INTERNATIONAL DESIGN CONFERENCE - DESIGN 2006
Dubrovnik - Croatia, May 15 - 18, 2006.

DESIGN 2006

DEFINITION AND RESEARCH FOCUS IN PRODUCT DEVELOPMENT PROCESSES

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Keywords: process management, process optimisation, simultaneous engineering, concurrent engineering, project, project management

1. Introduction

Processes that form Engineering are marketing, product development, production process planning, prototyping, and testing. They form a complex process net, in which some activities run serially, some run in parallel. As a further complication, process participants are distributed over different locations and they often use different tool sets for the same application area. Engineering processes are of increasing dynamic today, because creativity never followed strictly a given way, and because nowadays processes are usually started before all requirements and boundary conditions have been sufficiently clarified (e.g. within Simultaneous Engineering).
This paper is a summary of a questionnaire of the members of the DS SIG "Modelling and Management of Engineering Processes". The objectives in the following workshops are to discuss and to evaluate significant influence factors that fix and improve the quality of Engineering processes. Such factors are e.g. strategies, approaches, methods, procedures, and tools ("classical", IT-based, knowledge-based, etc.) for modelling of, building up, for optimizing of, for working with, and for managing dynamically Engineering processes.

2. Definition of Terms

It is helpful to begin the research of an area with concept definitions, as concepts build up the basis of research and affect the result. Therefore, the definitions in the field of processes in product development of our own and of other sources are compared here, so that a general understanding can be achieved before the discussion. We suggest that concepts should be divided in:

- task
- activity
- process element
- process
- project
- process/project management

According to our opinion, we also need to define [1]:

- A **process** is a set of activities or sub-processes to solve a task.
- A **sub-process** is a subset of a process and is also a set of activities or other sub-processes.
- A **process element** describes an activity (respectively one or several working steps). It is started by one or several events and ends in one or several events. Their description is based on a defined structure so that they are suitable also for the application in a computer-aided system.
- A **working step** is the smallest subset of an activity in product development.

- A **workflow** is a dedicated, rigid sequence of working steps, process elements, or sub-processes.
- A **project** initiates one or more processes and workflows. It defines the initial conditions of a process like e.g. time, dates, budget limitations, resources, etc.

The hierarchy relations between process, sub-process, process element and activities are shown in fig.1.

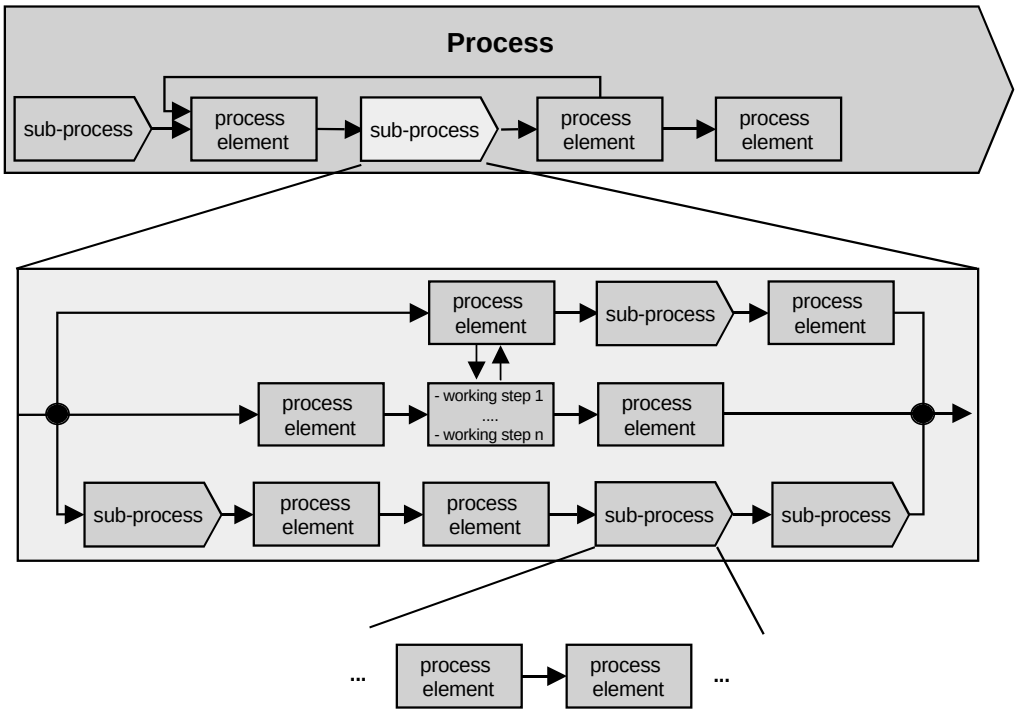

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Figure 1. Relations between process, sub-process, process elemen

Furthermore, we would like to define process management and project management as:

- **Process management** is the description, modelling, analysis, optimisation and administration of processes, which have to achieve one or multiple goals in any industrial or organisation environment.
- **Project management** is the application of knowledge, skills, tools and techniques to a broad range of activities in order to meet the requirements of the particular project. It includes five steps: Initiating, Planning, Executing, Controlling, and Closing.

However according to Salustri [2], some other relevant concepts must be defined before the definition of the above terms. These pre-defined concepts are: Model, Specification, Concept, State, Goal, Plan. Accordingly, he defines the following keywords of the field process like:

- A **task** is a transformation of definable inputs to definable outputs, defined in terms of the inputs and outputs, but not in terms of *how* the transformation from inputs to outputs is implemented; i.e. a task is a specification of an activity.
- An **activity** is an action or sequence of actions by which a transformation defined by a task is actually accomplished.
- A **process** is an ordered set of tasks or activities meant to achieve a known goal. Processes can be actual or planned. An actual process is given by a descriptive model of what was done – the activities – to achieve the goal. A *process plan* is a *prescriptive* model of tasks.
- A **project** is an entity that embodies the application of a process plan (re-specifying it to a particular context). Thus one may think of a project as a context containing a particular goal, a

process specified to the given goal, plus all the other entities needed for the process to execute (in a sense, the values to be assigned to the parameters in the generalised process).

- **Process/project management**: As processes are elements of projects, I consider process management to be a element of project management. *Management* is defined as directing, monitoring, controlling, reporting, and improving a (process or project).

Duffy [3] has concentrated his research on design co-operation. He gave eleven frameworks to contribute to the target of design designing. In additional he has defined four process-related concepts:

- A **goal** reflects a desire, need and/or requirement (e.g. a customer's requirement).
- An **activity** is taken to be a physical or cognitive action that creates an outcome. Thus, it has a starting state, condition or input, and an output. An activity is carried out by a resource of some kind. In some ways an input and a goal can be considered resources.
- A **task** reflects the desired or expected output or outcome that is required to meet the goal. It is not in itself the goal, as the output shall meet the goal to a degree of effectiveness.
- A **managed activity**, i.e. any activity in design aimed at achieving design and design activity goals.

Thus, every researcher carrying out research in this field uses different or partly different definitions to facilitate their own work of different interest and application. And they also define more or less other relative concepts other than the mentioned ones. For example, Schönheit [4] defined the following concepts to facilitate the calculation of process cost:

- An **activity** is the aggregation of actions.
- An **activity driver** is the measure of frequency on demands by cost object.
- A **process** is a predetermined series of activities that are linked to perform a specific objective.
- A **Non value added activity** is an activity considered not to contribute to customer or to the organisation's needs.
- A **Value added activity** is an activity that is judged to contribute to customer value or meet an organisation need.

One more thing still to make clear is, we consider a project and a process as two different things. Therefore, process management and project management are also different. For a comparison, a project is a unique process, consisting of a set of coordinated and controlled activities often with start and finish dates, undertaken to achieve and objective conforming to specific requirements, often including the constraints of time, cost and resources ([16], [17]). A project is the process to make something or to increase knowledge. A project is e.g. the input of a production process while the work in a project can follow a process plan. There are different resources like employees, machines, customers and other concrete information involved in a project.

A process is often described on a more abstract level than a project leaving out the people and machines involved, instead stating the qualification that is needed to complete the work. Processes have no start and end point.

Different definitions described above are listed in table 1 to facilitate a clear picture.

Table 1. Overview of concept definitions

	Freisleben [1], Burghardt [15]	Salustri [2]	Duffy [3]	Schönheit [4]	ISO 9000 (1994) [16]	ISO 9000 (2005) [17]
task		a transformation of definable inputs to definable outputs	reflects the desired or expected output or outcome that is required to meet the goal	the aggregation of actions		

	Freisleben [1], Burghardt [15]	Salustri [2]	Duffy [3]	Schönheit [4]	ISO 9000 (1994) [16]	ISO 9000 (2005) [17]
activity	is started by one or several events and ends in one or several events	an action or sequence of actions by which a transformation defined by a task is actually accomplished				
process element	describes an activity					
process	a set of activities or sub-processes to solve a task	an ordered set of tasks or activities meant to achieve a known goal		a predetermined series of activities that are linked to perform a specific objective	a process is a transformation from input to output that adds value. The output is a product tangible or intangible.	a set of interrelated or interacting activities which transforms inputs into outputs.
project	initiates one or more processes and workflows	an entity that embodies the application of a process plan				unique processes, consisting of a set of coordinated and controlled activities with start and finish dates, undertaken to achieve an objective conformation to specific requirements, including constraints of time, cost, and resources.
process management		a element of project management, directing, monitoring, controlling, reporting, and improving a process				
project management		directing, monitoring, controlling, reporting, and improving a project				

In the area of product development processes, there are also many researchers that use the concepts of activity or process directly without defining them [5-12]. However, it is generally agreed that an activity is the unit of a process, and a process is consisted of more than one activity to complete a task or to reach a goal.

The process is the core concept for process management. After a process is defined and tested other concepts will be easier to define and apply.
There are a few things that must be considered when the concept of process is to be defined:

- Has a process input and output?
- Is a process consisted of a serial of activities? Are these activities arranged or not?
- Has a process have a goal or a task?
- Does a process reference people, material or resource?
- Does a process add value or not?
- Is a process clued to other processes with input and output?
- Will a process be planned and executed?
- Has a process sub-process?
- Does a process transform the state?

According to these criteria, the following table is given to compare some definitions of different sources.

Table 2. Comparison of different definitions of process

A process …	has input and output	can consist of activities	has a task	references people or other resources	adds value	clues with other process	can be planned and executed	has sub-processes	transforms state
Freisleben, Vajna [1]	-	*	*	-	-	-	-	*	-
Salustri [2]	-	*	*	-	-	-	-	-	-
Schönheit [4]	-	*	*	-	-	-	*	-	-
Burghardt[15]	-	*	*	-	-	-	-	*	*
DIN ISO 9000 (1994) [16]	*	-	*	*	*	-	-	-	-
DIN ISO 9000 (2005) [17]	*	*	*	-	*	*	*	-	*
Schmidt [29]	*	*	-	-	-	-	-	-	*

From the above table we can see, that every definition is to some extent reasonable, when they consider some of the above items. The question is only which items they take into account according to their own needs of research or applications.
In [1] a process element is considered to have the following contents:

- Preceding process
- Process name
- Description of the work being performed
- Combination with other processes (e.g. sequential, parallel, or iterative)
- Person, resources
- Methods, working techniques, and tools to support the work
- Input description
- Output description
- Estimated and allowable duration

These contents formally describe the process, so that processes can be built into computer systems and can be navigated dynamically.

3. Research focus

With the concepts that are defined above, our research at Otto-von-Guericke University concentrates on product development process modelling, analysis, and optimising. The software of the chair – the

proNavigator – makes it possible to design, model, optimise and review processes for industry or other organisations. Fig. 2 shows the content of proNavigator.

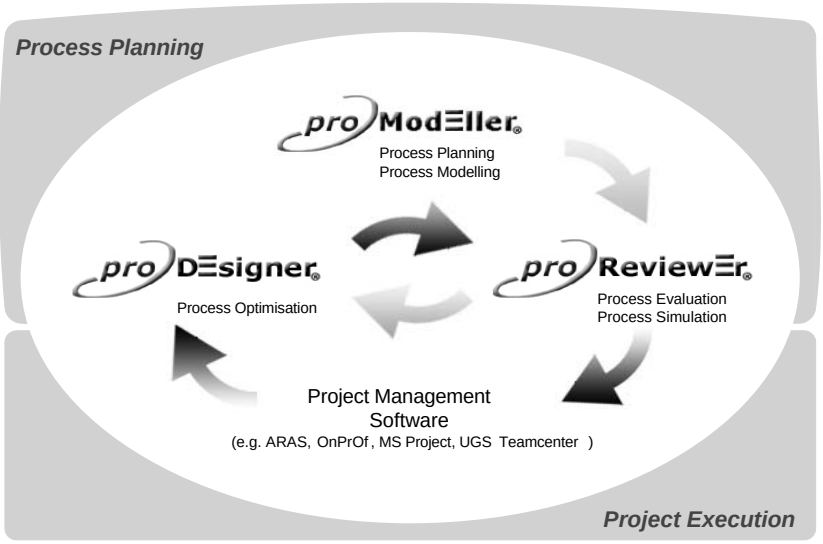

Figure 2. Content of proNavigator

We consider that process optimisation has four steps as it is shown in fig. 3. The first step is using more efficient methods and tools in a single process, so that a process is done in shorter time or with better result. It is considered that the second step is to involve employees with suitable qualification to achieve better process performance. The third and fourth step are supposed to be Simultaneous Engineering (SE) and Concurrent Engineering (CE), which we are intensively studying ([13], [14]).

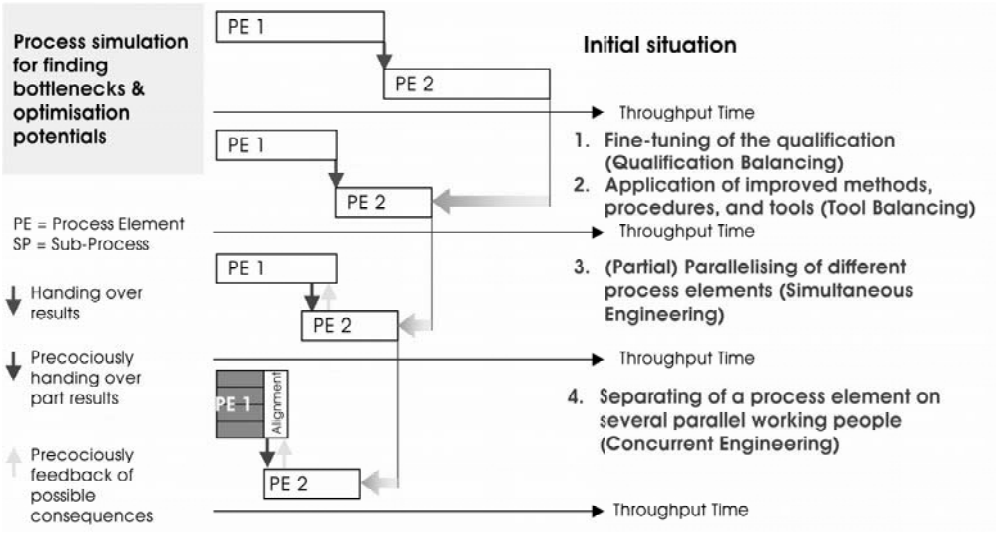

Figure 3. Steps of optimisation

SE is defined as the parallelisation of processes (sub processes, process elements or activities) in product development to achieve shorter time to market. CE is defined as the decomposition of a single process (sub processes, process elements or activities) into smaller pieces and parallelisation of these pieces. These two concepts are based on essentially the same basis and they aim to reduce the time needed for product development.

To parallelise two or more processes, the concept of dependency between processes must be defined. Dependency is the relation between processes, especially how the processes rely on each other to complete their own tasks. It is calculated by the input and output association degree between processes. It means, when one process needs much information (as inputs of the process itself) from another process (as outputs of this process), then it is said that the dependency between these two processes is strong. When these two processes are to be parallelised, a lower degree of parallelisation is supposed to be needed. How to define, calculate the dependency and how to parallelise the processes has been written in reference [13]. This is the basis for parallelisation, which is used for both SE and CE. For CE, the special point to take into account to carry out CE, a process or other process elements must be divided into smaller pieces. How to divide a process or a process element and what the influence of the division on the parallelisation is, is important to discuss, which is described in reference [14].
SE and CE bring the industry higher efficiency on one hand, on the other hand it means that the next process can begin before a process is mature. That is, the information being transferred among the processes is not mature. The direct result is a risk. What the risks are and how to reduce the risks to the least is also one of our questions to answer in the future.
In table 3, a few researchers who study the same area but with different interest and research focuses are listed. A different understanding about the concepts *process management* and *project management* can be seen.

Table 3. Comparison of the research focues of a few researchers

Researchers	Research Focus/Interest
Freisleben, Vajna [1]	dynamic project and process navigation
Salustri [2]	formal system and languages that describe what happens during designing
Duffy [3]	model, control and improve process with simulation tool "Design Co-ordination"
Schönheit [4]	process cost calculation system
Lee [8]	knowledge based consulting of processes modelling
Wache [10]	to achieve transparence of processes with "ARIS SmartPath"
Koch [11]	review and evaluation of processes with "Key performance indicators"
Florek [12]	PLM concepts to support organisation and processes in manufacturing industry
Burghardt [15]	planning, inspecting, controlling of development projects
DIN ISO 9000(1994) [16]	quality management for products
DIN ISO 9000(2005) [17]	quality management for products
Schabacker, Vajna [18]	evaluation of the benefit yield of technology project
McMahon, Busby [19]	Risk in Design Processes
Le Cardinal, Mekhilef, Bocquet [20]	decision making process
Le Cardinal [21]	dysfunction analysis in project management
Björk [22]	Insider Action Research on product development
Holmdahl [23]	Insider Action Research on product development

Researchers	Research Focus/Interest
Cooper [24,25,26]	approaches to strategy and tactics in product development
Ottosson [27,28]	Dynamic Product Development

The study of product engineering process includes process definition, process modelling, process analysis, process optimisation, tools and methods, process management etc. Of course, multicultural views and visions play also a role in this field.
The study of project includes project definition, project planning, project execution, project control, project closing, project tools and methods etc. A research map is illustrated in Fig. 4 to give a better understanding. Lines in the figure are used to cover the research interest of different researchers.

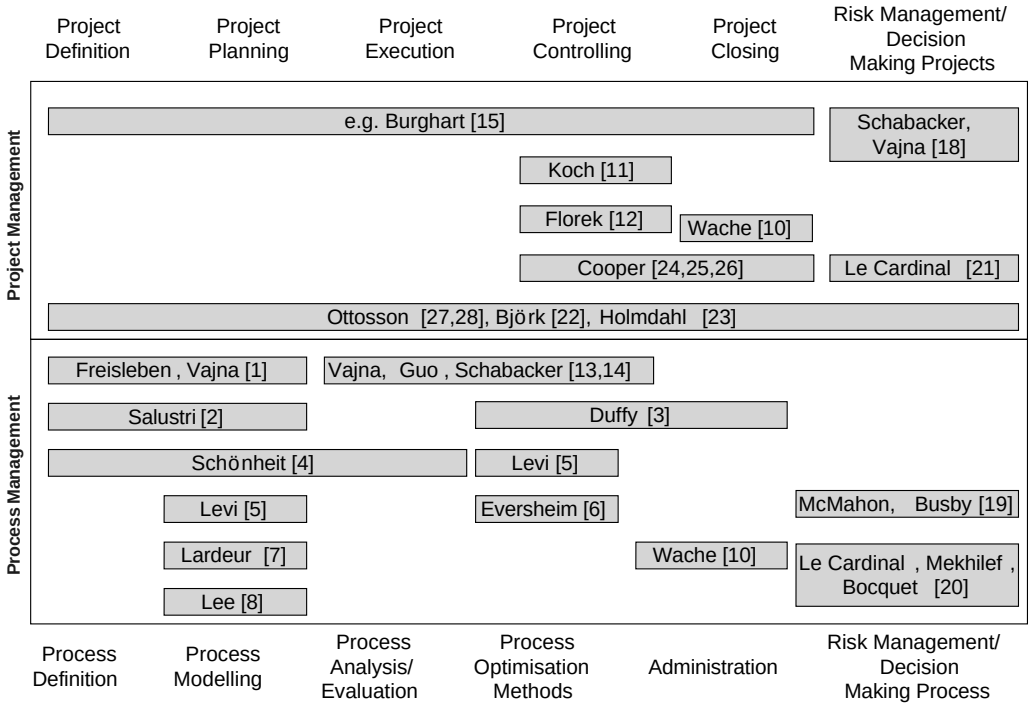

Figure 4. Research map of process and project management

4. Conclusion

In this paper a comparison among the concepts defined in the area of process is made to build a general understanding of processes. As described above, there are differences but also similarities in this field. The similarities make it possible that we understand each other and the differences make it possible that every researcher contributes with his work to a special field. The interests and key points of view of the authors are also introduced in this article both with the related job that they have done. Future work will be concentrated on SE and CE methods and their risk analysis.

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