Project factors

- A possible way to create a data bank of project experience.

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Sammanfattning

Denna magisteruppsats syftar till att effektivisera projekt. Uppsatsen är gjord vid flygradardivisionen vid Ericsson Microwave Systems (EMW). Deras projekt kostar ofta mer än planerat och tar ofta längre tid än planerat. Flygradardivisionen vill veta varför slutresultatet i de flesta fall överskrider budget och varför tidsramen inte kan hållas. Deras mål är att lära sig från erfarenheten i tidigare projekt och att samla all denna erfarenhet i en erfarenhetsbank.

Abstract

In this master thesis I investigate how to make projects more efficient. I did my thesis at the airborne radar division at Ericsson Microwave Systems (EMW). Their projects often cost more than estimated and they also tend to last longer than estimated.

The airborne radar division wants to know why the final result, in most cases exceed the budget and time plan. Their goal is to learn from the experience in previous projects and to gather all that experience in an experience base.

They gave me the task to start the process towards an experience base. The theory I base my result and conclusions on is The Experience Factory. The Experience Factory is an example of an experience base that was developed primarily for software projects. I started investigating projects at the airborne radar division trying to find common denominators (factors). I found some factors that I believe have a major impact on the projects. The projects really have to rely on these factors to be able to reach the goal of the projects. These factors are the first step towards an experience base. Starting a process towards an experience base is a work that takes many years especially at a company of this size. My thesis is a start towards the goal and in my result I present the factors I found and in the conclusions I give suggestions for the continuing work towards an experience base.
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1. **Introduction**

The airborne radar division (FN), at Ericsson Microwave Systems (EMW), wants to create an experience base on the basis of estimation of projects and the experience from projects. This goal is strived for to improve project realization and to make them more efficient. At FN today they have problems to follow the estimated budget and time plan in projects. Projects often tend to take longer time than estimated and the cost increases. The purpose with an experience base is to understand what part of the projects that works well but also to learn from their mistakes and to see where improvements can be made. If a process works for one project it is important that this experience is spread so that other projects can be more successful. It is also important that the mistakes in projects are spread so other projects do not have to make the same mistakes. The goal is to create an experience base on the basis of estimations, tactic planning and project results in order to reach more confidence in estimations and in the planning of a project.

1.1. **Problem definition**

Which factors are relevant in a project in order to create an experience base, based on estimation and result?

1.2. **Purpose**

The purpose of my thesis is to find factors in the projects that could affect projects in a positive or negative way. The factors should if possible be measurable to really see the impact they have on projects. I will present a model for the information flow between a project and the experience base. To support the model I will create a prototype to demonstrate how the information is put into the experience base and how the information can be found in the experience base.

1.3. **Method**

My assignment here at FN is to read reports and learn about their projects so that I can give suggestions to improvements. Together with my instructor at FN I decided that the first step is to find factors in the projects.

To find the factors I am going to read reports from different projects here at FN, I will mainly focus on information from two projects. I am going to study estimation reports and budgets to get a view of the expectations of the project, and I am also going to study intermediate reports and final reports. I will have discussions with project leaders and other project member. I will attend an estimation for a project that will start at FN.

1.4. **Delimitation**

There is not enough time to establish an experience base. Therefore I am only going to start the process towards that goal. I will not study all the projects at FN, I will mainly focus on two projects to get a deeper and better understanding of the selected projects. I will try to get enough knowledge about the projects to find the factors. Because of the time limitations I will present a model for the information flow and a simple prototype that supports this model. I will not be able to measure the affect my work will have since the experience base will not be implemented during this thesis. To implement an experience base takes several years at a large company as Ericsson and therefore it is not possible for me to see the affect of my work in this thesis.
1.5. Outline
In chapter two I present the background for my thesis. The processes used today at FN are presented in chapter three. Here I explain estimation done with the successive principle and PROPS a model for project management. In chapter four the theory for the Experience Factory is described. The result are presented in chapter five, here the factors are given. In the conclusion in chapter six I discuss the outcome of my work and further work that needs to be done.
2. Background
The projects at the airborne radar division at EMW differ in size and complexity. The large projects last for example 5 years and occupy 100 employees or more during the project. The larger a project is the more difficult it is to predict the outcome. Before starting a project an estimation (explained in chapter 3) is done. An estimation is done to be able to create a budget, a time plan and to submit an offer. The problem today is that the estimation does not seem to be as accurate as wanted. The budget and time plan is often not accurate. Projects tend to cost more and be more time consuming than estimated. To be able to make a more precise estimation the division wants to learn from the experience.

Progress and final reports are written today in the projects but the information is not stored so that it can be easily accessed. There are no general rules for how the reports should be stored. The reports are also written differently in different projects and there is not much consistency. It is therefore difficult to compare different reports and to see what the issues were in the projects. Another problem is that not all project leaders write reports and even if they write a report it is not always in a satisfactory way.

The purpose for writing a report and especially a final report is to inform the company and the project sponsor. The project sponsor might not have the information on why all the unexpected events in the project happened therefore it is important to give explanations. The final report should summarize the project, give explanations and evaluate why the outcome is what it is.

2.1. Reporting progress in projects
Information about the projects needs to be gathered in order to create an experience base. Today progress and final reports exist in most projects but they are brief. There is a need for continuity and rules for what should be considered when writing the reports. Every quarter the division has meetings discussing the progress for each project. As a first step the division has introduced a sheet, see figure 2.1, which should be completed at every six months follow up. The sheet should be used at the meeting to give a good overview of the situation in the project. It should give explanations to why the cost is what it is, and explanation why for example the project is over budget. This sheet is only a first step, and it is just introduced so there is no output to consider. It does not give enough material for starting an experience base. The further development towards an experience base will be my assignment in this master thesis.
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**Kommentar till risker som fallit ut:**

Hänvisa till genomförda riskanalyser

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Figure 2.1, sheet used to report the present situation in the project
3. Processes used today at EMW

In this chapter I explain how a project is started at FN and what tools they use for project planning. Before a project starts, an estimation (see chapter 3.1) is done. At FN they use the successive principle (see chapter 3.2) at estimation. For project management FN uses the general model PROPS (see chapter 3.3).

3.1. Estimation

Planning and investigation needs to be done before starting a project. These preparations are summarized and evaluated in an estimation. The point of estimation is to get a fair picture of how to reach the goal of the project. Everything that will affect the project in a positive or negative way should be taken into consideration.

Estimation is done to be able to submit an offer on an offer demand. It is also done when there is a need for it in a project, for example when the indications are that there is overdraw of the budget or time plan. A new estimation is then needed. At the airborne radar division they use the successive principle at estimation. The estimation is done to calculate the cost and the time for the project.

A very important aspect of making an estimation is to get a common picture of what shall be done. It is also important for the project members to get the same idea of the requirements, the product and how to reach the goal. The possible problems that could occur in the project and the possibilities that can be taken advantage of are important to understand. The project members that attend the estimation get motivated and committed for the project. It could therefore be a good idea to have more than one estimation in a project. Estimation should always be done before starting a project but it could also be done before starting important steps in the project to get the project members gathered before starting the new step. An important step in a project could be starting a new increment. A project is often divided into increments, especially if it is a large project. This is because it is easier to work with increments and to have some part goals.

3.1.1. Prerequisites

The first thing discussed at estimation is the prerequisites for the project. The prerequisites are what the project starts from, for example the environment, the tools they have access to and so on. A projects success depends on the prerequisites. Some of the prerequisites are help tools that are expected to work as expected to facilitate the project. All projects within FN are in one way or another dependent on some type of software. Employees expect to have help tools on the computer, hardware and software are expected to work in a satisfactory way. Everything should work in a helpful way and not cause problems. The project could be delayed if some software is not working as expected.

Many projects at FN are dependent on other projects. A project could estimate that another project is finished with software at a specific time; this is a prerequisite. This is not always the case; it is seldom that things are done according to the time plan. FN are working with extremely technical difficult software and hardware, therefore problems sometimes arise. The time plan and budget get affected when the prerequisites expected at estimation do not occur as wanted. At the estimation this is a problem since the estimation is done before the project starts and before you know if the other projects have completed their work. To do an estimation for a project that is going to last for several years and to decide the budget at the estimation is very hard since it is difficult to know if the prerequisites will be fulfilled. It is therefore important to understand what goes wrong in projects, and to find positive and negative factors.
3.1.2. Discussion about estimation

At the estimation general conditions for the project and potential risks and possibilities are discussed. One thing that surprised me was that within the same company there are no general conditions to start with. Every estimation starts from zero when trying to establish general conditions. The working climate for example should be something that is fairly common, that not have to be considered at every estimation. The working climate could of course be different between the departments in a big company, but there ought to be some common base for it. To create some general conditions and start with them at the estimation would facilitate the estimation. These general conditions would of course change after a while and needs to be updated.

Today at the estimation you start with nothing and come up with the general conditions. The estimation is lead by a chairman that knows many general conditions that normally affect a project. If any of these conditions are not mentioned at the estimation the chairman steers the discussion in a way so that these general conditions are discussed. The people attending the estimation should be open minded and be able to come up with their own ideas in order to create an open discussion. If there is general conditions to start with it could be more difficult to come up with new ones, it is easy to agree with already decided conditions. To work this way seems to give a fair view of the specific project and the conditions for it. Projects are different so it can be a good idea not to be locked on to some things that is decided in advance for all projects.

A problem at estimation is the urge to make the cost low or to make the cost as low as possible to be able to present a low price for the customer. This could lead to the fact that the costs at the estimation are not realistic because the only intention is to put pressure on the cost.

At the estimation where I attended, the work packages were estimated to take 771 man weeks (â 36 h) to implement. The general conditions for the project was considered and the possibility for them to happen. It was now estimated to take 1451 man weeks to complete the project. That is a good example on how much the general conditions could affect the project. The prerequisites are relied on at project start. It is not always the case that the prerequisites are fulfilled during the project and therefore the general conditions are added.

3.2. Successive principle

The problem with projects lasting for many years is that you do not know the outcome until the project is completed and that could be many years away. When an estimation is performed at FN they use the method successive principle as a help.

The successive principle has been used at FN for 20 years but it has not always been done accurate. An improvement process started 2002 at FN and one of the improvements was that the successive principle needs to be done more accurate. It was decided that 10 employees should learn more about the successive principle to be able to be a chairman at estimations. At each estimation two of these employees are involved, one as a chairman and one as an assisting chairman. These two employees are not involved in the project besides the estimation.

Today the estimations are done according to the successive principle but improvements can still be made during the progress of the project. During the project it is important to see that the progress is working according to the estimation. It is important to find common factors in the projects that affect the projects. It is important to do a follow-up to see how accurate the estimations are.
The successive principle has four cornerstones [13]:
- Uncertainty
- Estimation technique
- Top Down
- General Conditions

The uncertainty deal with the fact that there is an uncertainty what the future might bring. A project might expect something to happen but there might be an uncertainty if it is going to happen. The estimation technique deals with how you should judge facts and numbers. The top down structure means that everything in the successive principle method is handled top down [14]. The project is first divided into a main structure and then broken down into more specific structures. General conditions are conditions that will affect the project in a positive or negative way. The general conditions are considered during the estimation.

Examples of general conditions [13] [14]:
- Priority/Resources
- Customer
- Interface
- Motivation
- Currency
- Business cycle (boom/recession)
- Competition
- Culture
- Changes

All these conditions could have an affect on the project.

The process of the successive principle has three steps [13]:

Step 1, Qualitative part

![Figure 3.1, the qualitative part of the successive principle [13].](image-url)
Step 2, Quantitative part

Figure 3.2, the quantitative part of the successive principle [13].

Step 3, Measures

Figure 3.3, measures in the successive principle [13].

3.3. Props

FN uses PROPS, it is a general model for project management in a multiproject organization. The purpose of PROPS is to support a business-focused, efficient and successful project management and management of projects in a multiproject organization [15]. PROPS is a model for project management that supports managers and project members at all levels in an organization. PROPS has been developed within Ericsson and has been in use since 1988 in all types of projects and in different Ericsson companies all over the world. Years of experience from project work are compiled in the model and it has been improved and developed throughout the years. The content in PROPS is open for everyone to use, but PROPS™ is a registered trademark and Ericsson owns the copyright. Semcon has the global rights to adjust, market and sell the PROPS documentation and education.

PROPS sets a standard and the model is intended to serve as a source of inspiration and support for the individual and the organization. PROPS should be used as a model and not as a prescriptive set of instructions.
PROPS provides a general model for project work defining what should be done in the project and when it should be done. The model describes the steering and management activities needed for integrating and controlling the project work and coaching the project members.

The project flow in PROPS is described as a U. The U includes three different models:
- The red framed U represents a project steering model. The project steering model includes business and strategic project decisions.
- The blue part of the U represents a project management model. This model contains planning, procurement, integration and control.
- The yellow part of the U represents a project work model. The work model includes operative processes that are applied in the project.

### 3.3.1. Tollgates

The fundamental of the project steering model is six tollgates. In a project there are predefined decision points; in PROPS these are called tollgates. The project sponsor decides on how to continue the project at these tollgates.
The decisions made at these tollgates are [15]:
- TG 0 (optional) Start of prestudy
- TG 1 Start of project feasibility study
- TG 2 Start of execution of the project
- TG 3 Continued execution according to original or revised plan
- TG 4 Start of hand-over of project outcome to the receiver and the customer
- TG 5 Project outcome accepted, start of project conclusion

3.3.2. Phases

The project management model is divided into four phases [15]: prestudy phase, feasibility phase, execution phase, and conclusion phase.

Before the formal project start there is a preparation phase called the prestudy phase. The prestudy phase is to verify if a business idea is technically and commercially negotiable. The project is outlined during the feasibility study phase. The feasibility study phase should provide a solid foundation for successful project execution and completion. During the execution phase, the project is executed and the outcome is handed over to the customer and to the receiving unit. During the last phase, the conclusion phase, the experiences made in the project are documented and lessons transferred to the organization. The purpose of the conclusion phase is to ensure that the organization will have access to and be able to learn from the experiences made and the competence development achieved in the project.

The project work model includes the activities that should be performed to reach the project goal. A project work model should be developed from the relevant parts of operative processes in the life-cycle of a product, or in the sales flow [15]. Such operative processes consist of well-defined activities with a given input and output, as well as entry and exit criteria.
The project organizational perspective in PROPS, see figure 3.5, is about identifying project stakeholders and their responsibilities in and demands on the project [15]. PROPS provide a model for a project organization, defining who is responsible for doing what in a project.

### 3.3.3. PROPS information flow

In PROPS the reports and steering documents in the general project model are described. The project sponsor prepares an *assignment specification*, in this document a pre-study for the project is initiated. A new *assignment specification* is written to initiate the feasibility study. The project is specified and planned during the feasibility study. The outcome of the feasibility study is documented in the *project specification*. The sponsor decides whether or not to continue with the project and approve the *project specification*, at tollgate two. The signed *project specification* describes the agreement between the project sponsor and the project manager on how to execute the project [15].

During the project the project manager reports progress in the *progress reports*. The progress reports keep the stakeholders informed about the status of the project and its prospects. A *final report* is the last document, in which all the experiences and observations made in the project are put together, and the project performance and the project outcome are evaluated. The experience is transferred to the organization to be made use of in future projects and operations.
4. Theory
The theory I base my conclusions on is the Experience Factory (EF). I searched for a theory to base my thesis on and I found the Experience Factory. I found some other theories but they all seemed to be developed from the EF or the theories had some parts from the EF. With this as a background it was an easy choice to base my thesis on the Experience Factory since it is the most extensive theory when it comes to experience bases. The EF is an example of an experience base. The EF is mainly produced by Victor R. Basili, University of Maryland and H. Dieter Rombach, University Kaiserslautern in Germany. Most of the information I have found regarding the EF is published at the University Kaiserslautern. The University has done much research and application of the EF.

4.1. Experience Factory
The EF approach is to define a framework for experience management. It acknowledges the need for a separate support organization that works with the project organization to manage experience. The goal of the Fraunhofer Center for experimental software engineering Maryland is to capitalize the ideas of the EF, and to apply them to the management of software and other experiences [3].

NASA (National Aeronautics and Space Administration) has applied the EF for many years. They started using the EF to institutionalize the collective learning of the organization that is at the root of continual improvement and competitive advantage [3]. According to NASA the EF is a successful process for collecting experience from software projects.

The EF is an infrastructure for capitalization and reuse of life cycle experience and products [1]. The EF approach tries to rebuild human “learning from experience” to further support organizational learning [9]. The way the EF organization should work is that its activities are independent from the development organization. The development organization, whose job is to develop and deliver a system or product, provides the EF with product development and environment characteristics, data, and a diversity of models (resources, quality, product, process) currently used by the projects in order to deliver their capabilities [1]. The EF process this information and returns direct feedback to each project activity, together with goals and models tailored from previous projects increments. It will also produce, store and provide upon request baselines, tools, lessons learned, data, all presented from a more generalized perspective.

The EF is mainly used in the software business, but almost any business today involves the development or use of software. To be able to create competencies for future business and learn from experience you need to model, measure and reuse processes, products, and other forms of knowledge relevant to the business.

The basic methodological device for the EF is the Quality Improvement Paradigm. The Quality Improvement Paradigm (QIP) developed by Basili [4] is the result of the application of the scientific method to the problem of software quality improvement.

The Quality Improvement Paradigm is divided into six steps [1]:

- **Characterize**: Available models, data etc are investigated to understand the environment. Establish baselines with the existing business processes in the organization and characterize their criticality.
- **Set goals**: Set goals based on the initial characterization and on the capabilities that have a strategic relevance to the organization. The reasonable expectations are defined based upon the baseline provided by the characterization step.
- **Choose process**: On the basis of the characterization of the environment and of the goals that have been set, choose the appropriate processes for improvement,
and supporting methods and tools, making sure that they are consistent with the goals that have been set.

- **Execute**: Perform the processes constructing the products and providing project feedback based upon the data on goal achievement that are being collected.
- **Analyze**: Analyze the data and the information gathered, at the end of each specific project, to evaluate the current practices. Determine problems, record findings, and make recommendations for future project improvements.
- **Package**: Consolidate the experience gained in the form of new, or updated and refined, models and other forms of structured knowledge gained from this and prior projects. Store it in an experience base so it is available for future projects.

The characterization is important to distinguish the relevant project environment for the current project, it provides a context for goal definition, reuse of experience and products, process selection, evaluation and comparison, and prediction. There are a lot of environmental and project characteristics that affect the software development process and product [12]. These characteristics include people factors, problem factors, process factors, product factors, and resource factors.

It is important to make a realistic definition of the goals. Models and goals need to be established for the processes and products. The goals should be measurable, driven by models, and defined from a variety of perspectives. There are several techniques for defining measurable goals, the Goal/Question/Metric (GQM) Paradigm is the mechanism used by the QIP for defining and evaluating a set of operational goals using measurement. It represents an approach for tailoring and integrating goals with models of the software processes, products and quality perspectives of interest, based on the specific needs of the project and the organization [12]. The foundation of the GQM paradigm was established by Basili and Weiss in 1984 and since then evolved significantly [5].

A wide variety of data can be collected from a project, for example resource data, change and defect data, process measurement and product data. Resource data include type of personnel, effort by activity, computer time, and calendar time. Change and defect data include changes and defects of different severity. Process measurement includes process definition, process conformance, and domain understanding data [15]. Product data includes product characteristics (logical and physical), and use and context information.

The main idea with GQM is to define measurable goals but there are other products involved in GQM that are relevant for software projects and improvement programs for various reasons. According to the Goal-Oriented Measurement Using GQM Handbook “These additional products are the characterizations of organization and project, the project’s process model and project plan, and the experience base” [6].

A GQM-based measurement program can be described using two perspectives on a measurement program:

- The project perspective
- The strategic perspective

According to the Goal-Oriented Measurement Using GQM Handbook “The project perspective focuses on the detailed aspects of goal-oriented measurement within one software project, for example for better understanding and guiding a project” [6]. A measurement plan is derived from measurement goals in accordance with the characteristics of the project. It also involves collecting data, identifying and packaging
the experience gained. The figure 4.1 shows an overview of the project perspective of GQM-based measurement.

“...The strategic perspective focuses on using goal-oriented measurement as a tool for strategic improvement, for example uncovering improvement potentials or deriving prediction models“ [6]. It also focuses on improving the organizations maturity of applying goal-oriented measurement. This perspective involves performing goal-oriented measurement in one or more software projects. The figure 4.2 shows an overview of the strategic perspective of GQM-based measurement.
QIP is based on the idea that improving the software process and product requires the continual accumulation of evaluated experiences in a form that can be effectively understood and modified into a repository of integrated experience models that can be accessed and modified to meet the needs of the current project. [1] The paradigm separates project development from the EF. The project development is performed by the project organization. The EF performs the systematic learning and packaging of reusable experiences. The idea is that the EF should be a separate organization that supports project development by analyzing all kinds of experience, acting as a storing place for such experience, and supplying the experience to projects when needed [1]. It packages experience by building informal, formal or schematized, and productized models and measures of various software processes, products, and other forms of knowledge via people, documents, and automated support [10].
The development organization provides the EF with information: project and environment characteristics, development data, resource usage information, quality records, and process information. The analysis organization processes this information received from the development organization and returns direct feedback to each project, together with goals and models tailored from similar projects [11]. On request it provides baselines, tools, lessons learned, and data, parameterized in some form in order to be adapted to the specific characteristics of a project [11]. The support organization handles the interaction between developers and analysts, by saving and maintaining the information, making it retrievable and controlling the access to it.

The data that is analysed and interpreted can be used to:

- Characterize and understand, for example, what project characteristics affect the choice of processes, methods and techniques? Which phase is typically the greatest source of errors?
- Evaluate and analyze, for example, what is the statement coverage of the acceptance test plan? Does the inspection process reduce the rework effort?
- Predict and control, for example, given a set of project characteristics, what is the expected cost and reliability, based upon our history?
- Motivate and improve, for example, for what classes of errors is a particular technique most effective?

For the experience base to be effective it should contain an accessible and integrated set of analyzed, synthesized, and packaged experience models that capture past experiences [11]. An organizational structure that supports the EF is required to be able to reuse existing experience. This includes: a software evolution model that supports reuse, a set of processes for learning, packaging, and storing experience, and the integration of these two functions [11]. The EF is the organizational unit that performs this integration.

The term reuse in software development projects is more than reusing code, the context from which the code originates should be reused. The reuse of experience should be more formal it should be incorporated into the development models. The experience needs to be analyzed, evaluated and appropriately packaged for reuse potential. The experience needs to be tailored before it can be reused.

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**Fig. 4.3**, separate organizations in the Experience Factory.
The project organization and the EF need to be separate organizations, see figure 4.3, at least from a logical point of view; the EF for packaging experience and the project organization for product development [2]. Both organizations have different focuses and priorities, use different process models, and have different expertise requirements.

There are a variety of forms for packaged experience [2]:

- Equations defining the relationship between variables, (for example, Effort = a*size).
- Histograms or pie charts of raw or analyzed data, (for example, % of each class of fault).
- Graphs defining ranges of “normal” (for example, graphs of size growth over time with confidence levels).
- Specific lessons learned associated with project types, phases, activities, or in the form of risks or recommendations.
- Models or algorithms specifying the processes, methods, or techniques.

Examples of resource models and baselines include cost models, resource allocation models for staffing, schedule, and computer utilization, and the relationship between resources and various factors that affect resources, e.g. specific methods, customer complexity, the application, the environment, and defect classes [R. Basili, J. Beane, “Can the Parr Curve help with the Manpower Distribution and resource Estimation Problems”].

When the EF is building resource models it is interested in capturing data associated with a variety of factors associated with prior projects, e.g., size, effort, pages of documentation, and calendar time.

Experience package is the main product of the EF, the content and structure of an experience package vary based upon the kind of experience clustered in the package [1].

Examples of experience packages are:

- Product packages, for example: programs, architectures, and designs.
- Process packages, for example: process models, and methods.
- Relationship packages are time based relationships and time independent relationships, these packages are used for analysis and/or forecast of relevant events. Examples: cost and defect models, resource models.
- Tool packages is a specific tool, either constructive (Examples: code generator, configuration management tool) or analytic (Examples: static analyzer, regression tester) [2].
- Management packages are a container or reference information for project management, for example: management handbooks.
- Data packages is a collection of defined and validated data relevant for a software project or for activities within it, for example: project databases.
5. Result

First in the result I present information from two projects that gives examples of mistakes made in those projects. In this chapter the factors, that I have found important for a projects success, are also presented.

The quality of the reports I have read has been very varying. Some reports have been good and gave a lot of useful information. Most of the reports were written so that I could understand what the difficulties had been in the projects. The good reports also presented what had been successful in the projects. The process of finding factors in the projects has been more difficult than I thought it would be because of the lack of quality in some of the reports. The reports that gave less information were the reports that did not give any explanations to the different actions in the project. To write a report and not give any explanation at all on why events occur does not give any valuable information to someone not involved in the project. To get a better insight in the projects I interviewed the project leaders to get the necessary information. The interviews with the project leaders and other project members were the source that gave most information about the projects. Below I present preferences from two of the projects I studied, here I call them project A and project B. The projects at FN are company confidential and most of them are also military secret. That is why I can not present any details about the projects.

Project A had a goal to deliver a system computer for a fighter aircraft. The project lasted for 5 years from 1996 to 2001. The final product was basically delivered on time, even if the project did not follow the time plan during the progress of the project. The final cost for the project was 30 % higher then in the budget.

The biggest problem in project A was to get the necessary resources. During this project the so-called IT-boom occurred, which resulted in an extensive staff turnover. New resources had to be trained up and a lot of competence was lost during each rejuvenation. Another problem in this project was that it was underestimated how much such a complex product would cost to develop and to test. When the project got problems with system integration they had to have a group of 10-15 people working with the trouble shooting. No individual alone had enough knowledge about the entire system.

Improvement proposals from project A are for example that the people that are responsible for different parts in the project should be dedicated early in the project. A verification plan should be developed in the beginning of the project that includes every step in testing. Many of the proposals show how important it is that the communication and information works in a project. In the final report it is emphasized how important the communication is in a project for it to be successful.

Project B is to secure the production of a radar system for a fighter aircraft. This was needed because of obsolete components. New functionality was also going to be added to the radar. The project started in July 1997 and was scheduled to deliver the result in June 2004. Today the prognosis is that the cost will be 21 % higher than budget.

Project B also had problems with an extensive staff turnover that made it difficult to carry out the project. The documentation of the products in the project was done poorly and that became more obvious because of the loss of several project members. The EF improves the documentation in a project, the documentation flow is visualized in figure 6.1. According to a report written in October 2001, the biggest mistake that had been done in the project was that not enough time was spent on preparation work. An example is that the requirements were not defined enough before starting the designs of components. More time should be spent on preparations in the beginning this saves time in the end.
Another mistake in project B was that new tools and processes were introduced in the project after project start. Processes for the project should be established before the project start, otherwise work may have been done for nothing and needs do be done all over again.

5.1. Factors
The factors I found most important for the projects at the airborne radar division are time plan, resources, requirements, risks, and communication. These factors have a major impact on the projects. There are more factors that affect the projects but these are the ones I have found most important during my analysis of the projects at FN.

- Factor Time Plan – If the time plan is not followed it is a first indication that everything is not working as expected in the project. The progress can be measured in Earned Value.
- Factor Resources – The resources are a major factor in a project. Resources are needed to be able to perform the project. To measure if the project got the resources needed you can look at the resource contracts. Another important aspect with resources is if the resources have the right competence.
- Factor Requirements – If the requirements for a project changes during the project it affects the project. The affect it has on the project depends on the severity of the changes. The requirement changes can be measured by looking at the change requests that have been made in ClearDDTS.
- Factor Risks – If risks in the project occur it affects the project in a negative way. What affect the risks have on the project can be measured with a risk analyse that is made at estimation.
- Factor Communication – To be able to work together in a project the communication has to work in a satisfactory way. Both the internal and the external communication have to work.

5.1.1. Time Plan
FN use Earned Value to measure the progress in projects. Earned Value Management is a methodology used to measure and communicate the real physical progress of a project taking into account the work complete, the time taken and the cost incurred to complete that work [16]. Earned Value helps to evaluate and control project risk by measuring project progress monetary terms [17].

Earned Value is an objective measurement process of how much work has been accomplished in a project [20]. There is no problem to measure completed work since the work packages have been closed, the budget has been earned and progress has been reported. The concern lies in measuring the work packages that are planned to be or are actually in process in the end of the reporting period. Short work packages can minimize the work-in-process measurement problem. The longer the work packages are the more difficult it is to determine the actual status of the work. The case normally is that you have long work packages in a project; the work packages are difficult to divide into smaller work packages. A measurement system is therefore needed for projects and ongoing work packages. If it is large work packages the use of milestones is important if you want to measure the progress. The milestones are used as progress indicators, and values, either in terms of individual budgets or percentages of the total work package budget, can be assigned. When a milestone is achieved, the budget associated with that milestone is earned. In that way you can measure parts of the work package and it is desirable to have at least one milestone per reporting period.
Using the Earned Value process, members of a management can compare how much work has actually been completed against the amount of work planned to be accomplished [19]. In Earned Value the project manager should plan, budget and schedule the authorized work scope in a time-phased plan. By comparing the earned value with the actual cost you can indicate an over or under run condition. Planned value (BCWS), earned value (BCWP), and actual cost (ACWP) data provides an objective measurement of performance, enabling trend analysis and evaluation of cost estimate at completion within multiple levels of the project.

The Earned Value system provides data and reports required for effective analysis of variances:

- Work Breakdown Structure (WBS) is a breakdown of the products and services that constitute the project. It is often described as a product-oriented family tree, which organizes, defines, and graphically displays the product to be produced as well as the work to be accomplished to achieve the specified product [18].

- Budgeted Cost for Work Performed (BCWP), the planned costs of the completed work. This is the Earned Value.

- Budgeted Cost for Work Scheduled (BCWS), the budgeted cost for all planned activities.

- Actual Cost of Work Performed (ACWP), the real costs of the work charged against the completed activities [18].

The WBS is used as a basis for BCWP, the cost for each work package is calculated. Therefore you can compare the cost so far in the project with the budgeted cost for the completed work packages. The outcome of this is that you can see if a work package was more expensive than the budget for it. To learn why a work package costs more than planned you need to ask why this is the case.

All the basics of Earned Value are easily shown in a “S-Curve”. The “S-curve” could be a graph showing how project budget is planned to be spent over time.

![Image of S-Curve](image)

Figure 5.1, the basics of Earned Value [21].
The BCWS curve is derived from the project budget, and the Work Breakdown Structure. The cost of each work package is calculated and the cumulative cost of completed work packages is shown based on the planned completion dates [21].

The ACWP curve is found by measuring the completed work. Actual costs from invoices and workmen’s time sheets.

The BCWP is the planned cost for work completed so far in the project.

Scheduled Variance (SV) is the difference between the Earned Value and the planned budget [21]. \( SV = BCWP - BCWS \).

Cost Variance (CV) is the difference between the Earned Value and the actual costs of the work performed [21]. \( CV = BCWP - ACWP \).

Schedule Performance Index (SPI) and Cost Performance Index (CPI) give indications if the project is on time and on budget.

SPI is a ratio of Earned Value and the planned value of completed works. A SPI < 1 is not good if SPI = 1 the project is on schedule, and if SPI > 1 the project is before the time plan.
\[ SPI = \frac{BCWP}{BCWS} \]

CPI is a ratio of Earned Value and the actual costs of completed works. A CPI < 1 is not good if CPI = 1 the project is on budget, and if CPI > 1 the project have not cost as much as budgeted.
\[ CPI = \frac{BCWP}{ACWP} \]

New method
The previous curves and methods are used today at EMW in projects to measure the progress. A new method that could be used to get a signal of what the real outcome of the project would be is EAC (Estimated At Completion). EAC uses the numbers and progress so far in the projects and calculates what the final cost for the project will be. This is very useful if the project have divided the project into milestones.

EAC gives an idea of the final cost of a project. It takes into account the original budgeted cost (BAC), and the Cost Performance Index of the already completed works.
\[ EAC = \frac{BAC}{CPI} \]
The EAC is the most valuable indicator of the outcome of the project. Here you will see what the probable cost of the project will be. This value is very important because it indicates if the project is way over the total budgeted cost and need to do something about it. It is difficult to predict the exact final cost of a project therefore it is interesting to have a max and a min of EAC, to be able to at least predict in what area the cost will end up.

\[
\text{EAC min} = \frac{\text{BAC}}{\text{CPI}} \\
\text{EAC max} = \frac{\text{BAC}}{(\text{CPI} \times \text{SPI})}
\]

Figure 5.3, visualisation of EAC min and max.

Factor time plan
The use of Earned Value curves is an indication if the project is on time and on budget. If a project follows the time plan is an important factor and to measure it Earned Value can be used, for example the EAC value. Earned Value indicates early in the project if the time plan is not followed, if not then something needs to be done. It is important to find the reason why the time plan is not followed. Earned Value does not tell you were the problem lies; it is just an indication if you are over or under budget or time.

This factor is important to use as a main indicator for the progress of the project. Since this factor does not have the answer to what is wrong in the project more specific factors are needed to really find out where the problem lies.

The model presented in the conclusion support the job to find more specific factors. Everything that has affected the project in a negative or positive way is documented and
stored in the database. The documents that give information about more specific factors are for example progress reports and risk/possibility analysis.

5.1.2. Resources

The outcome often differs from the estimation in projects, the main reason for this seems to be the problem with resources. The main problem with resources is to get the resources needed, another problem is the competence of the resources. The employee’s competence is often overestimated, to make a correct estimation the employees limitations need to be considered.

To reach the goal for the project on time it is necessary to get the resources needed for the project. When a project do not get the resources needed it will affect the project in a negative way. There are different kind of resources some are more significant than others. It is important to see how significant a resource is, how much the project depends on different resources.

The most common reason for not getting the resources assigned is that the resources are assigned to another project that has higher priority. A project can get into complications that are not expected, therefore that project needs the resources longer then planned. At the estimation for a project it might not be taken into consideration that other projects could get into trouble and therefore are not able to let go of the resources according to the time schedule. The resources might not be available for other projects. Different projects have different priority, the project with the highest priority more likely get the resources needed. The projects with less priority have to wait to get the resources.

To get the resources with the right competence is difficult. A lot of employees have a specific knowledge and carry a lot of expertise but they do not always share their knowledge with colleagues. It is a problem that a few people have a lot of knowledge about a specific area and therefore a lot of projects want that specific person in their project. That the information is stored in the EF makes it easier, it is a risk not to share knowledge within the same company.

Another aspect on problems with resources is that the employees work part time on more than one project. An employee could work on two or more projects at the same time. This could be a problem because it takes some time to get the focus back on one project when returning from another project. The employee could be assigned to work half time on one project and half time on another. The normal case then is that the employee works more on one project then the other, even if he was assigned to work equally on both projects. One project could be more interesting to work with or there could be other reasons. When an employee is assigned to two projects and one of them has higher priority and get problems then he will work more on that one. Therefore the best solution is that employees only work in one project at a time.

When a project is started, and even before that, it is important to find the key persons in the project and to get them involved in the process as soon as possible. The key persons are the resources that really are necessary for the project to function at all. If one of the key persons in the project for some reason is absent it will have a large affect on the project. It is therefore important to know who the key persons are in the project. The EF is a help in finding key persons for a project. Other similar projects indicate which persons in a project that is key persons. By learning from other projects it is easier to find the key persons. Similar projects could for example be projects with the same type of product. To find similar projects in the EF it helps to search after different keywords in the project, product type is an example of a key word.
Factor resources

A resource contract is written in a project for each quarter, it is a specification of the resources in a project and if they are going to work fulltime or not. When writing the progress reports the project leader should report if all the resources worked as they were supposed to according to the resource contract. If not all the resources were available for the project as planned the project leader should explain why and what importance that resource should have for the project, is the resource a key person. It also is important to explain the actions that were taken when the resources were not available. The most important thing is to reflect on what affect a loss of a resource had on the project. The resource contract can be used as a help to measure how significant a resource is for the project. A resource not already identified as a key person, could be identified during the project. When a resource is lost in a project, competence is lost. “An employee learned a lot during a project, but has no time for packaging and dissemination so the knowledge cannot be leveraged” [3]. Therefore writing down experience makes projects less dependent on specific resources.

Organizations know that to learn from experience it is important to document and share knowledge and experience in order to [3]
- Become less dependent on its employees
- Get new employees to become productive sooner
- Promote collaboration among employees and groups

The content is that to get resources and specific key employees to a project is very important in order for the project to be successful. If the experience is shared and documented the significance of key employee’s decreases, they are still very important but they are easier to replace. This experience is stored in the experience base.

5.1.3. Requirements

To be able to perform the project effectively everyone that has an assignment in the project needs to understand the requirements. It is important that everyone working in the project has the same goal, and one main basis is that the requirements are understood. If a designer has not fully understood the requirements then complication will eventually arise. The better you know and understand the requirements the better you can make a more correct estimation of the project. Often when starting a project not all the requirements are known. The project management should strive for having all the requirements defined before the project starts, but that is not always the fact. Sometimes it is impossible for all the requirements to be defined before the project start, the customer might want to test things in the project before they can define all the requirements.

Requirements could be changed during the project or new ones could be added. The affect on the project in total varies depending on the extent of the changed or new requirements. It could be external customer requirements or internal from one part system to another. Depending on where the new requirements originate from and what type of requirement it is, the affect on the project can vary.

The requirements should be a definition of the product. There are different requirements both external from the customer and internal. The company needs to set up their own internal requirements to be able to fulfil all the external requirements. It is important to do a verification plan before the requirements are completed. The verification plan has an impact on the requirements; some requirements could be added or changed after the verification plan is completed. In most projects a verification plan is made before starting the project but it might not be done as thorough as it should be.
When it is time to do the verification the requirements might need to be changed because the verification plan was not thorough enough.

The reason for not doing a thorough verification plan is because they want to start with the project as soon as possible and therefore postponing important things. Through the verification plan you get demands on observables that affect the project specification.

Often a project is divided into different increments that are parts of the project. A verification plan should be completed for each increment before it starts. The requirements for the first increment should be completed and fully understood before starting the project. The case might be that you cannot fully express the demands for following increments before starting the first increment. But even if you cannot completely finish the requirements for all the increments at least the requirements for the product or system should be set at a higher level. The projects need to have a goal to work towards and the requirements decide that goal. Before starting any of the increments in the project that specific increment needs to have the requirements set before starting it.

FN use the tool ClearDDTS from Rational for problem reports. The problem reports are used both to verify the requirements and after project start. In ClearDDTS you can define a process to handle change requests [23]. FN has not defined a process for handling change requests. To be able to keep track of the number of change requests that occur in a project and what severity they have a process defined to handle change requests is needed. If you get the information on what change requests that have been made you can compare it with the Earned Value curve. The Earned Value curve might indicate that the project does not follow the time plan and one reason could be that many or severe change requests have been made. The severity of the change request matters a lot, a change request do not always have a major impact on the project. Sometimes a change request is just a small adjustment and therefore do not affect the project in a way that the time plan can not be followed.

The process to handle change requests (see figure 5.4): The person that suggests a change of a requirement included in the project Requirement Baseline submits a change request (CR) in ClearDDTS [22]. The CR is automatically sent to the project manager and the project manager decides if the CR will be analysed or rejected.

If the project manager decides that the CR should be analysed he assigns it to the person or persons responsible for analysing the CR. Now the person analysing the CR have to answer some questions. The main questions that needs to be answered are the impact the CR have for instance on the product and the product identity. What impact the CR has on the budget and the time plan, if it is possible to perform the CR. He also needs to answer what impact it has on documents and the impact the CR has on sub projects. The CR might be dependent on other sub projects. The analyst also needs to answer what resources that are needed for the CR and if the resources are available. Important is to understand what risks implementing the CR brings.

If the CR is approved the project manager assigns the CR to the person responsible for implementing the change. The implementation of the CR will be started. The project manager verifies the implementation of the CR.

The CR has been implemented and tested and the affected product and project documents have been updated. The change request is given the status verified in ClearDDTS and is thereby closed [22].

Factor requirements
The factor requirements should be used and measured to see what affect the changes of the requirements have on the progress of the project. From ClearDDTS it is possible to
get reports on how many and what kind of changes that has been done to the requirements. This information compared to see if the time plan and the budget are followed will give us an indication of how much impact a change of the requirements have on the project. The type of change will of course matter; a change of the external requirements ought to have a greater impact on the project then a change of the internal requirements.

The requirements are easier to define using the EF as a knowledge and experience base. In the experience base similar projects can be studied to get information about the requirements in those projects. It is interesting to see how much the requirements were changed during a project. These documented changes of the requirements help new projects to define the requirements.

**Status in ClearDDTS**

![Flowsheet of a CR](image)

Figure 5.4, flowsheet of a CR.
5.1.4. Risks

Risks in a project are an important factor. When progress reports are written it is interesting to look at the risks that has occurred and what affect they have had on the project. Different risks have different affect.

The big challenge at estimation is to predict the future. Many projects last for several years and it is difficult to predict things so far in the future. To predict how the labour market is going to be in a couple of years is not an easy job. One example of unexpected things is the IT-boom, it made the manpower more expensive than predicted the salaries increased a lot. It became more difficult to hire competent personnel since it was easy for employees to find new and interesting jobs. This was not predicted so projects that had been running for a couple of years were strongly affected by this. Today the situation has changed and most people are glad to have a job because of the recession going on and therefore tend to stay longer at their job. If a new boom is going to happen in a couple of years is difficult to predict. It is very hard to predict how the financial situation will be in a couple of years.

The situation within the company can change and if there is a customer involved the company is also dependent on other companies. It is therefore very important to have a good communication with the customer and that there exist a mutual understanding between the company and customer. In some projects the customer provides the hardware and the projects job is to improve it or to start on a new project by starting with that hardware. In these cases you are very dependent on the customer for the project to proceed as planned.

The most important things are to understand what the customer wants and that the customer has understanding for how your company works. This understanding is necessary to be able to define the requirements, if this understanding is not the case the project is at risk. The customer must have clarity in how the work is going to proceed, when things will be done and in what quality, and if all their requirements will be fulfilled or if only some parts can be fulfilled. It is important to inform the customer if there are any limitations, if the company cannot fulfil their demands. Do not promise too much. By not telling the truth the company can get this specific project but it is not good advertise for the future if you make a commitment you cannot live up to. It is necessary to be realistic at estimation for the estimation to be realistic.

Risks are a factor that should be taken under consideration when evaluating what affects a project. Before starting a project a risk evaluation is done. All possible risks are mentioned and the possibility for them to happen is discussed. The idea with a risk evaluation is to find the possible risks to prevent them from happening during the project.

It should be an ongoing process during the whole project to try and prevent the risks from happening. In some projects a risk evaluation is done before the project starts and then they think they do not have to worry about the risks during the project, but it needs to be taken into consideration until the project is finished. A risk evaluation needs to be updated during the project. Some risks may not be a risk anymore in the project because the project could have passed some critical steps. Therefore new risk evaluations must be done during the project. A risk analyse should be done every quarter in a project at the division.

Factor risks

The risk analyse in the successive principle contains risks that has a value. That value could be used to calculate the affect it has on the project both for the time plan and for the budget. This value could therefore be used as a measurement, to measure the affect the risks has on the project.
Risks affect the project in a small or major way depending on the severity of the risk. In the process of writing a progress report it should be evaluated if any risks have happened and what the consequences was. Some risks might not have any affect at all on the project because there could be an easy solution to the problem. The risks that have occurred should be compared with the time schedule to see how much affect they have had on the project. That will give an indication of the severity of the risks that has occurred.

Risk/possibility analyses are produced before project start, and should be reproduced several times during a project. The analyses should all be stored in the experience base. The experience gathered in the experience base makes it easier to define the risks and possibilities. The risks are also easier to prevent by learning from other projects.

5.1.5. Communication

The communication in a project is very important, both the communication between different parties and within the same group. The communication between the customer and the contractor has to work so that the parties can understand each other. The communication within the project also has to work; the project leaders have to make sure that all project members are informed so that they fully understand what their task is. It is not enough that the leader in a project understands everything, he has to forward the information. How the communication in a project works is an important aspect on the working environment. The commitment in the project is affected by how the communication works. The geographical locations in the project and between the customer and contractor affect how the communication works. It is always easier to communicate if you meet in person instead of sending emails or talking on the phone, and it is easier for mistakes to happen if you do not meet in person.

Communication is a factor that I do not have enough time to investigate further. To proceed with communication I should have done an analyse of how the communication works today in different projects. That analyse itself would have taken a couple of weeks and would not have fitted in the time frame.
6. Conclusion
The goal for the airborne radar division is that all projects should land within the uncertainty interval from the estimation. The start towards that goal is to start with an experience base and the way to that is:

- Point out a responsible person
- Collect material – based on factors
- Structure the material
- Database (projects, positive and negative, seek criteria)
- Evaluation – (division-level, project-level)

If FN agrees that improvements can be made and that this is a start in the right direction they have to put a lot of effort into it. A new process can not start working by itself. According to the EF [1] the development organization should be separate from the organization for the EF. There should be an organization that supports project development by analyzing all kinds of experience, acting as a storing place for such experience, and supplying the experience to projects when needed. The goal for FN to start an experience base is the same as for the EF. If FN sees possibilities with the project they should decide what they want with it and how much they should work with it. For the project to continue they need to give someone the task to continue with the work that has been started. For the experience base to be effective it should contain an accessible and integrated set of analyzed, synthesized, and packaged experience models that capture past experiences. To be able to reuse experience it requires support for using existing experience. Therefore an organizational structure that supports them is required, according to the EF [7].

To start an improvement process takes a lot of time and effort. It is a process that is more than just implementing the new process. It needs to be followed-up to find out the results of the new process. A lot of new processes are implemented and never followed-up. There is no point in implementing a new process if you do not investigate if it really is an improvement or not.

The outcome of my thesis is recommendations on how to report the progress in projects and what factors that affect the projects. The factors that I present should be used as a start to see what significance they have. The factors should be used to test if they are the ones to use. The factors could be important and new ones could be added, starting with some factors hopefully leads to finding more factors that affect the project. The process with finding factors is a way to make projects more effective and to understand what can be done to improve the projects.

The goal for FN is the EF, but that goal is many years away. It takes a while to understand if a new process would improve the job or not. That is why the process have to start with small steps and after applying a new step it needs to be evaluated to see what affect it had. For an experience base to be successful many factors are important.

According to Success Factors for Software Experience Bases [24] there are four success factors for software experience bases:

- Cultural change: There need to be a cultural change for it to be a successful implementation. It is important that people provide knowledge to the experience base and that they use knowledge that is available.
- Stability: A stable business environment that can change in a controlled way is more likely to succeed with a software experience base.
- Business value: The employees a more likely to see a software experience base as successful if it brings a high amount of concrete, and obvious business value that is easy to demonstrate.
• Incremental implementation: A software experience base is more likely to success if it is implemented in small increments in close connection with its future users.

In the future when the project leader writes the progress reports he should give comments on why things have happened and explain what the causes are. He should take the factors into consideration and see what affect they have had on the specific project. Some factors may have different affects on different projects. After reflecting on the cause of the project situation whether it is positive or negative the report is written and then the situation is discussed with the steering group. The report should now be archived and eventually put in an experience database.

This process of writing reports helps the project leader to reflect on where to do improvements to make the project more effective. It also gives motivation to the project members if you find out what is working well in the project. If the project leader finds some issues that could be improved in the project it is positive to find them as soon as possible to start working with them. When not realizing the problems with a project while working with it you cannot do anything to improve them. Finding out when the project is finished is too late. It is important to make reflections on the project while the project is still running, and introduce improvements before the project is finalized.

“The benefits of an EF become obvious to a project if it can profit from experiences gained in past projects” [8]. The reports are not only for reflecting this specific project they should also be written so that other projects can learn from them. A lot of knowledge and information in a project is never written down, it is talked about and only some specific persons have that special knowledge. In order to be a successful company the knowledge and information needs to be shared within the company. It is not for the company’s best if there is an internal competition or if the employees have too much prestige to share knowledge or to ask for help. The reports written in the projects should be gathered in an experience base, for easy access by others working in similar projects. This is necessary in order to spread the information and knowledge. It is important to learn from others success and mistakes.

The general model for project management PROPS is a very useful model for project management [15]. It also gives instructions on how to write the documentation in projects. It is a great help for writing progress and final reports. If everyone at FN followed PROPS then the reports would be very useful and give important information so that the experience could be gathered in an experience base.

PROPS is not written so it should be followed completely by all projects. All projects are different and therefore some parts of PROPS are useful for some projects and some parts for other projects. What could at least be expected is that project leaders write reports from the projects in order to share their experience. The guide in PROPS is easy to follow and there would be a consistency if the project management followed the guide. Using the PROPS guide at least for writing reports and commenting the factors I have suggested would be a good start in the direction towards an experience base.

6.1. Collecting the experience

The information needs to reach the employees that could use it in order to improve or to make their job easier. As mentioned about project B in chapter 5 there was a lack of documentation about the products. The model I present for documentation flow, figure 6.1, would have been very useful in that project. All the product specifications would have been done and saved in the EF. A manager of the EF is therefore needed to manage that the specifications and everything else is written and saved in the EF.
There is no point in writing reports about the experiences learned in a project if no one gets access to the information. For the information to reach other employees it needs to be gathered, sorted and categorized to make it easy accessible. As described in the EF they have a separate organization taking care of the experience. The information needs to be stored easily and it should be easy to get access to the information after it has been stored. The best way to store the reports and information from projects would be a database. In the database the information should be stored in a way that makes it easy accessible and retrievable. The model (see figure 6.1) and prototypes displayed later in this chapter demonstrates how this can be done.

Figure 6.1, documentation flow between a project and the experience base.

Figure 6.1 shows a model of how the documentation flow should/could be between a project and the experience base.

(1) An idea or inquiry starts the process towards a new project. Relevant information for the project is gathered and possible scenarios are investigated.
The information could be project specifications and risk/possible analyses from other similar projects. One good source of information is the experience base (7). The information from the experience base give you experience from previous similar projects. When enough information and knowledge is gathered an estimation is done.

(2) An offer is produced based on the outcome of the estimation.

(3) If the offer is accepted it leads to an order.

(4) When the order comes the project starts. The project starts and a project specification is produced. This project specification should be stored in the experience base (8).

(5) During the project many activities are performed. Two activities are performed several times during a project and they involve documentation. The activities are risk/possibility analysis and progress reports. When performing these activities information could be gathered from the experience base (9) (10). These activities produce documentation and that documentation should be stored in the experience base (9) (10).

(6) The project reaches the goal and the project ends. A final report is produced (11) and it should be stored in the experience base.

(7) As explained in (1) information is gathered in the beginning of the project. And the source for experience from previous projects is the information they gather from the experience base. Here the project uses information from the experience base.

(8) Here the information is used in the experience base. The project specification is written and stored in the experience base.

(9) The risk/possibility analyses uses information from the experience base and the information produced is used in the experience base.

(10) Progress reports are written every quarter. Information from the experience base is used to produce the reports and the progress reports are used in the experience base.

(11) The final report is produced, here all parts from the project is carefully reflected. The final report is stored in the experience base.
The manager of the experience base has full access to the experience base, but also the project leader and project members have access to the experience base, see figure 6.2.

- **Manager** – Is the manager of the experience base, he/she is the person that has full control of the experience base and most knowledge of it. All input to the experience base first lands at the manager’s office. The information needs to be synthesised and analysed before it is put into the experience base. This procedure is necessary to maintain a quality in the experience base. Information gathered from the experience base could also go through the manager.

- **Project leader** – The project leader produces a lot of information that is stored in the experience base. But the information always goes through the manager. The project leader also gathers a lot of information from the experience base. He can get it himself but if he does not find what he needs he can get help from the manager.

- **Project member** – Project members can search in the experience base to get information. And if they do not find the information they need they can also get help from the manager.

At estimation, information from the experience base is valuable. To get useful information from the experience base the manager of the experience base needs to get information about what the idea is for the new project. When the manager has this information he can get relevant experience from the experience base for this project. When the project starts the project specification should be sent to the manager of the experience base. During the project information from the experience base should be collected when needed. A good idea is to get information from the experience base when a new risk/possibility analyze is under development. Information from the project
to the experience base should for example be the progress reports. At the end of the project a final report should be written and sent to the experience base.

To demonstrate the experience base I have done two prototypes. One prototype demonstrates the administration of the experience base (see figure 6.3) and the other prototype demonstrates how to search in the experience base (see figure 6.4). In the prototype the complete projects are not in the database. In the database the projects should be described and categorized so information easily can be found.

Projects are added by putting a name on the project and writing a short description of the project. Different items are added to the project, each item get a name and a short description. Items can at anytime be added to a project. Information about the project can therefore be added to the database before it is finished, and items added as the project goes along. The types of items that can be added are Event, Risk, Time plan, Resource, Requirement and Communication. I decided that it is best to categorize the projects into these items since it is the factors that are taken into consideration when the project reports are written. The item Event is not one of the factors but I thought it could be useful to write down specific events that can not be categorized into the factors.

In the prototype for search it is possible to search in the free text field for an event. Search options are also chosen; Events, Risks, Time plans, Resources, Requirements and Communications. The project(s) that include the result of the search is shown in the left window. If a project on the left is clicked on, the items in the project that includes the search is shown in the right window. If the search was for risks the search only shows the risks that includes the search word. At the bottom to the left the description of the marked project is shown. At the bottom to the right the description of the marked item is shown.

The database schema for the prototypes is presented in figure 6.5.

![Figure 6.3 a prototype for the administration of the experience base.](image)
Figure 6.4 a prototype for searching in the experience base.

Figure 6.5 the database schema for the prototypes.
6.2. QIP

The methodological device for the EF, the Quality Improvement Paradigm (QIP) is a method that could be used to get a better structure in the projects. This structure includes organizing the experience so that it can be stored [1].

I could compare the steps in QIP with this thesis. The first step characterize is the first thing I did in this thesis. I tried to understand the environment, what methods that was used today and how the processes for projects worked here at FN. In the next step set goals I decided what I could do, what the goal was for this thesis. I decided that the goal would be to make better estimations and to achieve that the experience needs to be used. In the step choose process I decided how I should be able to reach my goal in the best possible way. We decided that I should investigate prior projects to learn what experience could be used. The step execute correspond to how I did my investigation for the thesis. In the step analyse I analysed all the material and other input I have gotten during the thesis. I analysed it to get a result and to reach the goal. The step package is my report, this written thesis. It is in this thesis I gather all the experience that I have learned during my thesis.

QIP could also be compared to my model of the documentation flow to and from the experience base:

- Characterize: Gather information from the EF
- Set goals: This is done in the project specification.
- Choose process: Choose process for the project from the EF
- Execute: Perform the project according to the chosen process
- Analyze: Analyse the project, write progress/final report
- Package: Package the gathered experience in the EF

This process for projects is important if experience should be stored and learned from. Most of the steps in QIP are performed in all projects but the last step package is not always used. The projects reach their goal and then no reflection is done. To be able to learn from projects, the experience needs to be packaged so that others can take part of the experience.

6.3. Six-months report

As mentioned in the chapter “reporting progress in reports” (see page 8), a new sheet was introduced that should be filled in at every six-months follow up meeting. The next step in the process of starting an experience base is to make useful comments, and to be able to explain exactly what the cause is for different events that have occurred. To get continuity it is necessary to decide what comments/question that should be written/answered. The continuity is needed to make a good experience base with the right content and to make it structured to get access to the information easily.

To get the pattern and the information wanted in the reports we decided that it is necessary to find factors that affect the progress of a project. Common factors in the projects should be considered to be able to measure project success during the project and when the project is complete. The factors would be a base for the comments we want in the report. The factors should be different criteria’s that affect the project in a positive or a negative way. To be able to see the affect the factors have on the project it is desirable to find factors that can be measured. I have added my factors to this sheet. This sheet should be used as an experiment to see if the factors are important for progress in projects or not. On the next page the sheet is presented.
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Ordernr: ENJA00
Datum: 2003-08-25
Uppgjord: FN/JP Namn på projektledaren

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### Kommentarer

**Allmänt**

**Nuläget** (Vad har påverkat nuläget positivt/negativt?)

**Tidläget** (Earned Value varför ser det ut som det gör?
Vad blir estimerad slutkostnad i nuläget?)

**Resurser** (Har man fått de resurser som var kontrakterade? Påverkat nuläget?)

**Krarvändringar** (Har det gjorts några kravändringar? Vilket omfattning? Påverkat nuläget?)

**Risker** (Vilka risker har fallit ut? Hur stor påverkan har de haft?)

---

Fig 6.5, based on the factors I have added question to the sheet presented in chapter 2.
6.4. Future work
This is a limited thesis of 10 p therefore a lot of work is still to be done. The area of my thesis is wide and contains many different aspects. As I have written, my thesis is only a start towards an experience base. The factors I have found need to be carefully reviewed and further investigated. I mention measures for the factors but they have not been tested. To test these measures for the factors is a time consuming process that is not covered in this thesis. It would be very helpful with significant measures, but it is difficult to test them. The future work could also lead to new factors that are relevant for project success. The model for documentation flow could be revised when it is used in projects.
References


Appendix 1

Glossary

ACWP  Actual Cost of Work Performed, used in EV for the real costs of the work charged against the completed activities.

BCWP  Budgeted Cost for Work Performed, used in EV for the planned costs of the work allocated to the completed activities. This is the Earned Value.

BCWS  Budgeted Cost for Work Scheduled, used in EV, is the budgets for all activities planned to be completed.

ClearDDTS  A tool from Rational for problem reports.

CPI  Cost Performance Index, used in EV and give indications if the project is on time and on budget.

CR  Change request.

CV  Cost Variance is the difference between the Earned Value and the actual costs of the work performed.

EAC  Estimated At Completion, used in EV, gives an idea of the final cost of a project.

Earned Value  Earned Value Management is a methodology used to measure and communicate the real physical progress of a project taking into account the work complete, the time taken and the cost incurred to complete that work.

EMW  Ericsson Microwave Systems

Experience Factory (EF)  An example of an experience base.

FN  The airborne radar division at EMW.

GQM  Goal/Question/Metric Paradigm, a technique used for defining measurable goals.

NASA  National Aeronautics and Space Administration.

PROPS  Is a general model for project management in a multiproject organization.

QIP  Quality Improvement Paradigm, it is the basic methodological device for the Experience Factory.

SPI  Schedule Performance Index, used in EV and give indications if the project is on time and on budget.
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<tr>
<td>Successive principle</td>
<td>A method used at estimation for a project.</td>
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<td>SV</td>
<td>Scheduled Variance is the difference between the Earned Value and the planned budget.</td>
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<td>WBS</td>
<td>Work Breakdown Structure, used in EV, is a breakdown of the products and services that constitute the project.</td>
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