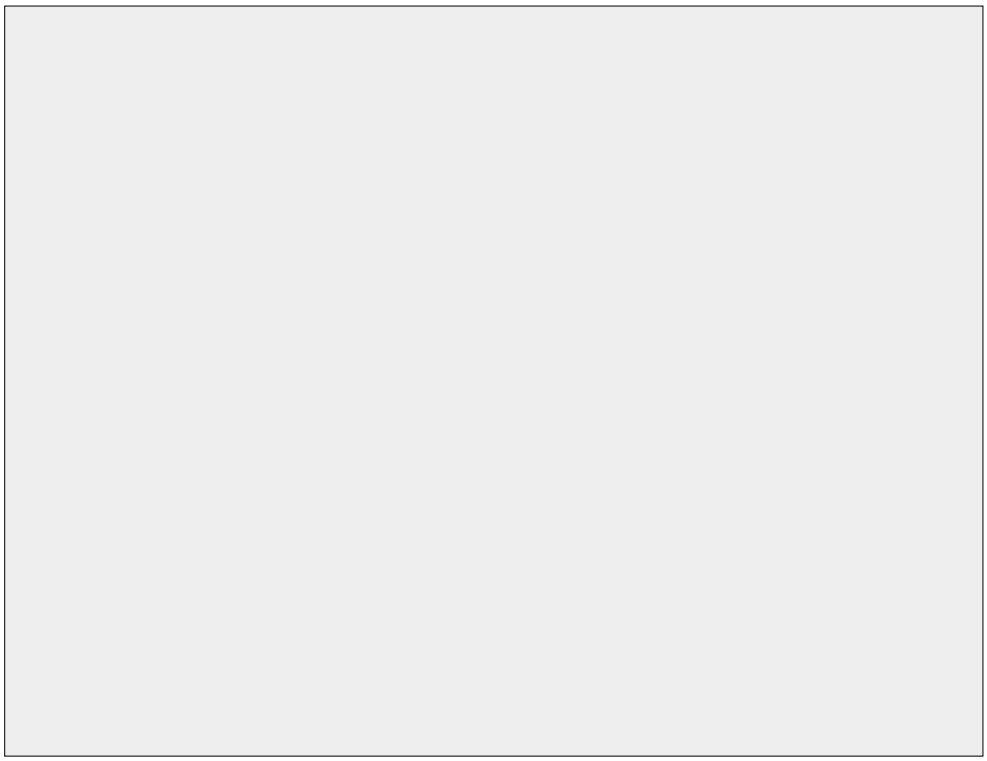

Figure 1: A monoplane Integris system (Photo: Philips Medical Systems Nederland B.V.)

develops the product line *Integris*, which is the most complex line of X-ray systems used in cardiac, vascular, and neuro applications. These systems consist of three subsystems: (1) the *geometry* subsystem, which is the patient table and the stands for the X-ray system, (2) the *acquisition* subsystem which coordinates the X-ray tube, and (3) the *viewing* subsystem, where the images from the acquisition system are collected and shown after a number of image enhancement steps. The images are shown real-time on monitors in the examination room, and are stored on hard-disks, at a maximum rate of fifty images of 512^2 pixels per second. After the examination is finished, it is possible to review the images and change the image enhancement steps, while the results are shown real-time on the monitors. During the review, it is possible for the system user to select the images that need to be printed, archived, or sent to a workstation.

Within the viewing group of the cardiovascular department, a number of projects are performed. The largest of these projects has the task to develop the viewing subsystem described above. About 20 software engineers and 10 hardware engineers are working within this project. Another important project is the development of a CD-Medical player, which has just been introduced for the cardiac market. The cardiologists working with the viewing system can archive images on CDs, which can be loaded on the CD-Medical player, where further diagnosis can be done.

How we work

The viewing group can be seen as a number of (partly overlapping) projects, namely the various releases of the viewing subsystem. There is roughly one new version of a viewing subsystem each year. Both the hardware and the software can, and usually do, change for a new version. Before a version is released for sales, a large number of development steps are taken. We start off with writing the *Subsystem Requirements Specification*. This document contains the wishes of the marketing department that have to be implemented in the new release. The software architects, which were also involved in the writing of the Subsystem Requirements Specification, then produce a *Software Overall Design*. Because these documents are on a very global level, another Requirements Phase and Design Phase are executed to further detail the system aspects that are changed the most during this release. These phases are called *Functional Requirements Specification* and *Functional Overall Design*.

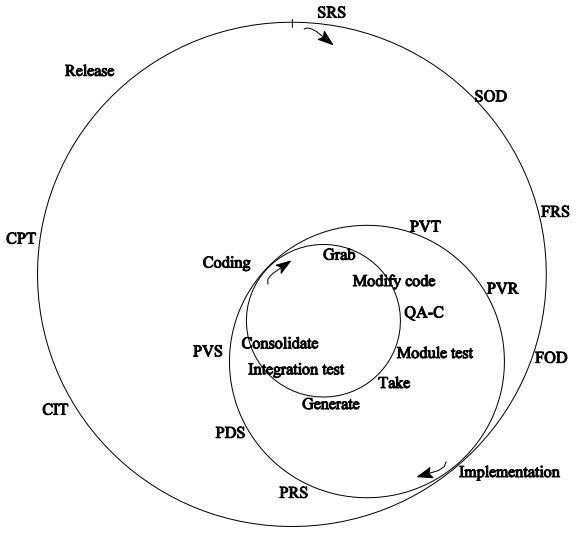

Figure 2: The development cycles.

The functionality which is specified in the high level requirements documents is realized by a large number of software packages which run on the proprietary real-time operating system of the viewing subsystem. To implement the functionality of a release, a number of packages are created or adjusted. For all the packages that are new or adjusted in a release, the phases *Package Requirements Specification* and *Package Design Specification* are performed.

After all these requirements and design phases, the actual implementation starts. The program code is produced, tested statically with a tool for coding standards and frequently-made mistakes. All packages are white box and black box

tested. For this purpose a *Package Verification Specification* is written for each package. After the package tests, a *Package Verification Report* is written.

The development of a release is then completed in two test phases, the integration test where the interfaces between the packages are tested, and the performance test which tests if the implementation satisfies the requirements. For both these test phases Verification Specifications as well as test plans are written. Some test tools are available that make it possible to test specific parts of the software. Part of the tests are performed automatically.

After the two test phases are passed successfully, the software is released and handed over to be tested by another department within PMS, which performs tests on system level.

SPI within Philips Medical Systems

Within PMS a quality assurance department checks the quality of all PMS departments. The quality assurance department is a permanent department within the PMS organization. Next to the quality assurance activities, there are a number of improvement actions, for example TQM (Total Quality Management) and SPI (Software Process Improvement). These improvement actions have their own organization. There exists a lot of interaction between these departments. The SPI organization is organized in the same way as the PMS organization itself. The various departments have SPI coordinators on various levels. On a central level the SPI coordinators take care of improvement measurements through IMPA (Incremental Maturity Progress Assessment) assessments. The progress is also reported through a special two-monthly SPI bulletin. The SPI coordinators on a central level also give SPI courses.

The SPI coordinators within the software development departments support and manage the improvement actions.

SPI in our department

Within this section the approach of Software Process Improvement in the viewing department is explained. Within the department the SPI process started about two years ago. During the two years the approach has been changed a number of times to improve the outcome of SPI and because of new views on the SPI process. The various approaches are described in a chronological order. In the description of the approaches the improvements compared to the previous approach are explained. The critical success factors management support, project organization, resource management and information sharing are used in this explanation.

The first approach to improve the software process during the SPI action started two years ago within the viewing subsystem project. In this project a software engineer was appointed as SPI coordinator who had to manage and push the SPI process. The goal of SPI was to improve the product quality. The SPI coordinator defined a number of improvement actions. These improvement actions were for example the improvement of a number of standards which are in use in the project. A number of software engineers were assigned to work on these improvement actions. They were allowed to spend two hours per week on the improvement actions. Because the SPI coordinator was allowed to work full-time for SPI, the average time that was spent on SPI was 10% of the development capacity. One of the critical success factors for the SPI process is the role of management. Within Philips Medical Systems the attitude of senior management towards SPI has always been positive. This is obvious considering the fact that within our products the role of software has been increasing for years. It is expected that this trend continues. The positive attitude of senior management is illustrated for example by the fact that an entire SPI organization was built. Another example is that 10% of the software development capacity is allowed to be spent on SPI. Also line- and project management have a positive attitude towards

SPI. The project leader actively participates in the improvement actions. During a number of occasions however, all capacity was reassigned to the viewing subsystem project. The SPI project has a high priority, but does not have the same priority as the viewing subsystem project.

After a couple of months the assigned SPI coordinator left PMS. At this moment the SPI project within the department was reconsidered. An assessment was performed, which resulted in more improvement actions. The goal was broadened, next to product quality also development efficiency was added as a goal. A new SPI coordinator was hired to manage the SPI process. The new SPI coordinator was from outside Philips and was hired for his experience with SPI. The already defined improvement actions were continued, but a major change was rapidly made by adopting the Capability Maturity Model (CMM). The main reason to do this was that the improvement could be measured and could be compared with other departments. The other departments of PMS which were involved in SPI had also adopted CMM. During the weekly software progress meeting where all software engineers of the viewing subsystem project are present, the adoption of CMM was discussed. All software engineers (Philips employees as well as subcontracted personnel) were sent to a one day SPI course where the CMM model was explained. The adoption of the CMM model did not immediately change the improvement actions. First the already defined improvement actions, which were considered useful, had to be done. The SPI process improved, because more attention was paid to information sharing. During the weekly project meetings, SPI became a point on the agenda. During these meetings the progress of the various improvement actions was reported. Also the groups responsible for the improvement actions presented their results. The presentations were not only used to communicate the results, they can be seen as reviews of the results. The communication was only done internally. In a later stage, the communication was also done by means of a bulletin board which could be accessed by all project members. External communication was only done during meetings of SPI coordinators of various departments. The progress made by the various improvement actions did not really show in the viewing subsystem project. This resulted in a number of groups that were not motivated to work enthusiastically on the improvement actions. There were no, or not enough, *champions* who could complete the improvement actions.

The SPI process changed again when the SPI coordinator, who was responsible for the SPI process at various PMS departments was replaced by a SPI coordinator especially for this department. Again the (external) SPI coordinator was experienced in the field of SPI. The change of SPI coordinator resulted in two major changes. The first change was that a number of new improvement actions were introduced. These new improvement actions were actually the key process areas for CMM level 2. The second change was that the SPI coordinator was also actively participating in the improvement actions. This was now possible because the SPI coordinator was hired especially for this department. The SPI coordinator was not only hired to manage the SPI process, but also to be the champion in the improvement actions. The idea was that a lot of progress could be made in the improvement actions. Progress is important, but it is also important that the improvement actions really result in a process improvement. The results must be accepted by the people who have to work with it. Therefore, for all new improvement actions (the key process areas), large work groups were appointed. The project leader and the team leaders were involved in all new improvement actions. The critical success factor resource management is in this approach better taken care of because a champion is hired and people are involved. The work groups started from scratch, the description of the requirements of the key process areas were read and interpreted. There were a lot of discussions within the work groups, therefore progress was only slowly made. Because some people were involved in a

lot of improvement actions while they only had two hours per week to spend on SPI, progress was even more slowed down. At that time eleven improvement actions were worked on, while the team leaders were either participating in the improvement actions or reviewing the results of them. The capacity was divided over so many improvement actions that no real progress was made. It was concluded that groups of about five people with full attention (i.e., all their SPI capacity) to that specific improvement action was a basic requirement to make progress. The only exception to this rule is the SPI coordinator.

It was concluded that this approach did not give the desired results. Again the SPI process changed, into the approach we use now. If we look at the critical success factors, the project organization factor was not fulfilled. Therefore it was decided that the SPI project had to be organized and executed as any other project within the department. This included a project plan and a project planning. The improvement actions were given a priority, and based on their priority entered in a schedule. The second change in the approach is that we decided to approach SPI department wide, instead of only for the viewing subsystem project. It was also concluded that the work groups should not start, again, from scratch but the work groups should use the progress made thus far and the results of improvement actions of other departments. This has to give results faster. The first result of the new approach is that the improvement action for metrics was executed within one month, including the deployment within the projects. We are currently working on the second improvement action which is project planning and tracking.

Conclusion

In this article the various approaches we used to make Software Process Improvement a success are described, as well as the reasons to change the approach. A number of lessons can be learned from these approaches.

1. Adoption of the CMM model makes it possible to measure improvements.
2. The communication of progress and results keeps all people up to date. This improves motivation and involvement.
3. It is not wise to divide the scarce resource capacity over a number of improvement actions. This is slowing down progress and thus decreases motivation.
4. Software Process Improvement has to be considered as a project, with a project plan and a project planning.

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