Development and Integration Issues about Software Engineering, Systems Engineering and Project Management Processes

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Abstract

This paper describes the steps taken by our organization to develop, implement and integrate software engineering, systems engineering, supporting processes and project management process over a period of six years.

Background

Oerlikon Aerospace (OA) is the integrator of an air defense missile system. The system consists of a missile launcher mounted on a tracked vehicle, together with radar and optical sensors, electronic control systems and communication equipment. Over 120 engineers are involved in the development and maintenance of the system.

Development of Core Engineering Processes

Software Engineering Process

The software engineering process improvement initiative was initiated, in 1992, by the establishment of a Software Engineering Process Group (SEPG) and the approval to conduct a formal Software Process Assessment. An action plan was developed by the SEPG using, as a framework, the Capability Maturity Model (CMM) for software [1]. Working groups were mandated to develop specific parts of the software process under the close coordination of the SEPG. A second formal assessment was performed in 1997. The assessment confirmed that the organization had made substantial progresses by attaining level 2 and by satisfying 8 of the 17 level 3 goals.

Oerlikon Aerospace has mandated the software engineering manager as the owner of the software process. The process owner is responsible for the effectiveness and the efficiency of the process, methods and tools. Each year, the process owner, in collaboration with the SEPG, develops a software Process Improvement Plan (PIP). The owner has also been delegated the responsibility to review the tailoring of the software engineering process before a development or maintenance project is approved. Knowing that project managers and the process owner may, occasionally, have conflicting views about the tailoring of the process, the software engineering 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 and consequences.

Systems Engineering Process

In 1995, the organization wanted to benefit from the progress made by the software initiative by launching a similar initiative in systems engineering. It was also felt that the organization would greatly benefit from the synergy resulting from the implementation and integration of these processes. The Systems Engineering Capability Maturity Model (SE-CMM) [2] was used, as a framework, together with the Generic Systems Engineering Process developed by the Software Productivity Consortium (SPC) (SPC 1995 [3]). A working group composed of systems engineers, software engineers and quality assurance practioners developed the systems engineering process. The main contribution of software engineers was to provide guidance for the integration of the software engineering process to the systems engineering process. Also, since the organization had been certified as an ISO 9001 supplier in 1993, the representative from quality assurance made sure that the newly

developed systems engineering process would still comply to the ISO requirements.

The systems engineering process was pilot tested in 1996-97. In 1997 each practioner attended a two-day training session on the new process. In addition to the conduct of audits, the organization is planning to conduct an independent assessment of the process in 1999. The systems engineering manager has been mandated as the owner of this process. Similar to the software engineering PIP, a systems engineering PIP is also developed on a yearly basis.

Supporting Processes

Document Inspection Process

A Document Inspection Process (DIP) was developed using the method described by Gilb [4]. After conducting a few inspections, it became evident that software engineers had a higher level of confidence of software documents that were inspected. Although, the organization had a document management process imposing a structured review by peers, software engineers requested that documents that were used as an input to the software process had to go through the inspection process. Since the inspection process had been, on purpose, documented to be a generic document inspection process, other engineering disciplines, such as systems engineers, will be able to use the inspection process as is. Dedicated checklists will be developed for other engineering work products. As a mean to foster a smooth deployment of the inspection process in systems engineering, representatives of software engineering, systems engineering and quality assurance were trained as inspection leaders.

Documentation Management Process

Initially, the Document Management Process (DMP) had been developed to support software engineering activities. At that time the process ownership belonged to the software engineering manager. A few years after its initial deployment, the scope of the process had been enlarged such that it would cover all engineering documentation activities. The process ownership was transferred to the director of engineering services. Recently, with the introduction of new management processes, it was decided that the DMP would be applied to all documents produced by the organization. The process ownership had been transferred to the manager of data and configuration management.

Also, with the successful deployment of the document inspection process (DIP), the DMP was modified in order to accommodate two types of reviews: a peer review and the inspection process. The first type of review is where an originator circulates a document to his colleagues. They individually review the document and forward their comments to the originator. No metrics are collected as part of this process while metrics, such as the number of errors, are collected as part of the document inspection process.

Project Management Process

It was felt that it would also benefit from a standardized project management process. A mandate was given to a working group, in 1996, to develop and implement a Project Management Process (PMP). The working group selected the Guide to the Project Management Body of Knowledge, developed by the Project Management Institute [5], as the framework for the organizational process. The working group was composed of project managers and representatives from engineering disciplines, and representatives from quality assurance, manufacturing, configuration management and logistic support. The process owner of the PMP is the vice-president - Project Management. Figure 1 illustrates the main components of the project management process.

Lessons Learned Process

A lessons learned process had been originally developed for the software engineering process. In order to make sure that lessons learned from a project would be captured at the organizational level, a feature borrowed from the NASA [6] was added to the process. Once a lessons learned session is completed, the process owner is mandated to make appropriate modifications to the process, procedures or methods. This process is now used by other organizational processes such as the systems engineering process and the project management process.

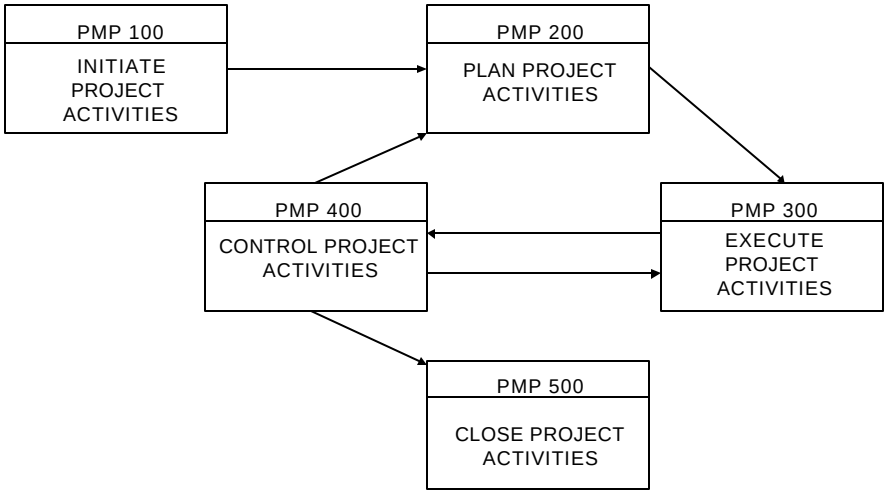

Figure 1. Project Management Process

Quality Assurance and Configuration Management Processes

Other supporting processes that were developed during the software initiative are: configuration management and quality assurance. The scope of both processes were enlarged to be used by other organizational processes. Also, ownership of these processes had been transferred from software engineering to configuration management and quality assurance managers.

Integration of Processes

Integration of Software Process to Systems Process

Throughout the development of the systems engineering process, the working group kept on the agenda the integration between the systems process and the software process. It was decided to adopt, as a framework for the integration the Integrated Systems and Software Process (ISSEP) from the SPC [7]. Since many problems, when developing complex computer-based systems, are discovered at integration time, the solution is to use a process that will decompose the systems in parts that can be developed independently and easily integrated together at the system level. It was also noted that, because of digitization of electro-mechanical systems, the apparent space of software was increasing on projects from nominally 30% in the mid-70's. Software has now reached 60% to 70% of the non-recurring activities in system development.

Furthermore, the expansion of Integrated CASE technologies, which crossed departmental barriers, through common process framework, reinforced the desire of the organization to integrate both software and systems engineering process and to focus the organization into an integrated project team approach. In other words, software and systems engineering are beginning together at the inception of a project. Therefore, the working group selected ISSEP as the reference model.

The ISSEP model defines a decomposition strategy for system development as well as a set of management and technical activities and interfaces between processes. ISSEP describes activities at three levels: the system level, the configuration item (CI) level and the component level. It is at the component level that software and hardware are developed. Figure 2 illustrates the integration between processes. The manage development effort and define system increment boxes are described in detail in the systems engineering process, the develop software configuration item box is essentially the software engineering process, while the develop hardware configuration item box, i.e. the design

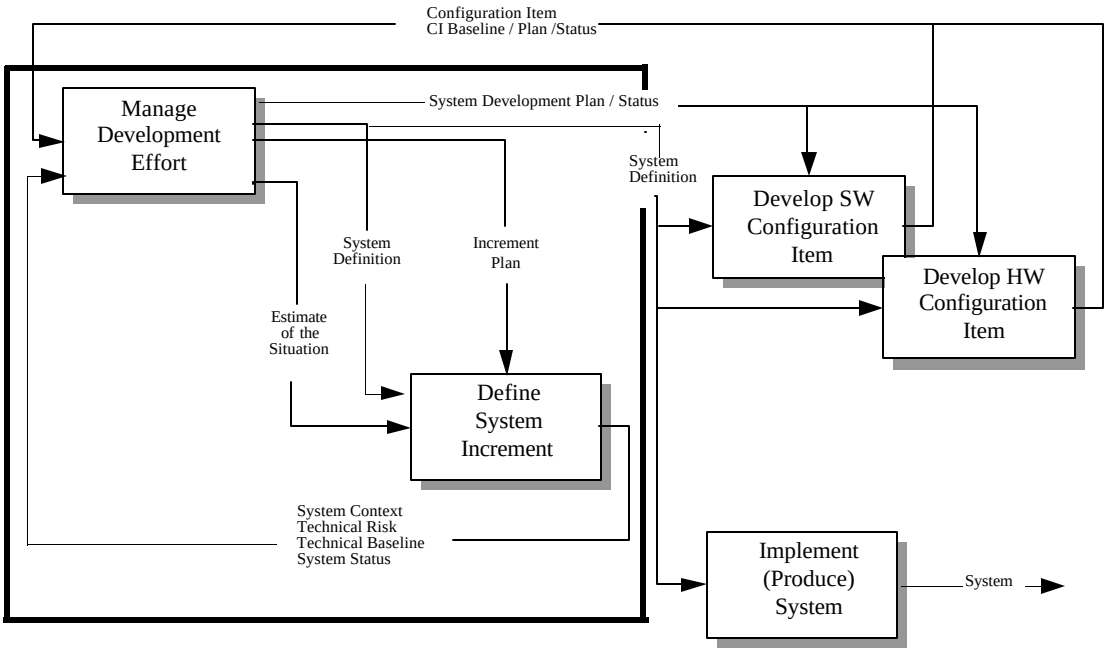

Figure 2. Integration of Engineering Processes

engineering process, represents a process presently being documented.

Integration of Activities Mandated by more than One Process

As we integrated the processes, two types of issues surfaced. First, some activities had been documented in the three processes because they were developed, sequentially, in a bottom up approach. As an example, risk management activities have been defined, back in 1994, in the software engineering process because it was felt that risk management was important. Then, risk management activities were defined in the systems engineering process and the project management process. In order to prevent duplicating these activities, the issue was resolved by assigning the primary responsibility for risk management to the PMP process, and inserting in the engineering processes dedicated risk activities.

Another type of issue surfaced because some activities were mandated by all frameworks used. As an example, the management of subcontractors is mandated by the SW-CMM, the SE-CMM and the PMP from the Project Management Institute. Since the subcontractor management process had already been defined during the software initiative, the scope of this process had been broadened to include hardware acquisitions. Even though, this process is part of the PMP process, it was decided that the process ownership would remain with the department responsible for acquisitions. The relationship between the PMP process and this process is viewed as a client-server relationship where a project manager issues his requirements for a particular acquisition, the requirements are then transferred to the subcontractor process, and once the goods are delivered to the satisfaction of the project, the subcontractor process is stopped.

Integration of Plans

Since engineering and management processes are mandating the development of plans (e.g. software development plan, systems engineering master plan, project plan), a tailoring of the processes was needed in order to develop plans that would use the same vocabulary and would not contradict other plans for the same project. As an example, the word prototype had a different meaning for software engineers,

systems engineers and project managers. In order to resolve similar issues, a common vocabulary was developed in collaboration of stakeholders.

Integration of Design Activities between Engineering Processes

Another integration issue in the design process is to determine when to stop the design using the systems engineering process in order to hand over the design information to the software engineering process. As the processes are integrated, other issues are also considered. As an example, the selection of engineering methods and tools is important in order to facilitate the transfer of information between processes.

Integration of People

One of the biggest issue in integrating process is the ¨people¨ issue. Great pain must be taken to avoid inter-departmental conflicts as the organization is transitioning from a matrix organization based on technical disciplines to a matrix organization based on processes. If not managed properly, this transition can create stress and resistance to change.

It was decided, as a mean to foster collaboration and understanding, to train together all users of a process, i.e. users from different functional departments. As an example, two-day training sessions on the Systems Engineering Process were held with representatives from system engineering, software engineering, sub-system engineering, quality assurance and configuration management. Students, assembled in mini groups of six and originating from different departments, were guided through the process, by a facilitator.

As another mean to foster integration of processes, Integrated Project Teams were established. In such a team, people have to work together from the beginning to the end of a project. They have to develop project plans and therefore they have to tailor and integrate different processes.

Team Startup Process

A team, as defined by Katzenbach [8], is a small number of people with complementary skills who are committed to a common purpose, performance goals, and approach for which they hold themselves mutually accountable. Becoming committed to a purpose and performance goals and a common approach and hold themselves mutually accountable does not happen by itself. Neither is a team "created" by a mandate from senior management. In our organization, teams are developed using a startup process [9]. The process describes a series of practices, grouped in stages, that guide a leader in developing a team. The typical stages of team building are: member orientation, trust building, goal and role clarification, commitment, implementation, high performance and renewal.

Performance Management Process and Reward System

Establishing new processes, practices, tools and teamwork require additional changes to the organization. As an example, when individuals are requested to work in teams, the old performance evaluation system based solely on individual contributions has to be transformed to take into account the new team structure. It becomes almost impossible, in a team structure, to evaluate a member of a team since his performance is also greatly influenced by the performance of his teammates. Similarly, the reward system of the organization needs to be adapted to the new team environment since, in a team everybody win or everybody loose. The reward system should not reward the lone ranger or the lone hero anymore. Reward system must evaluate the performance as a team and reward individuals as team members.

Organizational Process Coordination

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

- Establish time-to-market, quality, costs and product performance objectives to be supported by organizational processes
- Set priority in accordance with company vision and yearly objectives
- Liaise with executive committee
- Establish consensus among different groups
- Provide support for process performance improvement:

- Review results of assessments and audits
- Charter technical area working groups
- Budget for resources for process groups
- Monitor process performance

Since early 1997, process owners report their progress to the PACT on a regular basis.

Conclusion

Oerlikon Aerospace has been working on the development and integration of core engineering and management processes. A key ingredient for the success is the close collaboration and common vision of all stakeholders.

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