UNIVERSITY OF AGDER

A Study of Manhour Overruns in Projects

Identifying main contributors to manhour overruns in projects.

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Preface

This thesis represent the end of a five-year long education taken at the University of Agder. The process of writing the thesis has been a interesting journey and a joyful learning experience that will never be forgotten. I have learnt a lot from writing this thesis and got a great and wide insight into the world of Project Management.

There are several people who has helped me get through the process of producing this thesis, and they need to be acknowledged. First of all I want to thank my supervisor at UiA, Øystein Meland. He has been very helpful and supportive all the way, from start to finish, giving me detailed and constructive feedback. Thanks to SubComp who gave me the opportunity to write this thesis. Thanks to my supervisors at SubComp who have been huge help in the process of finding interview objects, discussing what to consider in the thesis, and of course finding the thesis itself. Thanks to all my interview objects who took the time to meet me. Hopefully it will help you in some of your management activities. Last, but not least, my family has been a great deal of help. They have been my discussion partners when I have needed it and supported me all the way throughout not only the semester, but all five years. Thank you.

Kristiansand, 2. June. 2014

Ida Helgesen Næss

Abstract

Project manhour overrun is a common issue in all type of projects, particularly in large complex projects in the construction industry. General data on manhours and costs used in projects is available in companies' databases, but often the time used to analyze it is an area that lack focus and dedication. This thesis tries to explain why overruns on project manhours occur, and what the main contributors are. Hopefully the result can help Project Managers to forecast more precise in future projects and improve their overall execution of Project Management. To get the necessary information to do the analysis, and get insight into how the status of Project Management is today, empirical data was based on raw project data collected from 2009 until December 2013 from five projects, supported by six Project Managers experience and knowledge through interviews.

The findings in this thesis are leading towards several issues. There is a clear tendency to increase labour activity for a short-time period after a project exceeds its budget and after replacing Project Managers. The increase after exceeding budget could be overstaffing due to rework. An increase of manhours after replacements could be due to the fact that Project Managers and project team need to get an overview of the project and its workload. Replacements could also generate hours if new hires are assigned to projects. New employees require training and follow-up, which often will be performed by experienced personnel.

Reduced labour activity occurs some time after a project exceeds its budget, and lasts until the end of a project. Reduced manhour activity reduce progress, and could be due to a lacking focus towards the end of a project's life-cycle, or resource constraints due to Project Portfolio Competition. Other factors found to contribute to manhour overruns in larger projects are lack of knowledge sharing across projects and between employees, lack of direct and frequent communication with customer to collect as much information and changes as possible, lack of sufficient forecasting and re-planning due to time-constraints for Project Managers, lack of standardizations of roles, tools and processes and therefor influencing the degree of optimal use of resources.

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Abbreviations and Explanations

Documents = specifications of items created by subcontractor and SubComp, i.e drawings, specifications, manufacturing records, user manual. Documents to be delivered either to customer from SubComp where selected documentation is required by end customer, or to SubComp from subcontractor.

Italic text = used when I have directly quoted interview objects

Knock-on effect = problems at an early stage (in projects) can create problems at a later stage.

Labour hours = hours performed by the workforce within the case organization

LE = Lead engineer, technical responsibility in projects

Long lead items = e.g raw material which can take several months or years to receive

Mhrs = manhours

PERT = Program Evaluation and Review Technique

PM = main Project Manager

PPM = Product Project Manager / Work Package Project Manager

PRM = Project Risk Management

RM = Risk Management

R&D = Research and Development

SMART = Specific, Measurable, Accepted, Realistic/Relevant, Timeline/Time constraint

SPS = Subsea Production Systems

SubComp = is the case organization, pseudonym for a subsea company, supplier of subsea production systems.

WBS = Work Breakdown Structure

WP = Work Package

1. Introduction

Forecasting is a challenging task for any Project Manager (PM) in any kind of project. Theories on how to estimate time and cost for activities in projects started to bloom in in the late 1950's, and has since then been important tools for Project Management and forecasting. Different tools and techniques are used for planning a project, and there are many aspects that has to be identified before implementation can start, but also along the way (Rolstadås, 2011: p.19). Projects are known to either overrun on their budget or delay the time of delivery, and the increasing complexity in projects is important to incorporate in Project Management (Bosch-Rekeveldt, Jongkind, Mooi, Bakker & Verbraeck, 2011). Bosch-Rekeveldt et al also stated that there is no concrete framework for supporting or help to increase Project Management's understanding of complex engineering projects. Along with complexity comes uncertainty as an influencing factor to overrun and scheduling difficulties. Ward and Chapman (2003) expressed that Project Risk Management (PRM) has a lacking focus on managing uncertainty. They argued that a focus on *uncertainty* rather than *risk* could provide Project Management with a more accurate or different view on PRM, which could further increase a focus on *opportunities* as a result from uncertainty.

The goal of this thesis is to give insight into what factors that have the ability to change and possibly worsen a projects end result. The research will also try to explain why overruns of manhours (mhr) in projects occur by looking at five projects in a department within a case organization.

1.1 Problem Definition

The dependent variable in this research is mhr overrun and my problem definition is;

> *What are the main contributors to manhour overrun in projects?*

The issue revolves around finding tendencies or specific contributors to labour hour overruns in projects in a case organization. Projects are defined as temporary organizations outside the case organization's hierarchy with specific goals that are to be achieved within a certain timeframe according to an agreed contract.

The problem definition is wide and the solutions and contributing factors can be many. I have therefore limited the research to only look at mhrs in projects, and focused on a detailed analysis on this. To help try to answer the problem definition above, I have come up with additional research questions:

1. Are budgets underestimated?
2. When does an overrun occur?
3. Is rework a major contributor to overruns?
4. Is resource constraint a contributing factor to labour hours overrun?
5. Does low productivity have an impact on overrun?
6. Could deficient monitoring and controlling affect an overrun?

The research is mainly based on a qualitative interview method, supported with raw data from an internal database. The raw data collected was systematically gathered, sorted and updated as work progressed. The case organization called SubComp is a privately held global company that produces and sells highly technological products internationally. The foundation for the thesis are hand-picked projects the company finds important and of interest to research.

1.2 Why This Research Is Important

In large corporations it is often found that projects overrun on their mhr budget, which creates cost overruns and time schedule delays. When a project is planned to have a given timeline, optimally it would give a perfect overview of the process and every activity that should be carried out, without any off-track incidents or delays. That is not the case in real life. Most projects experience changes that affect the schedule and possibly increase the length of a project and delays the time of delivery. New technology or new design of products may require different processes for development and implementation. If a timeline for delivery and completion is delayed due to changes, it can affect the number of resources needed, possibly an increase, and further involve an increase in costs.

Rolstadås (2011), Fisher (2003) and Lamers (2002) all agreed that Project Management is tricky when looking at uncertainty of activities, resources, change in requirements or demand etc., and is highly important to comprehend to be able to execute successful projects. «Nobody plans to fail, but fail to plan» is a statement which grasps the sense of project planning and management.

This research is important as it can give the case organization and other organizations an idea of what the main contributors to overrun on mhrs are, and possibly give an incentive to take action where it is implied as most needed according to discussed findings.

2. Relevant Theory

For the reader to get a basic understanding of how Project Management works and what project planning involves, I will introduce what I find as the most relevant theory for this thesis.

2.1 Project Management

2.1.1 Project Management Theory

In Project Management there are two main factors, planning and follow-up. Planning involves designing a plan for how a project will be implemented, defining goals to be achieved, identify tasks needed to achieve the goals, define the amount of resources needed, and determine a budget and timeline for completion. The task of planning also involves follow-up, making sure goals are achieved by registering how resources and time is utilized, actuation, and managing necessary actions if change or failure occur (Rolstadås, 2011: p.55). In today's changing work environment, the role of Project Management is highly important. That is, to be able to deliver products or services in a more controlled and cost-conscious way than before, and to make best use of limited resources to meet customer demand (Fisher, 2011).

A project plan is the key to save time and money, and to have control over resources. Theory suggests that there are certain steps to follow when planning a project, and by having basic knowledge of this, a PM will have a better idea of what to consider when creating a plan (Haughey, 2000):

Define goals that are in the interest of the customer's needs as well as the company's. Goals have to be measurable, and one method is to look at the SMART principle. Are goals specific, measurable, accepted by all parties, realistic and relevant, and do they have a timeline?

Project deliveries need to be listed according to when and how it is supposed to be delivered. In the project plan it is important to include estimated delivery dates for the different components for the finished product.

Scheduling phase is created to have a clear vision of when tasks and activities are supposed to be executed relative to delivery dates. For each delivery, all necessary tasks need to be identified, which can be several. When the schedule has been created it is possible that estimates for delivery made by the customer, are not realistic according to the schedule. Unexpected changes need to be

handled immediately by rescheduling, either renegotiating delivery date, adding resources, increase budget, or deliver less than planned (reduce scope).

Additional plans such as having a list of what roles individuals have in a project, how to communicate progress and to whom, is also important along with PRM.

Figure 1 shows an example of how a *control loop* in Project Management could look like. The model shows four main blocks needed in Project Management. These are Human Resource management (HRM), planning, production and controlling (White, 2011).

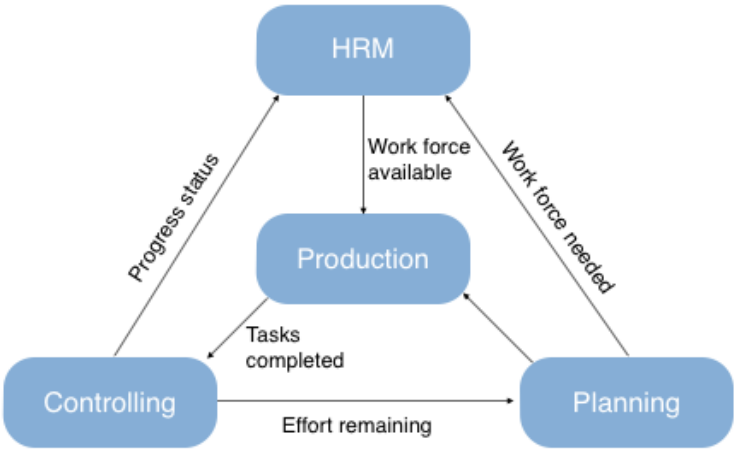

Figure 1: Control loop in Project Management (White, 2011)

2.1.2 The Project Contract

A contract is a binding agreement between project parties describing what will be done, to what cost, delivery date, the parties commitment to each other and what is to happen if one part does not uphold the agreement (Husby, Kilde, Klakegg, Torp, Berntsen & Samset, 2003: p.121).

The contract strategy has an impact on how risk is allocated between parties and handled in a project. Risk is allocated through the contract terms and through what risk factors are included in the contract. Contracts can have a *fixed price*, be *cost based*, or a combination of the two.

In a fixed price contract, the supplier holds the responsibility to complete the project according to specifications on time and cost. If the customer on the other hand, has requirements beyond the negotiated terms, the customer must pay for the change. The supplier carries all the risk related to the execution of the project, while the customer carries responsibility for the risk related to external conditions.

In a cost based contract the customer compensates for the suppliers costs related to the execution of the project. The costs could be hours, material, equipment etc. If the supplier use more hours than planned the customer has to compensate. With these contractual terms the customer holds all the risk.

If the contract is a combination of the two, the supplier can do the design work based on a cost contract, and the execution of the project with a fixed price contract. In the execution phase the supplier may hold the risk as he defines the work scope through the design phase (Husby et al, 2003: p.127-132).

2.1.3 Project Management Triangle

Projects have to perform and deliver what is promised under certain constraints that are traditionally listed as scope, time and cost. These three constraints define the Project Management Triangle or the Iron Triangle, shown in figure 2 (Atkinson, 1999, & Lamers, 2002).

Figure 2: The Iron Triangle (Kerzner, 2013)

The constraints often compete with each other. If one of the three changes, it will affect the performance of the other two. Say, if scope increases it will often increase time and cost as well (Patel, 2008: p.5-6).

«The discipline of Project Management is about providing the tools and techniques that enable the project team (not just the Project Manager) to organize their work to meet these constraints» (Patel, 2008).

Patel (2008) and Lamers (2002) further described the three constraints:

A Work Breakdown Structure is used to create work packages and describe the work to be done in a project. Such a description include; activities to be performed, required input to perform activities

and finally the output result. A product is defined by its specifications, reports, drawings and design, which are deliverables specified in work package activities (Lamers, 2002).

Scope refers to what has to be done to produce and get the promised end result. Part of the scope is a detailed description of what the end result should look like, and the quality of the end result. The time put into each task in the project can determine the quality of the work and the overall project. To produce better quality it is often necessary to put in more hours than originally estimated for the complete product. In a complex project with many tasks and components, the focus on quality can have a huge impact on time and cost, and can delay a projects completion time (Patel, 2008).

The time constraint defines how much time is available to complete the project, and establish a relationship between the work packages. It is the activities that have a time-constraint, not the product in itself (Lamers, 2002). This constraint has to be broken down into how much time is needed for each component. Also, defining how much time is needed on each task for completing each component is necessary for analytical purposes. It is easier to execute a project if splitting up tasks into smaller parts (Patel, 2008).

The cost constraint is the budget given to the project. It is related to the work packages, and can be related to the time schedule directly (Lamers, 2002). A budget depends on several variables such as material rates, mhrs needed, labour rates, risk management, buildings, machines, equipment, administration (indirect cost) and profit. If a consultant is hired, the cost is determined by an hourly or daily payment rate and estimated time for completion (Patel, 2008).

Project Management is the task of trying to balance the three corners of this triangle; the known budget for time and cost, which is easily exceeded, and the scope which has uncertainty that can occur and is easy to underestimate. When projects are complex they have a bigger amount of variables such as work packages and activities, reports, drawings, specifications, individuals and resources, and participating parties. Variables therefore need to be accurate, reliable and available, but as variables can change it is challenging to assure this (Lamers, 2002).

2.2 Planning

2.2.1 Work Breakdown Structure

The Work Breakdown Structure (WBS) is used to define what 100 percent of a project's work is and is a useful tool for PM´s. By using this tool they can define tenders by listing all the necessary work and decompose or split tasks into work packages. It is challenging and almost impossible to

define how much time and cost a new project need, and PMs have to make an assumption. The WBS can further be used in a project planning process by looking at risk, planning, scheduling work, estimating costs etc. (Fleming & Koppelman, 1998). Webb (2003) defined the WBS:

«The work breakdown structure is, quite simply, a method of identifying and classifying the work content of the project in a rational and easily understood way…»

A WBS can take many forms as projects often are unique in its nature. However, typically they are within four standard types: product based, organization based, task based or a hybrid structure of two or three of the above. Take the task based WBS as shown in figure 3, where cost or hours expected to be used for certain tasks will be related to the relevant tasks. By reporting costs like this will show peoples performance in terms of tasks. Through this structure it is possible to estimate progress and earned value, as a project plan is usually structured to include and build upon activities and tasks (Webb, 2003).

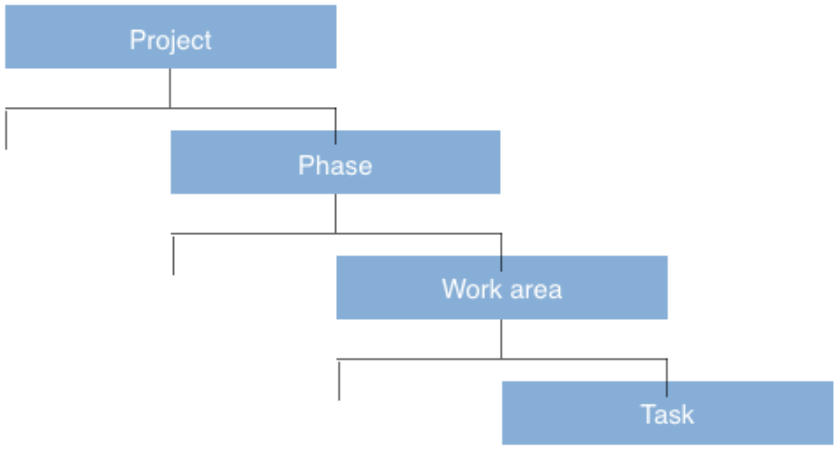

Figure 3: Task-based Work Breakdown Structure (Webb, 2003)

2.2.2 Resource Planning

As part of Project Management is the creation of teams with individual specialists from different departments of an organization. These individuals are grouped together for a limited time period to execute a project. When a project is finished the project team is split up and individuals are appointed to other projects. Traditionally, Project Management would consider projects to be independent from each other, however, in situations where there is a multi-project environment issues emerge (Payne, 1995, Ghomi & Ashjari, 2002; in Laslo, 2010). Research has in relation to this moved over to *Project Portfolio Management*, a method used by companies to manage a group of projects to find the best mix to achieve organizational goals while taking into account resource

constraint, a changing marketplace, or changing firm strategies (LaBrosse, 2010). Project Portfolio Management requires a balancing of resources as, in multiple-project environments, projects share resources with each other and there is an issue of handling a resource constraint (Cusumano & Nobeoka, 1988; in Laslo, 2010). As projects compete for expert resources and each project in a portfolio wish to achieve goals with an optimal use of resources – skilled individuals, it complicates resource planning and scheduling (Platje et al, 1994, Kerzner, 2000, Vals et al, 2009; in Laslo, 2010). In Research and Development (R&D) projects there is also an issue of uncertainty and complexity as planning and scheduling is exposed to change such as resources becoming unavailable or activities taking longer than expected (Pich et al, 2002, Williams, 1999; in Laslo, 2010).

2.2.3 Formalization

Studies have found that formalization in projects or temporary organizations is related to project performance (Lundin & Söderholm, 1995, Liu et al, 2008, Milosevic & Patanakul, 2005, Na et al, 2004, Nidumolu, 1996, Payne & Turner, 1999; in Teller, Unger, Kock, Gemünden, 2012). Formalization in Single Project Management (SPM) and Project Portfolio Management involves having standard tools, established standards, established processes and procedures, firm control, and consistency (Milosevic & Patanakul, 2005, Nidumolu, 1996, Dietrich & Lehtonen, 2005, Lui et al, 2008, Payne & Turner, 1999; in Teller et al, 2012). In Project Portfolio Management it is however, more challenging to ensure efficient and effective execution of projects (Ahlemann et al, 2009, Garcia, 2005; in Teller et al, 2012). Cooper et al (2001, in Teller et al, 2012) mentioned that is is highly important to have well-structured processes in Project Portfolio Management when there is new project development. In their study, Teller et al (2012) found that formalization in both SPM and Project Portfolio Management is directly related to portfolio success. Formalization could improve project's transparency in project portfolio environments, due to an increased level of available information. They also found that formalization is linked to the speed of allocating resources, level of reliable commitment, and that it can reduce conflicts in relation to resource endowment. Through formalization, willingness to assist project teams and PMs is increased, and through transparency more appropriate allocation of resources could take place. Overall cooperation between projects could be improved through formalization, as conflicts and competition for resources is reduced. A joint formalization between SPM and Project Portfolio Management strongly impacts the quality of Project Portfolio Management. The increased level of formalization

at one management level will therefor have a positive effect on formalization in the other. The positive effect is however, moderated by a projects level of complexity, but the benefits of formalization becomes stronger. Teller et al (2012) also stated that «there is no single method of formalization that fits all portfolios». The complexity of projects and their interdependency must be carefully considered.

2.3 Monitoring and Controlling

A planning-monitoring-control cycle is a continuous process throughout a project until completion. It is equally useful for the parent organization as well as the project. A PM has to monitor the three factors in the Iron Triangle; scope, time and cost, and define characteristics for each of the three. Other factors worth monitoring can be mhrs spent, changes and customer satisfaction. In addition, it is crucial to monitor the WBS and the RM-plan. Monitoring how resources are being utilized according to the planned amount of hours for activities, work packages, and monitoring potential risk, will keep the PM and project team alert and reduce the chance of surprise when risk occurs (Meredith & Mantel, 2012: p.435-437).

Meredith and Mantel (2012) introduced three fundamental purposes for controlling projects. One is *physical asset control*, which has grown to be difficult as outsourcing is being used more and more. In controlling the use of assets, concerned with the maintenance of assets, lies a question of timing and the quality of maintenance. Controlling inventory when it is received, certified and perhaps stored, is also necessary. Another aspect is the *human resource control*, concerning the development of people. As projects are usually unique, people can gain experience and grow in a relatively short period of time. This is however difficult to measure. A third aspect is *financial resource control*. It deals with the control of assets, budgets and investments. Analysis' are used to control these factors and it is conducted by an accounting or controller function in an organization. It is mandatory to include this function in project teams (p. 475-476).

Controlling projects is a complex process as it need to specify what factors to control, how to measure it, what amount of deviation from plan is acceptable before actions must be taken, how to notice possible future deviation and correct them before occurring, etc. Three types of control mechanisms are *cybernetic* control, *go/no-go* control and *postcontrol*. *The cybernetic process* wish to control how inputs become outputs, and through monitoring, outputs can be compared to predetermined standards. The difference determines whether it needs correction or not. *The go/no-go mechanism* is used to control whether specifications has been met. For output (scope) there can

be certain requirements that results have to fall under to be approved by the customer. For time and cost there can be fines for delivery if it is not sufficient with plan (either late or early). These are usually included in a contract. *Postcontrol* is, compared to the other two which concerns reaching goals in ongoing projects, concerned with future projects and their goals being met based on historical data from similar projects (p.476-483).

2.3.1 Project Forecasting

Hamel (2014) described forecasting as «a statement about how the future will turn out based on evidence or assumptions». So, either you will know what to consider in a forecast for a new project and use reliable historical data on what to include, or you may assume the amount of hours and costs needed to deliver the product or service on time.

Forecasting has been conducted since people started to make long-term investments. The basic fundamental idea is that; things that have happened before will happen again in the future, often in the same way. Looking back in time, farmers expected to harvest and therefor cleared land and planted crop before the harvesting season began. Assuming that things will happen the same way in the future is a somewhat naive forecast, but powerful. The world is changing rapidly, and forecasting therefor becomes a challenging task. Technology is one thing that is changing very quickly, making forecasts even more difficult as there is no historical data to build on (Porter, Cunningham & Banks, 2011). Porter, et al (2011) posited that:

«The test of the validity of forecasting only really comes with the passage of time. Yet, decisions need to be made in the present, and delaying them can also generate significant, even disastrous, costs.» (p.13)

2.3.2 The S-curve

Forecasting provides Project Management with schedule information that is supposed to help managers to evaluate project risk and control it. It has been introduced a variety of techniques for estimating the parameters of Project Management. Two types of methods are *project cost forecasting* and *project duration forecasting*.

Duration forecasting was developed at a later time than cost forecasting. Due to scheduling being measured in currency units, not time units, and other implications, the application of techniques for duration forecasting has been slow compared to cost forecasting. Two major aspects that affect the

accuracy of project forecasting are lack of information and the complexity and size of projects (Chen, Liu & Li, 2010).

The S-curve is a financial profile used for each project in a department. It is often used to develop a program expenditure profile, making analysis and forecasts, and acts as a limiting factor (Peters, 1984). Chao and Chien (2009) described it somewhat more simply as something used for project planning and control. It shows increasing progress over a project's life, and the graphic shape of it usually indicates that a project is slow to begin with and at the end, but has a steeper progress curve in the middle when work is at its most intense, as shown in diagram 1. The S-curve can provide a foundation for forecasting costs, and thereby be used for making future arrangements and set goals for future progress. It is important to update the S-curve as progress often deviate from original budget or plan.

In complex projects, as well as small ones, the start has a relatively small growth due to few tasks at hand, but when projects start handling multiple activities simultaneously growth escalates. Accelerated work or progress naturally increase the cost compared to the beginning of a project.

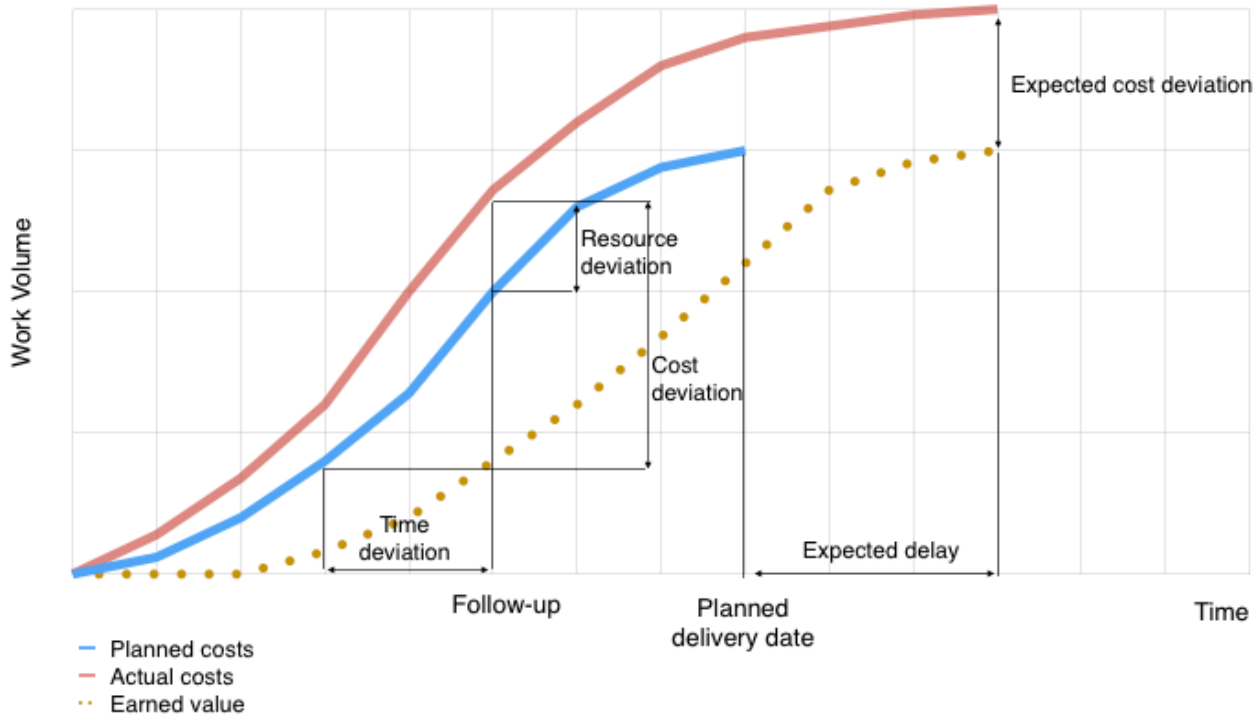

Diagram 1: Example of S-curve showing actual cost, planned cost and earned value (Rolstadås, 2013: p.304)

To be able to monitor a projects status, Planned Value (PV), Actual Value (AV) and Earned Value (EV) has to be registered continuously in an s-curve. This is shown in diagram 1. PV indicates the

original resource plan accumulated over a baseline. AV shows the real accumulated resources per period. EV shows the accumulated value created. EV is found by calculating the amount of completed work in percent or estimating how much work in percent is remaining before completion. When a project has follow-ups it can discover and analyze deviation between planned, actual and earned values. During these follow-ups, estimated productivity and effectivity can be used in forecasts. Diagram 1 shows cost deviation measured at the follow-up. Cost deviation is defined as the sum of volume deviation (PV-EV) and resource deviation (AV-PV) measured along the resource-axis, and time deviation (AV-EV) measured along the time-axis (Rolstadås, 2013).

Follow-up without controlling all three factors is pointless. If the costs are lower than expected in one period, it can be both positive and negative, depending on progress. If resources used is higher than expected in one period, it can be acceptable if the progress it better than planned in that same period (Mantel et al, 2008, in Rolstadås, 2013).

Any project should use the s-curve as it will give managers an early signal of the project's current progress and its forecast. When deviation between the three factors is registered it signals the need for re-planning. The forecast then has to be updated, new critical path is created and analyzed, new resource plan is made, and a new PV-curve is established. The original baseline should however, still be kept so that the project's progress and costs can be measured against the original plan (Rolstadås, 2013).

2.3.3 Earned Value

Earned Value (EV), or Earned Value Management (EVM), is used to measure progress in a project. It can give early warning signals if a project is going to have performance problems. EV measure performance and progress by integrating management from three factors which is important in projects. As mentioned earlier in the Iron Triangle, these factors are cost, scope and schedule or time (Naeni, Shadrokh & Salehipour, 2011). EV also provides an indication of the need for corrective action due to project performance (Vandevoorde & Vanhoucke, 2006).

Before the concept of EV was introduced, PM's measured project performance by using Gantt charts and the Critical Path Method (CPM) for scheduling, and looked at the difference between planned and actual costs or hours, to see how the project was doing. In its early days, EV was seen as costly, complex and as something including alien terms, and not as a performance measurement system (Webb, 2003).

2.4 Critical Path Method

The Critical Path Method (CPM) is a tool used for planning and scheduling projects, and it determines a project's reasonable duration time required to finish (Göçken, 2012).

CPM is a network that can be used to plot critical points in time when activities and events in projects have to be complete. Establishing what activities have to be included, what the activities depend on, and activities' duration, will show how activities are dependent on each other and in what order they have to be completed. In these networks, the start- and end-date can be determined (Rolstadås, 2011: p.147). Conde (2009) mentioned the fact that some activities have to be complete before others can start. The CPM estimates the overall completion time for a project, but also its minimum completion time. If delays occur in any activity, it will provoke a delay on the completion time for a project. This issue is the part where activities are seen as *critical* in projects.

2.4.1 AOA-network

Figure 4 shows a AOA-network (Activity on Arch) where events are represented by circles, 1 represent the beginning of a project, and 6 represent the end. Events are connected with activities, represented by the letters A-G. Activities can have, and should have, fluidity, so that it can change its duration to some degree without affecting the final date of delivery. Slack is connected to the events. It is described as the difference between an event's latest and earliest possible start for implementation. (Rolstadås, 2011: p.147). Activities' duration is defined in brackets.

To estimate the earliest start one goes through the network starting at the beginning. To find event 2's earliest start, one takes event 1's earliest time and add the duration of activity A, and get 3. For event 5 one can look at the duration of C and get the earliest start of 7, or by going through D one gets the earliest start of 12, which is chosen as it is the highest number.

To estimate the latest starting points, one has to go backwards. An end date is set for event 6, and the latest start is equal to the earliest as the project needs to finish as early as possible. Looking at event 3, it has two subsequent activities. By choosing the lowest number, event 3's latest start becomes (12-7) 5 through activity D.

To explain fluidity, activity E and F have earliest start 5 (event 3) and latest start 20 (event 6). The two activities then have to be executed in a time-frame of (20-5) 15. Their duration is however 13 in total, and get a *scheduling freedom* of 2.

To find events' slack, one can look at event 2. The earliest start is 3 and latest is 8, its slack is thereby (8-3) 5 (Rolstadås, 1997: p.152-161).

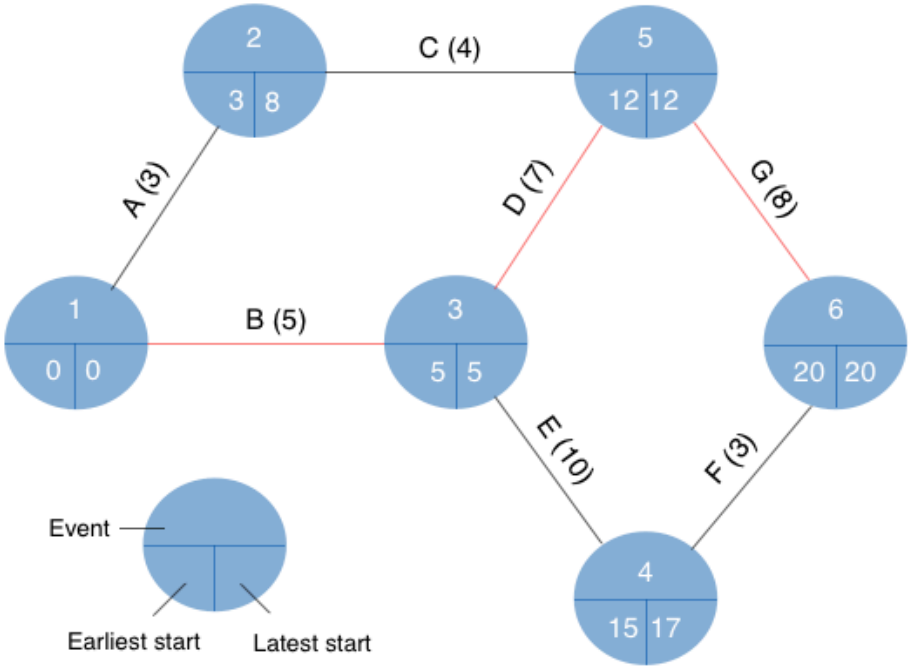

Figure 4: AOA-network (Rolstadås, 1997)

Table 1 shows estimated fluidity (FL) for each activity. It is calculated as: FL = LF (latest finish) - EF (earliest finish), or FL = LS (latest start) - ES (earliest start). The table shows that activity B, D and G have zero fluidity and are then characterized as *critical activities*. The critical path for this AOA-network is therefore through B-D-G (Rolstadås, 1997: p.160).

Activity	Duration	ES	EF	LS	LF	FL
A	3	0	3	5	8	5
B	5	0	5	0	5	0
C	4	3	7	8	12	5
D	7	5	12	5	12	0
E	10	5	15	7	17	2
F	3	15	18	17	20	2
G	8	12	20	12	20	0

Table 1: Estimation of earliest and latest start and finish for activities in a AOA-network (Rolstadås, 1997).

2.4.2 AON-network

In a AON-network (Activity on Node), the term event is absent and activities' ES, EF, LS, LF and FL is estimated directly. Figure 5 shows the different activities defined as the letters A-E, and their duration in weeks. Activity B can start when activity A is finished, hence after 5 weeks. 5 is then B's ES. This applies for all activities, and if one activity has more than one predecessor the highest value is used. Activity D therefor has (12+5) 17 as ES, as that is C's EF (Rolstadås, 1997: p. 161-162).

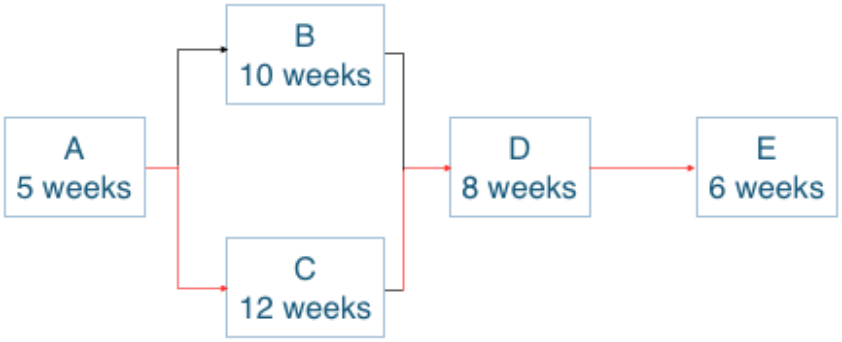

Figure 5: AON-network (Rolstadås, 1997).

To find LS for activities, one has to go backwards. As shown in table 2, LF for the last activity (E) is set equal to EF. LS for activity E is found by subtracting its duration from LF (31 - 6 = 25). LF for the other activities is the LS of its successor. The critical path in this example of a AON-network, is through A-C-D-E (Rolstadås, 1997: p.162).

Activity	Duration	ES	EF	LS	LF	FL
A	5	0	5	0	5	0
B	10	5	15	7	17	2
C	12	5	17	5	17	0
D	8	17	25	17	25	0
E	6	25	31	25	31	0

Table 2: Estimation of earliest and latest start and finish for activities in a AON-network (Rolstadås, 1997).

2.4.3 PERT and Lichtenberg

CPM has some disabilities. The issue is that the duration of activities are uncertain. The Program Evaluation and Review Technique (PERT) take into account that the duration follows a statistical

distribution with a known expected value and variance (Rolstadås, 2011: p.160), and that activities are independent of each other. Activities' duration is therefor assumed to not influence other activities' duration in the same project, and can be estimated (Hardie, 2001). Rolstadås (1997) mentioned that an expression for expected value and variance include three different estimates for each duration:

a: the shortest conceivable duration (optimistic)

m: the most likely duration (realistic)

b: the longest conceivable duration (pessimistic)

Expected value and variance for a selected duration (t) can then be solved as (p. 172):

$$E(t) = \frac{1}{6} a + 4m + b$$

$$Var(t) = \frac{1}{36} (b - a)^2$$

Lichtenberg (2005) introduced the *Successive Principle* in the early 1970s. The principle is a management instrument that can increase the chance of project planning reaching a result able to avoid overruns. It involves a top-down focus to have a complete overview at all times, starting with a detailed sketch of the most important and uncertain elements. The principle further focus on the use of interaction and combination of knowledge, experience and intuition. When all aspects are identified, including environmental assumptions, the resulting forecast should be accurate (Lichtenberg, 1989), and give project participants an overview of uncertainties. This to be able to focus on the most important issues, and avoid utilizing resources on less important or pressing matters (Lichtenberg, 2005).

2.4.4 Crashing

Project's completion time is determined by the CPM, and should be reduced to meet deadlines. This is where the *project crashing problem* is introduced. It involves shortening a project's duration time (Göçken, 2012), and minimizing costs related to crashing, while at the same time meet deadlines. To meet deadlines, projects may overlap activities or accelerate activities at an additional cost by adding resources (Yang, 2007). Resources can be determined as better equipment, material or more skilled personnel (Göçken, 2012). Göçken (2012) stated that the crashing problem analyze to what extent activities in projects can be adjusted to reach a desired trade-off between cost and time. He

mentioned that parameters (activity, duration, cost etc.) of the crashing problem are in general certain, and can easily be determined. However, in reality, environmental changes and lack of information can be uncertainties influencing the parameters.

2.5 Risk Management

Risk is something a PM faces in projects, and it can be defined as «a problem that has not happened yet». There is a question of what type of problems that can occur, and how to avoid them in a project. One would imagine this to be on the list of highly prioritized tasks for a PM. However, this is not always the case, as Risk Management (RM) is often not given the needed attention. This suggests that a PM might examine risk in a 'light' way, and add a margin for risk in the total budget (Cervone, 2006).

Wu, Chen & Olson (2014) defined RM as:

«the process of identification, analysis and either the acceptance or mitigation of uncertainty in investment decisions making.»

RM analysis is supposed to give an insight into present risks in a project, and to be used as a base for generating risk responses (The Project Management Institute, 2008; in Creemers, Demeulemeester &Van de Vonder, 2014). Insights could be; probability to achieve a desired target, distribution of completion time etc., and by using these insights, the risk response process can help Project Management to reduce risk by defining suitable responses to observed risk (Creemers et al, 2014). Ward and Chapman (2003) argued that PRM has a limited focus of managing project uncertainty. Project risk is known to be hostile effects on the performance of a project. Sources for risk are assumed to be something that can go wrong in a project or that threatens a project. It can seem that PRM is meant to identify and manage project performance threats, and not take into account the opportunities of a project - positive effects of performance. Threats and opportunities can be treated separately, but are usually not independent from each other. With this regard, it is inadvisable to reduce risk without considering the opportunities related. And the other way around, when opportunities are identified, the risk associated has to be incorporated.

2.5.1 Uncertainty

Uncertainty management is becoming a bigger part of risk and opportunity management preference, though it involves more than the other two (Ward and Chapman, 2003). They explained uncertainty management as:

«It is about identifying and managing all the many sources of uncertainty which give rise to and shape our perceptions of threats and opportunities.»

This explanation implies that one should explore and understand the source of uncertainty before managing it. Management is usually concerned with handling uncertainty from an early stage in a project, and to the very end. This is important to identify what actions can be taken, decide what to do, and make sure actions are conducted. Basic types of uncertainty that need to be addressed in projects are time, cost, quality (and perhaps scope). Estimates of project parameters, design, logistics, priorities and the project parties relationship can also be just as crucial to address. Causes for uncertainty can often be lack of experience for an activity, lack of specified requirements, complexity of influencing factors, or events affecting activities (Ward & Chapman, 2003).

2.5.2 Handling Changes

As discussed earlier, there are many existing tools Project Management can use to develop project schedules in the planning stage. But as we have learned, projects change, and the execution of projects include uncertainty. This can create delays and cost overruns. To handle changes more effectively, contractors need to adjust schedules, resource distribution and work plan. The CPM is a technique found to be one of the better to determine activity in projects. When a project schedule for activities, and tasks has been determined, it is not easily changed, and as changes occur due to customers need or owners budget, they are challenging to handle in terms of scheduling. It can lead to a loss in project efficiency, and further reduce contractors freedom to allocate resources or force contractors to implement more costly alternatives (Yan, 2010). Zhang (2013) agreed that changes often happen in complex projects. Planning is based on assumptions about what the future will look like. These assumptions can often fail and result in the original plan containing unnecessary (or time consuming) activities. Project changes are usually treated as to have a negative impact on implementation and completion, but projects can also be used for innovation, and that idea challenges the conventional assumption about project changes.

2.6 Reasons for Overrun

A large amount of complex projects overrun on their hours (and costs), which can suggest that control systems are inadequate (Hardie, 2001). He suggested that an issue can be that activities are assumed to be independent from each other, and take place in a linear order. However, in practice, activities often return to earlier stages to make changes or alterations.

Flyvbjerg et al (2003; in Bosch-Rekveldt et al, 2011) agreed that it is common practice that projects fail in terms of delays or cost overruns. The fact that projects have become more complex over time can be one reason for failure, or that the complexity is underestimated at an early stage (Williams et al, 2002, in Bosch-Rekveldt et al, 2011). The lack of a good framework for large engineering projects reduce the understanding and possibility to better manage complex projects that take place today (Bosch-Rekveldt et al, 2011). Reichelt and Lyneis (1999) mentioned that rework, feedback and a knock-on effects also are typical factors that are not always considered when planning a project, which can affect productivity and quality of work over a projects lifetime, and further create delays.

2.7 Earlier Research

It exists several previous researches done on the subject of overruns in construction projects, so information on the matter is not lacking. Table 3 lists the findings of four earlier researches done on overrun and delay in the construction industry.

AUTHOR (Year)	TITLE	AIM OF THE RESEARCH	DETAILS	RESULT
K. Reichelt, J. Lyneis (1999)	The Dynamics of Project Performance: Benchmarking the Drivers of Cost and Schedule Overrun	What factors are most significant in causing rework and productivity problems on large, complex projects?	10 projects Study of cost and schedule overrun.	•Design efforts have significant rework (30-65%). •Build efforts have less rework (13 to 40% of the total build hours), but because build is the last phase (outside of test), discovery and correction of this rework controls project completion (and/or delivered quality). •Many design efforts spend their entire budget on 'original' work, and therefore any rework leads to budget overrun. •Knock-on effects from a poor design effort cause schedule and budget problems in construction.

AUTHOR (Year)	TITLE	AIM OF THE RESEARCH	DETAILS	RESULT
C. Eden, F. Ackermann, T. Williams (2005)	The Ambiotic Growth of Project Costs	The aim of the paper was to contribute to an understanding of how projects go badly wrong, when they do, and in particular to draw some lessons from this exploration which are likely to help all managers.	Public projects. Study of cost overrun in large complex development projects.	•When projects are being estimated, it is important to acknowledge uncertainty from the outset •Underestimating at the planning stage is one of the most common triggers for cost escalation •Contract change •Different interpretation of contract requirements, specifications •Productivity, new labour acquire training, learning inefficiencies
M. M. Kumaraswamy, D. W. M. Chan (1998)	Contributors to construction delays	Important factors affecting productivity were examined in more depth, with a view to enhancing productivity and reducing delays.	Study of delays in Hong Kong. Questionnaire: building projects and engineering projects.	Some of their findings for engineering: •Unforeseen ground conditions •Poor site management and supervition •Low speed of decision making involving all project teams •Client-initiated variations •inadequate contractor experience •Slow information flow between project team members •Shortage of skilled labour •Delays in subcontractors work
S. Morris (1990)	Cost and Time overruns in Public Sector Projects	The study arrived at rough estimates of the delays and cost overruns…	Public sector projects in India.	Some findings: •Inadequate project preparation, planning and implementation •Delay in construction, supply of raw materials and equipment by contractors •Change in scope •Resource constraint •Delays in decision-making •Lack of experience The costs of learning by doing which are real costs, get passed on to the user firms in the form of delays in equipment supply, improper or faulty project design, cost escalation in equipment

Table 3: Shows earlier research and their findings.

3. Case Organization and Industry

3.1 Subsea Industry

The offshore and subsea industry has been growing since the 1960's, when the first subsea well was in production. In the 1980's the main focus in the industry was on how to move the oil and gas production down from the surface, to the seabed. In the 1990's it was established that it would be possible to move production down on the seabed and link the subsea systems to platforms on ships. After successful testing of equipment outside the coast of West Africa, international interests for the solutions increased. The new technology turned out to be cost efficient and soon became more common. Later, in 2005 and onwards, large amounts of gas was found in oil fields and presented new challenges, such as high pressure and temperature. New technology to extract the gas was again developed to handle the new measures of temperature and pressure. Distance was another challenge, and pipelines were developed to transfer the gas directly to shore, rather than traditional platforms on ships. (UTF, 2012).

3.2 SubComp

SubComp is a highly global and technological firm, and operates in around 16 different countries all around the world. They are one of the world's largest suppliers of subsea production systems and equipment. They design and manufacture products for the oil and gas industry. The company consist of four main regional business units, and one of them is the Eastern Region. This region has a total of 5500 employees, and covers 50% of the subsea business in the company. Related to this region, the department I have studied has approximately 400 employees, and thereafter called Department A.

Department A consist of engineering, procurement, assembly/construction at subcontractor, and testing. Engineering involves detailed design of a majority of the scope, and only smaller parts of the scope is procured as Original Engineer Manufacturer (OEM) for key components. The majority of scope is customer tailored made, and a minor part of scope is standardized according to a product catalogue. Large parts of Department A's scope are subcontracted. The company procure/ subcontract between 60-70% of the contract value, and there is very little in-house manufacture/ assembly or testing. Only internal type of production activities related to new product qualification and testing (R&D) take place at SubComp. These activities are typically not part of a customer Engineering, Procurement and Components (EPC) contract. When the activities are part of the EPC

contract they constitute only 1-2% of total value, and are usually SubComp funded. Sometimes some of the R&D is funded by customers. In general we can say that SubComp is dealing more with Project Management than fabrication and assembly activities.

Within Department A I have looked at different projects with different Product Project Managers (PPM). To understand the complexity of Department A and their projects, it is important to bear in mind that SubComp's customers are stationed in different parts of the world. Project teams may therefore be split up and work from different locations. The selected projects are all large EPC projects, and the department covers the majority of the scope, typically between 30-50%.

4. Research Method

4.1 Interview Method

Seidman (2013) mentioned that qualitative interviews can be a struggle due to the fact that they take time and effort. The researcher has to contact participants, interview them, then transcribe the information collected, and further analyze and share what was learned (p.11). On the other hand, he concluded that it is a powerful tool to get insight into «social issues through understanding the experience of the individuals whose lives reflect those issues» (p.13).

A semi-structured interview is often used when you have a clear vision of what you want to find, and is a conversation between the researcher and the one who is being interviewed. By using a set of questions the researcher can guide the interview object through the topics that will be covered. Compared to a structured interview, where the researcher has a list of questions which are asked in the same order for all participants, a semi-structured interview can vary between participants. Questions used in a semi-structured interview can either be simple and easy to stick to during the interview, or questions can be open and create a free conversation touching upon more than what was originally planned. The questions used in a semi-structured interview will cover what the researcher believe is important. The problem definition of the research will define how much structure is needed in the interview. When questions are formulated more complex, the less structure is needed according to Miles and Gilbert (2005: p.65-66). Semi-structured interviews are useful if the problem definition is *Why,* instead of *How many* or *How much*. As this kind of interview structure is flexible, the informant can talk freely, and questions can be adapted to each participant. This way the researcher can include aspects that are important for the informant, and get a better understanding of the problem definition. Questions are not formulated in such a way that answers will be *yes* or *no*, as that would be a structured interview. Questions would rather be ask around relevant topics to bring out what the participant find important (Miles & Gilbert, 2005).

By using a semi-structured interview approach in this research would give me an opportunity to identify topics I had not already covered in my pre-structured interview guide. Without forcing the participant, he would be allowed to share personal experience and additional topics.

People have the ability to pass on their own experience through language and speaking, and Betaux (1981) stated that «if given the chance to talk freely, people appear to know a lot about what is going on» (in Seidman, 2013: p.8). The purpose of an interview is to get an understanding of the experience of others and what they make of it, as others experience is worth something for the

purpose of the research. Creswell (2007) supported this argument that by being flexible with research questions is useful to capture necessary information. Participants might not always answer the question asked, and can end up answering questions that was supposed to be asked later in the interview. He also mentioned that questions must be constructed so that it will keep the respondent focused, and by using follow-up questions the researcher can collect valuable and credible information (in Turner, 2010: p.757).

In case studies or research, Kvale (2007) said that interviews are applied when the focus of the study is an individual, a company or a situation. He also stated that observation and informal interviews can be of importance to get necessary information (p.46). Becker and Geer (1957) argued that observation was a useful tool, or to be exact: the single best way to get information and data (in Seidman, 2013: p.10). Trow (1957) on the other hand, argued that interviewing was a better tool for some purposes (in Seidman, 2013: p.10).

For the purpose of this research it was useful to collect empirical data through interviews and conversations, as I was interested in the opinion and experience of PM's and employees in a company. To get the information, I had to speak to relevant staff rather than observing their attitude and behavior. By using flexible research questions I could get necessary information, and by supporting my questions with follow-up questions, I kept the respondents focused.

4.2 Choice of Methods and Selections

In 2013 I had a summer internship at SubComp, and already at that time I started collecting and analyzing mhr-data to see if I could find any trends on labour hour overruns in projects. The data was systematically gathered, then sorted into an Excel-file, and was updated every month. This was, and still is, a pressing issue that hopefully could benefit the company if resolved. At the beginning of this year it was decided that I would continue the work from last summer, and I met with my advisors at SubComp. They had some idea of what the main contributors to overrun could be, but needed me to get it analyzed and documented. Together we hand-picked and listed seven projects of interest to narrow down the amount of research.

4.2.1 Selection of Participants

I had to select persons in SubComp who had experience, people who were likely to have an idea of what caused labour hour overruns in projects. It had to be persons who could give me relevant

information. Together with my advisors at SubComp, we found that by selecting the PPMs from the seven projects would be the most appropriate, as they were considered to have the experience and knowledge to best answer my questions. The PPMs would more or less be qualified candidates and would provide credible information. Creswell (2007) argued that, to get credible information, you have to acquire participants that are willing to share their stories honestly. Also, by conducting interviews in an environment that will make the participant feel comfortable, can make it easier (in Turner, 2010: p.757).

SubComp is a large and global company with a complex organizational structure with many employees, and I had never met the people I was interviewing before. Therefore, after the selection of PPM's I sent out an email including an «Interview Guide» informing them of who I was, the purpose of the research and asking for an interview. After getting some response I started setting up meetings continuously. I had my own office-desk and access to the company premises so that I could come and go as I pleased. I was allowed to use, and had access to meeting rooms for my interviews.

I had to establish a connection with the participants first through emails, and later while interviewing them. Mostly they were more than happy to help answering questions and later clarify if I had further questions. They generally seemed to find my thesis interesting.

It was challenging to get in touch with all PPM's. Many of them did not reply at all, and I had to follow up with additional emails. After my first week of interviewing, I decided to send my interview guide as a questionnaire to all the remaining PPM's on my list. I wanted to see if I could get any more response. I realized that many of the employees had a heavy workload, and to take time and sit down with a student was not considered the highest priority. I only managed to get an interview with six of the listed PPMs representing five of the seven selected projects.

Burnard (1994) pointed out that it can be difficult to set up and organize face-to-face interviews, and that telephone interviews may be useful as an alternative to collect data. I had to set up one telephone interview as one participant did not have the opportunity to meet me in person.

4.2.2 The Participants

The participants were men and woman with different nationalities. Some had worked for SubComp more than others, some had more experience, some had worked with different projects and others only with one project. They were all knowledgeable in their field of work, but it differed between

the length of time they had worked in a project. To keep the informants anonymous I chose to give them pseudonyms and refer to them all as male, pseudonyms being identifiers for respondents (Fedderath, 2001). I also translated all answers into English.

Before creating my research questions for the interview guide, I had a look at raw data on mhrs. This was to get an understanding of what had happened in the different projects. The purpose of the interview was to create a conversation, and possibly get the PPM's to mention elements that I had not already considered, just like Creswell (2007) stated earlier. Some interviews were also conducted with two people at the same time, which created discussion between them and me. The questions asked were created on the basis of the raw data found in SubComp's database, but also according to the content of relevant theory. The intention was to be able to compare theory with real life application. I tried to formulate general enough questions so that participants would have some idea of an answer, if not a detailed one. Turner (2010) suggested to ask questions that are open enough to let the respondent discuss and reflect (p.758). That is what I tried to do.

4.2.3 The Interview Setting

As Kvale (2007) put it; «The qualitative research interview is a construction site for knowledge» (p. 7). Most of the participants were familiar with the problem definition before I introduced it, as it is something the company is focusing on on a daily basis. Throughout my interviews I learned that not all questions were as important or relevant as others, but still most questions created a conversation were I could clarify if necessary. Most of the participants touched upon topics from my interview guide themselves, before I brought it up. This made it easier for me to ask follow-up and clarifying questions on answers given along the way. I arranged interviews in meeting rooms at the company's premises. It was a formal setting, but informal enough for the participants to not hold back on their thoughts. I recorded the interviews when face-to-face to make sure I got everything they said. From my experience as a student, it is difficult to both listen and write down everything a professor talks about during lectures. By using my phone as a recorder I was hoping that it's presence would be less visible, and not affect the conversation. Recording by phone did not seem to bother the PPMs, and the quality was surprisingly good.

4.2.4 Transcription

I transcribed the recorded interviews immediately after the meetings to summarize and come across new topics before the next interview took place, and further use it in the next interview. I chose to

transcribe detailed enough to get the relevant information down on paper, but avoided every-day expressions and excluded irrelevant sentences for the purpose of understanding the interview better. In addition, I edited sentences to make them have a better flow and to bring out the importance of the conversation. I had to exclude some sentences from my transcription as I could not understand what was said. It was either due to the person moving around the room while talking, talking at the same time as another person, or that their pronunciation was challenging to interpret.

I chose to use quotes from the interview to better communicate the meaning of sentences to the reader. I sometimes had to rewrite sentences to get the full meaning of them in written form, as an oral explanation or formulation is not always suitable when formulated into text. By using a standardized approach when quoting, I cleaned up sentences to spare the reader. By being less faithful to the respondents dialect and feelings, and rather enrich the quotations, I hoped to reveal relevant information from the interviews. With this approach I would stay true to the original words and its meaning, but edit the extraction, making it easier for the reader to understand (Weiss, 1994: p.193).

4.2.5 Analysis

According to Rabiee (2004), «the process of qualitative analysis aims to bring meaning to a situation rather than the search for truth…». After transcribing and making sure that notes represent what was told in interviews, the researcher can analyze the content and draw common themes between the interviews (Halcomb & Davidson, 2006). Miles and Huberman (1994) meant that qualitative data can show what events led to certain consequences and give «fruitful explanations». A stage the researcher needs to go through, is the stage of reading through transcripts while making notes of general themes. The goal is for the researcher to get an overall view of the data to further create headlines describing the different aspects covered in interviews. It is important to make sure quotes include the context it is in, and is not separated from other text creating the context, as that could change its meaning. There is also an issue of what to leave out of the analysis, as there are usually some elements that are irrelevant, even if it was logical during the interview (Burnard, 1991).

Analyzing qualitative data can be seen as the core of a research. It involves developing an awareness of the data collected, how it can be examined and explained, and activities that will assist with the examination and description of data. An issue with qualitative data collection is that information often is personal or individual. Sometimes researchers are required to protect the

identity of the participants (Gibbs, 2007: p.8). This is the case in my research, and to keep participants anonymous I will quote information that I consider general enough to avoid revealing any personality treats.

During my research I analyzed throughout the interview as I sometimes deviated from the interview guide. I asked follow-up questions suitable for the situations, and sometimes I even got answers or explanations to questions I did not ask. In my transcription I left out irrelevant information to not confuse the reader. When analyzing my findings I compared the raw data collected with the outcome of the interviews.

4.3 Reflection

Initially it was decided that I would base my research on seven projects, representing three different end customers. Initially I planned to interview at least two PPMs per project as they represented different WPs. I wanted to look at three different work packages, WP1, WP2, and WP3, WP3 for those projects who included this. Projects at SubComp have additional WP's, but I was mainly looking at the three. This was to find trends on project mhr overruns in the chosen WP's and actual associated end customers.

It turned out to be more difficult to get an interview with all PPMs than expected, which resulted in a reduced number of interviews and reduced variation of results as shown in table 4 below. In total I interviewed six different PPMs and one additional PM, representing only five out of the seven different projects. Therefor, as I only got empirical data from only five different projects divided among the three customers, discussion directly aimed at the end customers is absent. In addition, I decided not to discuss my findings in WP3 as it is a much smaller WP than the other two, and not all projects included this one. WP3 is not comparable due to shorter lifecycle and limited information was given during interviews. I sent follow-up questions or additional questions to the PPMs by email regarding questions that had come up at a later point in time, or if questions were skipped or forgotten during an interview. Not all PPMs replied to additional emails that were sent, which restricted the discussion related to some subjects. Limited discussion on delays occurred due to low response from PPMs on additional email sent. Table 4 below lists detailed information about each of the projects that has been studied.

ACTUAL SELECTED PROJECTS					
Projects	Project A	Project B	Project C	Project D	Project E
Interview objects	PPM1	PPM2 & PM	PPM3	PPM4 & 5	PPM6
Work Packages	WP1, 2 & 3	WP1, 2 & 3	WP1 & 2	WP1, 2 & 3	WP1 & 2
Budgeted Hours					
WP1	44,000	36,000	20,000	56,000	26,000
WP2	32,000	26,000	15,000	41,000	33,000
WP3	1,000	300		8,000	
Actual Hours Spent (within the time of the study)					
WP1	84,000	68,000	10,000	113,000	24,000
WP2	90,000	42,000	14,000	68,000	24,000
WP3	5,000	200		18,000	
Duration (at the time of the study)					
WP1	41 months	40 months	29 months	43 months (ongoing)	19 months (ongoing)
WP2	51 months (ongoing)	39 months	34 months	43 months (ongoing)	19 months (ongoing)
WP3	44 months	21 months		40 months	
Delay on selected items					
WP1	6 months	Missing	2 months	Missing	No delay
WP2	16 months		5 months		
WP3	Missing				
Replaced after (no. of months)					
WP1			PPM3 (15 months)	PPM4 & 5 (20 months)	PPM6 (3 months)
WP2	PPM1 (11 months)	PPM2 (37 months)	PPM3 (17 months)		PPM6 (3 months)

Table 4: Showing details on each of the studied projects

5. Empirical Data and Findings

This chapter will present empirical data and findings. I have chosen to categorize my findings, and picked out what I find as the most central aspects. The aspects highlighted in this section is linked to my research questions listed in the Introduction.

The chapter is divided into 11 parts where the aspects of project overrun contributors are introduced in part 5.1-5.10. Part 5.11 describe the PPMs view on potential mitigating actions SubComp could implement to improve efficiency and effectiveness in their projects. The goal of this chapter is to highlight certain aspects of labour hour overruns in projects and give the reader an understanding of what the main contributors are in the study of SubComp, and how the engineers (PPMs) view the issue.

5.1 Earned Value

SubComp use an Engineering plan to measure progress in projects. This tool lists (engineering) documents that are associated with each item (equipment) to be delivered in a project. These documents need to go through a chain of processes to achieve 100% completion. First, a document is created and then sent to the customer for approval. When SubComp gets it back from review, it has either been approved by the customer or not. Sometimes a document has to be re-written and sent back to the customer again before final approval (PPM1).

Together with the Lead Engineer (LE), the PPM estimates the amount of hours that will be used in the project. This can be highly underestimated due to new specifications, new system development in the project, uncertainty or change orders (from customer or SubComp) which generate many (additional) hours (PPM1).

«Lets say a document need 40 hours, which is 100%. We can get homework/corrections and use 100 hours on that document, where it is only worth 40 hours. Sometimes we have to work a lot with return-documents that are not accepted by the customer, or accepted with a comment. Every time we get comments on documents, they are sent back and forth and no value is created. Worst case, we can use thousand hours, with no progress until it is accepted. Then we get progress.» (PPM1)

Diagram 2 shows WP2 in Project A, and its assumed accumulated actual progress based on raw data collected. In addition, it shows total hours spent each month over the life of the project.

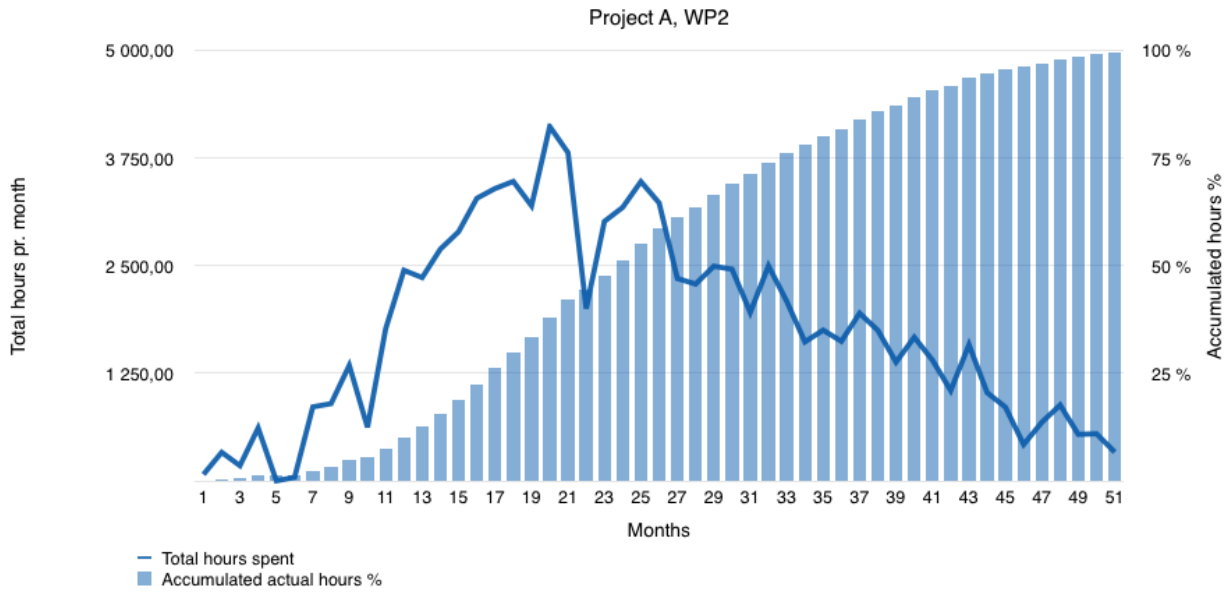

Diagram 2: Shows total hours spent & accumulated actual hours in %, in Project A, WP2

5.2 Updating Project Plan

An S-curve as a result of the project plan, is updated monthly with both PPM and a planner, and then sent to the customer (PPM2). A project plan is, according to PPM6, updated continuously. WP2 deliver products to the customer and other WPs', consequently it is more to control in WP2 than WP1. A project plan consisting of activities, milestones and delivery dates, is created and followed up to know what is to be produced, and by keeping a close dialogue with supplier, designers and engineers the PM and project team can maintain an overview of the timeline and delivery dates.

PPM2 in Project B updated criticality each month to show how progress was doing compared to the month before. Criticality for all WP's were updated, and reported to the PM's. In SubComp, however, the CPM is not used to measure hours, but used for hardware.

"We have two things. We report number of hours. So every month we have final reporting in each WBS, increase or decrease hours monthly. An Engineering plan is used for small team resources to share with the department if we need additional engineers" (PPM4)

5.3 Contract Constraints

5.3.1 Selling The Contract

SubComp use a standard catalogue for the products they sell. The customer can choose directly from the catalogue with SubComp's requirements and cost, or choose a product from the catalogue

but with their own requirements. In that case, SubComp has to change design, and the cost (time) will increase. *«When standard products are altered according to customers requirements (customization), the number of hours increase»* (PPM1). Project A to E used a fixed price contract (PM).

To win a contract in a competing market SubComp often have to reduce the price given to customers related to the hours needed to finish work, even if SubComp may have estimated a higher number of hours. At an early stage the PPM together with LE, tender team, etc., estimate how many hours are to be used in a resource plan.

«With fairly accuracy the company knows the content of their products and can price it. The budget is also based on earlier projects and experience. When in a better market situation, SubComp can increase number of hours in a contract, while in a worse position they might have to reduce hours» (PPM4).

5.3.2 Pre-Contract Activity

Projects in SubComp often start working before Contract Award (CA) as they know they will get the contract due to i.e «letter of intent» or «letter of award» (PPM1). Projects are then allowed, by SubComp, to use a certain amount of hours in this phase. This is a *pre-engineering phase* where the project prepares to order long lead items from subcontractors.

"We have relatively short deadlines, and some raw material has long delivery. To be able to deliver on time we have to order raw materials before signing the contract." (PPM3)

In this pre-engineering phase the tender team has to clarify what material and components to use and how to put everything together/assembly (PPM2). According to PPM1 it is also defined how many and what resources will be included, and start planning to get the people in time. Working with engineers, sales personnel, tender team etc., to develop the basis for a project generates hours, and the clarifications are exchanged with the customer. Customers are often in a hurry, however some customers can lag behind on signing the contract due to disagreement, change in scope, drawings, or design (see Change Orders in chapter 5.4) (PPM1), creating a need for higher use of hours.

"In an ideal world we would get something that was more or less complete including all exceptions and clarifications." (PPM2)

When the contract is finally signed the projects can order raw materials and hardware components (long lead items) which can take several months or years to receive. However, hours (often months of work) have then already been used before CA to prepare for the order, and as long as the tender team in SubComp does not approve the contract, the work cannot continue (PPM2).

Diagram 3 shows that hours are used before CA. As an example, WP1 in Project B used approximately 4,000 hours before CA.

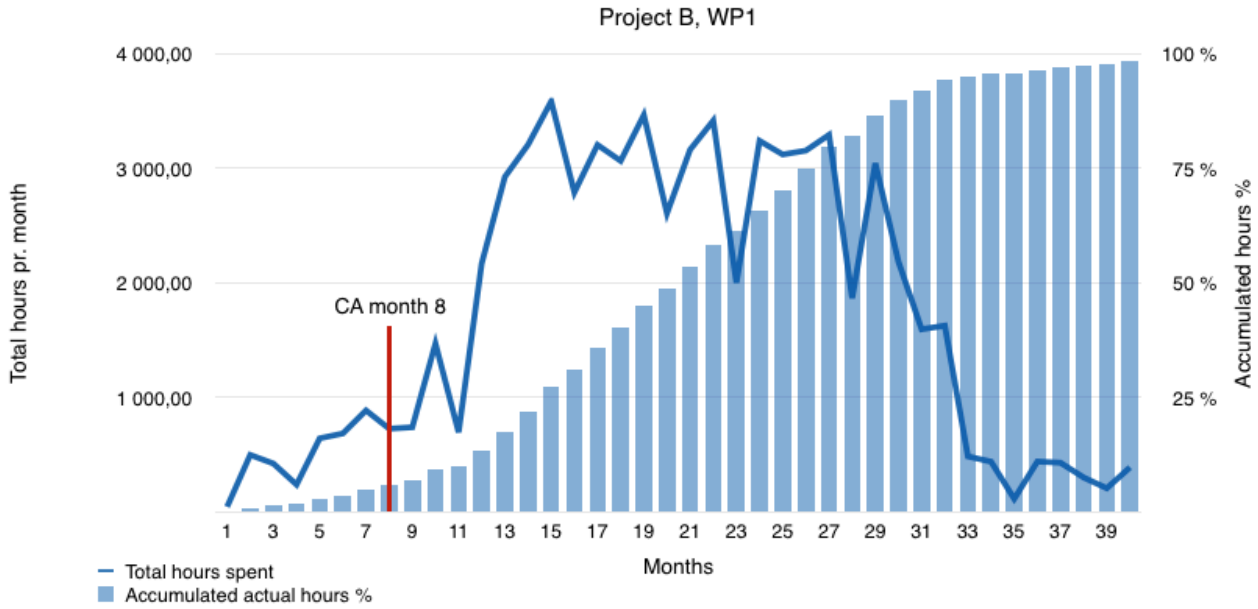

Diagram 3: Showing CA in the timeline of Project B, WP1.

5.4 Change Orders

If the customer request change of scope or an expansion of scope, SubComp need to perform the change. A Variation Order Request (VOR) is then created. This will be sent to the customer stating how much it will cost ($ and hours/months), and the customer can accept or reject (PPM1). Alternatively the customer can send a VOR to SubComp. If the customer sends a VOR to SubComp, SubComp replies defining new costs and hours, and the customer can approve by sending back a VO (Variation Order). The new requirements are then updated in SubComp's Enterprise Resource Planning-system (ERP) and an additional order is sent to the subcontractor (PPM3).

"This is how we should do it, but it happens that we get a letter from the customer saying what they want and we can put out an order before getting the VO." (PPM3)

A project can also make a *potential change order* (PCO) where they highlight what might become a VOR (PPM4).

"*We discuss, and if the customer agrees that it is a change to the contract, we can put forward a VOR. It is discussed again, and when we agree the customer puts forward a change order to us. Then we are able to increase our budget*." (PPM5)

A VOR may have been received from the customer this year, while the work was in fact performed last year. These hours are already spent, but if the VOR has not yet been accepted by the customer SubComp's budget cannot be updated. Hours are, however, updated as *actual hours spent,* showing a bigger difference between actual and budget than what it is expected to be awaiting the VO (PPM2).

"*We should in principle not work on things where a VOR is not yet accepted.*" (PM)

5.5 Delay

Work packages deliver different complex items (equipment), and when finished items are delivered to SubComp from a subcontractor, one possibility is that it may lack functionality according to SubComp's standards, which again can delay the delivery to the end customer (PPM1).

WP1's main delivery in Project A had its original delivery date in March 2012, but was completely delivered in September 2012, resulting in a 6 months delay. WP2 had a delivery where delivery date was originally April 2012, but delivery was not complete before August 2013 resulting in as much as a 16 months delay. The delays could possibly be due to customer changes, additional testing etc.

«*We had some difficulties with being pressed for time. We have to decide what items will be produced first, then we have to work on the documents belonging to that item to get to a certain level before a subcontractor can start working on it physically.*» (PPM1)

Customers have their view on what type of requirements are necessary, whereas SubComp may disagree from time to time. There are certain things that SubComp has a better understanding of than their customer, as that is also why the customer turns to them for assistance. Disagreements can create discussion between the two parties. If disagreements occur, meetings have to be arranged to solve the issues. If the customer has commented on documents, SubComp has to put in more hours which does not create value for them, but value the customer. *«The customer is not always right, but the customer is King»* (PPM1).

Project B had delays due to changes in design and unexperienced employees in the beginning of the project. If a subcontractor is having difficulties with creating progress, SubComp have to use their own resources to help subcontractors increase progress (PPM2).

"*Often faulty design occur and create higher cost and delays. These errors can be discovered during the testing of the equipment. If that happens it has to be sent back... Things are also forgotten. Then we have to start a development project. We are trying to avoid these mistakes in new projects... Concerning development projects: we sell a product to the customer, but as it is not completely tested and not yet developed, the customer does not want to pay for the development. It is SubComp's cost to develop the product to make sure the customer gets what he paid for*." (PPM2)

Project C had few delays on delivery. However, WP1 had one delivery that was delayed from September 2012 to November 2012 (2 months), and WP2 had one delayed from August 2012 to January 2013 (5 months).

Delays occurred in Project D as well. One explanation was due to new/additional customer requirements and therefore a lot more work. The project also turned out to be much more complex than what the first picture showed (PPM4). Project D had some issues with design and delivery of products, and PPM5 stated that *"Tough and strengthened demand from the customer is part of why we have used many hours."* He further said that "*Usually we don't notice the delays until the middle of the project and later, but we should have discovered it earlier to be able to do adjustments to get back to the (original) plan."*

In Project E, new design of existing equipment was one issue which resulted in using many hours. In addition, SubComp was stuck "in line" with a subcontractor. The capacity of subcontractors and design resources is an issue for SubComp. Project E did, however, make some standardizations with developing new design, creating a spinoff-effect on future projects. If one project use (invest) many hours, possibly another will save (PPM6). Project E did not have any delays as original and actual milestone was January and March 2014 for WP2.

5.6 Overrun

SubComp deliver products used for oil and gas extraction from the seabed, and as the seabed is constantly changing adjustments may be required. Data from the seabed affect the design of the products, and new data in Project A demanded new design and they had to redo their engineering work. SubComp did however get paid for that extra work, as change orders (VOR) that are accepted

by the customer become *additional orders*. Rework due to change orders additionally creates a dip in the s-curve, increasing the number of hours defining 100% of the project (PPM1).

"When changes are made by the subcontractor, we get paid. But if the changes are due to our own fault, the cost is a loss for SubComp."(PM)

Project A estimated at an early stage to use 70,000 hours in WP2, but sold the contract for around 30.000 hours (see diagram 4), creating a big gap to be covered by SubComp (PPM1). In SubComp they try to identify the GAPs through a GAP-analysis. They try to reveal what was missing or forgotten in the contract, as projects often start with negative numbers, so that future tenders are more exact, and PPMs can start with correct amount of hours (PM).

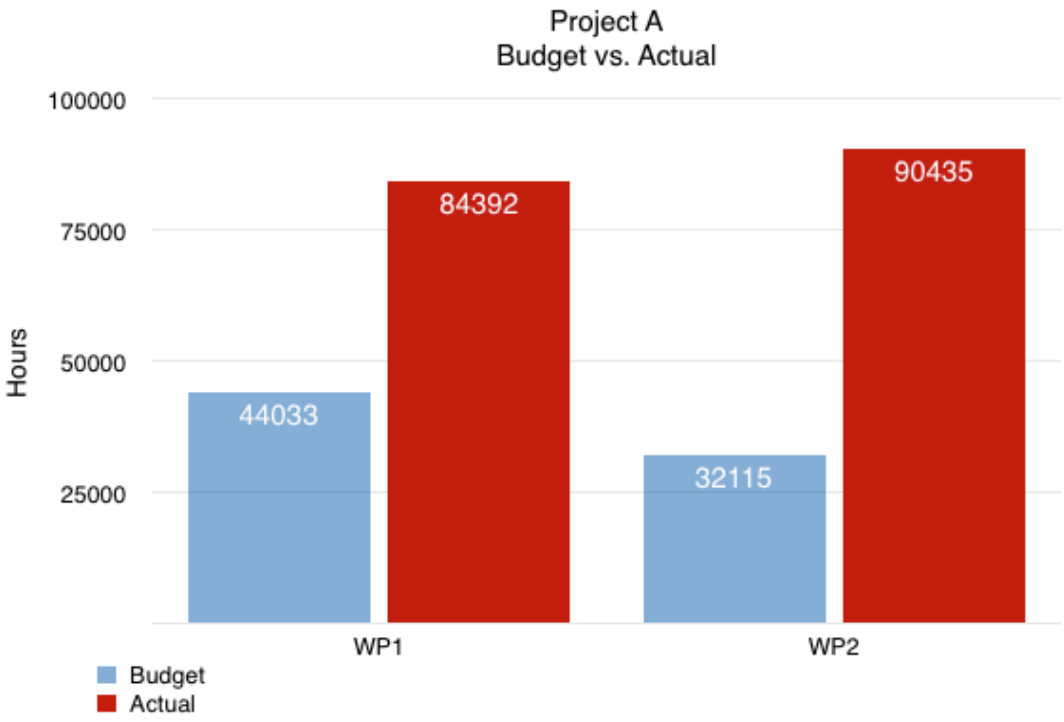

Diagram 4: Budgeted hours vs. actual hours in Project A.

PPM2 stated that *"by reporting monthly, when (number of) hours are closing up on the budget, experienced PPMs would start alerting that they will use more hours than budgeted."* PPM3 supported his argument by saying that *«an overrun should be noticed when having financial reporting each month»*. Project B went over budget in WP1 and WP2 as shown in diagram 5. An overrun could be due to a low offer in the tender phase due to *insufficient information*, or that *unexpected changes* occurred in the implementation of the project. The PM that was interviewed

commented that *"... rework can happen late in projects, as errors are discovered through a testing phase, which happens towards the end."*

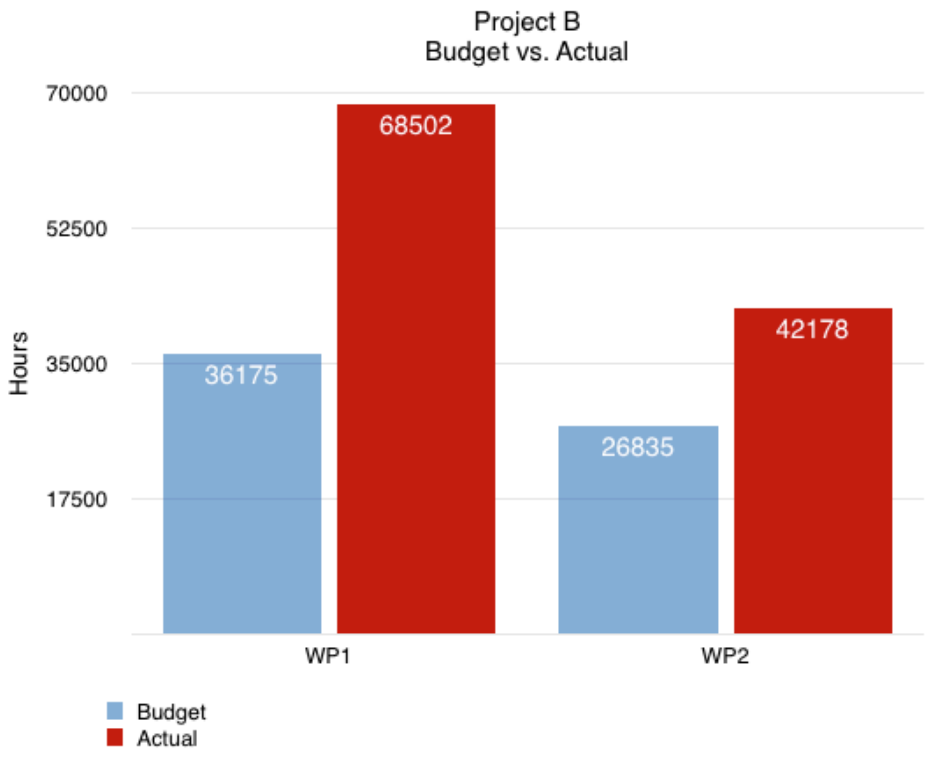

Diagram 5: Budgeted hours vs. actual hours in Project B.

Project C did not go over budget within the time of the research, as shown in diagram 6.

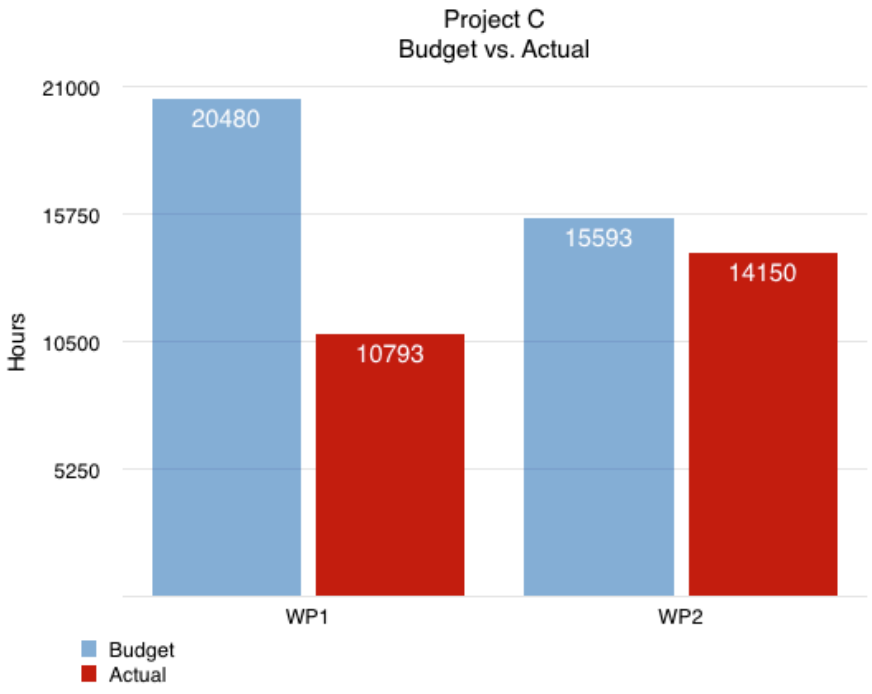

Diagram 6: Budgeted hours vs. actual hours in Project C.

Project D (and Project A) was awarded to SubComp at a time when business was low, and SubComp needed the project. PPM5 tried to explain the overruns shown in diagram 7 with three main reasons.

1. *Low initial budget* was one part of the reason for overrun. There was at the time a *downsizing period* earlier and workforce needed to be increased.
2. *Unexperienced personnel* could be another reason. When the company manned up and increased the activity it was difficult to get 100% efficiency out of every employee.
3. A third reason could be *customer requirements*. The customer strengthened their demand towards SubComp and focused on reviewing everything SubComp did in a more detailed manner than maybe before.

Strengthened requirements from customer together with unexperienced personnel, with lower efficiency and lower initial budget was one explanation of an overrun. PPM5 described Project D as:

"*When they did this tender, it might be that they evaluated it to be a higher budget, but because of the market situation they reduced it to get the contract. It's not a wrong decision, but one to keep contracts and get new ones later.*"

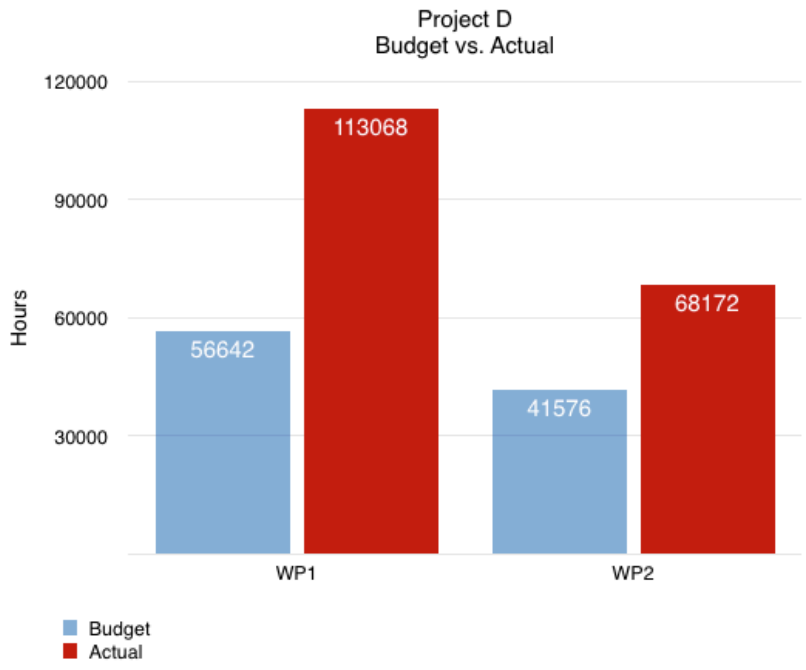

Diagram 7: Budgeted hours vs. actual hours in Project D.

To notice an overrun is highly based on experience, according to PPM6, calling it a «gut feeling». The PPM knows exactly what to buy and deliver to the customer, and if there has been used too many hours it should be reported in the monthly forecast.

During weekly approval of hours the PPM will notice where, on what activities, hours have been used and should check extraordinary hours that have been registered (PPM6). Project E did however not go over budget within the time of the study, as shown in diagram 8. This could be because the project was ongoing.

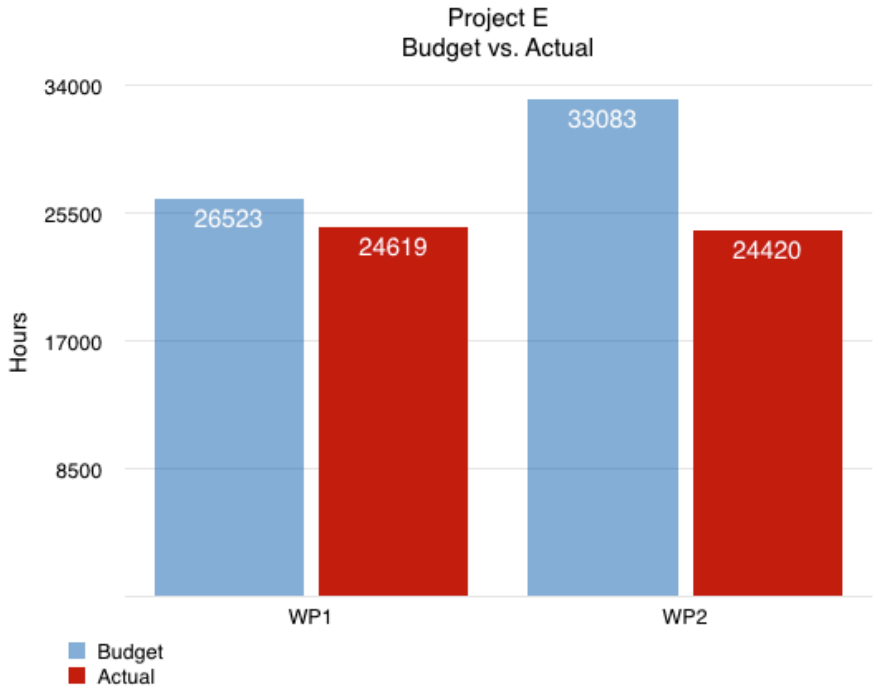

Diagram 8: Budgeted hours vs. actual hours in Project E.

PPM1 and PPM6 stated that when noticing an overrun, the PPM report to his PM as soon as possible and the PM can then help make work more efficient by assigning more resources to the project. However, there is an issue with "*blueberries*" being new employees with little experience. When they are assigned to projects they will not be as efficient as experienced employees, resulting in an additional increase in the amount of hours spent.

5.7 Project Experience

5.7.1 Experience and Productivity

A resource planning system is used by PPMs to inform the department what resources are needed for their project, and it is updated manually every month. Project A had a big workload and at the same time delivery was delayed. The end of the project, the last 10%, has taken around two years and is still not complete. This could be due to resources being used in other projects, making it difficult for Project A to get enough or the correct type of resources to finish (PPM1).

«The focus in projects drifts off near the end. If people were to work on the project two days, and on another project one day, the efficiency is low...When I first started working on Project A it was a lot to take in, but I am happy as have I have learned a lot. From the beginning I had to trust the PPM that started the project and my LE, as they are experienced and has been in the company longer than I. Learning from others is key.» (PPM1)

In addition, PPM1 stated that: *«We've had experienced and unexperienced staff. We have trained new employees which is costly as it takes longer for them to finish their work.»* The PPM receives a list of remaining documents throughout the project which he has to follow up until they are complete and approved. Towards the end of a project it is often only the PPM working on the project, and controlling documents then takes a lot of time and effort.

PPM2 commented that Project B had some unexperienced workers, and that it happened a lot in in 2012 with hiring of new employees. SubComp employed around 100 new people every month that year.

«Experience is not all about the amount of hours one uses, but also what product one releases. If it is a good product or not. If it has a leak. Maybe the employee did not know everything about the product. Time and quality, which is noticed after, creating "fire fighting"» (PPM2). He used and focused on the concept *"do it right the first time"*. By following this concept projects can avoid a lot of problems, save time, frustration and reduce the loss of money.

PPM3 commented that in WP1 in Project C, the LE and engineers were experienced, while in WP2 the LE was not so experienced and often needed help. As a project engineer, however, he was good. This problem was solved by when WP1 was finished with most of its documentation work the LE from that WP was set to help in WP2.

"He (the LE in WP2) had some trouble, and we helped him. A lot of people were available for him to ask, but people are not always good at asking for help. Some may think it's a defeat. That is a challenge." (PPM3)

Low productivity could be due to unexperienced personnel that are still in training, being less efficient and not yet as self-driven as others. Also it could be due to new demand from customers making daily work more difficult. PPM5 stated that the productivity and efficiency had been low in Project D.

"*When I came into Project D we were in the middle of the project. I used the first two months to get an overview...*" (PPM5)

In Project E there has also been a mix of experienced and less experienced employees just like the other projects. PPM6 stated that there had been a period with a lot of downsizing, reflecting an opportunity for improvement and challenge in all of SubComp's projects and departments.

"*The ones who delegate resources should talk to each other to find out how many unexperienced one can handle. One wants the best of the best.*" (PPM6)

5.7.2 Replacement of Staff

Project A replaced the PPM in WP2 four months after CA. CA was April 2010 and the replacement occurred in August 2010. Project engineers quit or were dismissed as a downsizing program occurred. Other resources has later been retrieved when needed (PPM1).

In Project B the LE and project engineer have been pretty stable. The project started with four PPMs, while one left for another project. The other three have been used to follow up on distinctive deliveries. PPM2 came in and took over WP1 in September 2013 (CA was April 2011).

In project C, PPM3 took over both WP1 in April 2012 and WP2 in July 2012, and was the third PPM in the project (CA was February 2011). He stated that:

"If it is a lot of replacements of personnel, PPMs or engineers, there will be used a lot of hours to get a hold of the history (of the project) and the work scope."

PPM4 and PPM5 took over WP1 in Project D in 2012, halfway into the project (CA was May 2010).

In Project E, PPM6 started as a PM during the fall of 2012 (CA was May 2012). Project E mainly had replacements of project engineers due to reasons such as; some left the company, while others were assigned to other projects (PPM6).

5.8 Budget and Forecast

The budget is based on the resource plan and mainly concerning hours. By entering how many mhrs will be needed to complete a project in the resource plan, a budget is created based on the estimated numbers of hours. (PPM1).

The PPM creates the forecast every month together with the LE concerning engineering hours. It is based on expected remaining workload and the LE's experience of how many hours are needed for certain items (PPM2). A resource plan is sent to the department showing the need for resources and when the different projects are to be finished. It is used in projects to give an overview of when resources are needed (PPM3). Forecasts are based on *experience*, and if the PPM and LE are able to predict what work is to come (VOR or future possible changes) the quality of the forecast may increase. It can however, be difficult to create a realistic forecast as it is dealing with both uncertainty of scope changes (VOR's) and engineers. Controlling people can be challenging (PPM2).

"A LE knows how many hours are needed to produce items. In Project A there was a new system implementation, and even though the numbers are looking red it is seen as a success for SubComp as we have sold a new system that will be used for many years into the future... The new system has a good spinoff-effect on other projects that will use the new system." (PPM1)

"Often the LE underestimate the amount of hours he will use" (PPM1).

5.8.1 Excel Forecasting Tool

In project D, PPM4 created an Excel sheet setting up all positions for each month saying how many hours would be needed in the future. The PPM's in Project D view it as a handy tool to get an overview and to be able to make better forecasts. The tool looks at accumulated sum of hours on a given date in time. The PPM can study planned and actual mhrs, and compare the two. When adjusting the figures, the full equation adjusts itself and the total trend can be viewed until the end of the project (PPM4).

"*At the beginning of a project you don't know everything, so you need to have a buffer for each item. Hopefully it is a realistic forecast.*" (PPM4)

"At the time we had 70 different people working, and you did not know how many hours they would use each month. With this table we put all the elements (admin, engineering, document control) into the table, got an overview and saw that we would use 116.000 hours. We did it in 2012, and after that we could follow up (update numbers) each month and see the trend. When we saw that we had to increase project duration, we looked at planned hours and saw how we had to adjust numbers (up or down)... Its been thought that this could be an improvement to our department, but I'm not sure it has been implemented yet. We have all the hours and follow-up system in our database, but it only gives a picture of where we are today. It does not really forecast the future. A simple tool like this is efficient." (PPM5)

The Excel forecasting tool used in Project D could be used from the beginning of a project. By including the budget, forecast-numbers could be adjusted accordingly to fit the original budget. If actual hours are found to be higher than the budget, it is possible to adjust the forecast for future months. Most projects are believed to use approximately the same tool, but neglect to do a deep-dive evaluation. The Excel tool does not, however, take into account that projects can have delays, as it is not expected in the beginning of a project (PPM5). PPM5 is a fairly experienced PM today, that is why he was able to created the Excel forecasting tool. It was based on his experience as he saw the lack of a (detailed) forecast.

«The further you get into a project, the easier it is to see if hours are within budget or not, or how good the initial forecast was» (PPM6).

5.8.2 Budgeting of Activities

The tender-team budget for each activity in a project, which are usually several activities (see diagram 9). They coordinate and discuss with managers and work within the system to collect necessary information to give a good as possible tender to the customer. Some activities do not have a budget, which could be because the activity had not been accounted for when sending out the tender (PPM3). PPM6 suggested that, depending on experience, work can be done quickly or take time, and work that has been started has to be finished. He further stated that:

"You take the hours you are given, and smear it out between each activity. It can be a challenge to see what activity should be prioritized. The budget is something you expect for the future, which always includes uncertainty."

Activities (i.e accounts) are sometimes created at a later time due to corrections and adjustments. This is to have an overview of what amount of hours goes into the corrections (PPM1). PPM4 agreed, stating that some activities do not have a budget during the life of the project. One suggestion is that, in order to have a better follow-up for certain items, accounts are created after the initial budget for people to be able to measure, at the end of a project, how much an item has cost. In addition PPM1 stated that:

"Activities without budget did not exist in the beginning of the project. I had to close accounts as people who did not work on the project started entering their hours on these accounts. I then opened new accounts replacing old ones, where the budget lies within old accounts. In large corporations like SubComp, managers want you to register hours on the project so that the project pays for those hours. This way people strive to get an account to register their hours on. However, when I open new accounts, these also spread out and more people start using them."

Looking at diagram 9, activity 4,6,7,9 and 14 did not have a budget in Project A, WP1. They all did, however, have actual spent hours registered (see Appendix for detailed graphs on activities for each project).

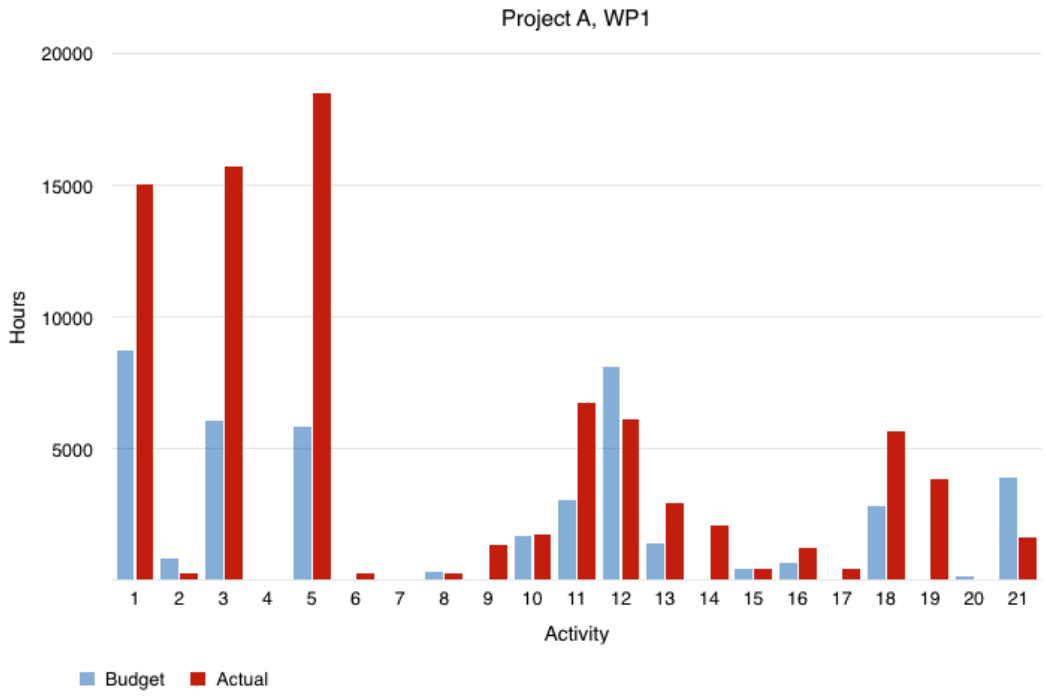

Diagram 9: Budget and actual hours in activities in Project A, WP1.

5.9 Registration of Hours

Every Monday PPMs control and approve hours on their project. The PPM knows who is working on their project, and if new names appear the PPM can ask why that person registered hours on his project before approving. It can occur that people register hours on the wrong account and wrong project, or that employees forget to register hours regularly and within weekly deadlines. When work is very hectic, it can be difficult to control hours as PPMs don't have time to ask everyone what work they have performed. Often the PPM must assume that people are working with what they are supposed to (PPM6). PPM2 agreed that controlling that employees register correct amount of hours on planned activities, can be difficult. Especially when work is at its most intense. It can be a challenge to control what work employees are doing. PPM1 expressed that as long as you know the account number for a project, anyone can register hours. In addition, when work is at its most intense, it is difficult for the PPM to control all hours as he cannot devote all his time to controlling.

«*What has to be done, however, is to control who records hours. If an engineer works on three different projects at the same time, it can be that he or she puts 33% of hours worked on each project, even though the distribution is totally different. That is something I can't control, I only approve the hours. I have to trust that my employees register correct amount of hours. If I on the other hand see an unfamiliar name, I have to check if it is correct before approving those hours. One hour is no hassle, but 20.000 is.*» (PPM1)

5.10 Lessons Learned

A Lessons Learned activity is used to evaluate and report what went wrong in a project, what can be improved, and what went as planned. The activity tries to describe success factors and experience from the project team. This information is then aimed to be spread back into the organization to avoid the same mistakes from occurring in future projects (PPM1). Only two projects included in this research had completed the Lessons Learned activity as the rest were not complete at the time of the study.

Project C was complete and had used Lessons Learned to look at what experience they gained from the project. Some of the highlighted points for possible improvement were:

- Contract with customer was not clear enough, creating an opportunity to interpret rules for progress differently.
- Scope of supply was understood differently by customer and supplier.

- Delayed delivery of some products as they were being unreliable.
- 36 project staff changes.
- WP1 and WP2 should not have had the same PPM as the workload required two persons. In addition, the mindset would differ, and WP2 required different skills and experience than in WP1.

In WP2 in Project C, there was a product that depended on getting data about the seabed from the customer. This was crucial for SubComp to be able to deliver. The information was however, not delivered in time and therefor created a delay (PPM3).

Project B also had completed the lessons Learned activity and some points for improvement are listed below:

- Clarify customer requirements, before Contract Award.
- New designers should be closely followed by an experienced engineer from within the same product.
- Ensure a better handover between product owners.
- Include sufficient budget for new product development.
- Delayed items on critical path.
- Delay and extra cost because there was no budget for extra raw materials.

5.11 Mitigating Actions

The PPMs were asked to list three preventive actions that could possibly reduce overruns and overall improve project work efficiency in SubComp. PPM1 listed three things he considered to be important to improve projects in SubComp:

1. The PPM should work on the project from the start, as to determine the budget and know what he is working with.
2. Get experienced staff.
3. Make it easier to find numbers to estimate budgets, and make it easier to see how many documents are remaining.

He also stated that: *«I believe it is important to be aware of what we are working with and how many hours are used in the end. It would help to have clearer tools showing how much resources*

are needed and that would make it easier to have an overview of remaining documents. As PPMs we do a good amount of administrative non-value creating work. If we had a document planner or someone who is skilled when it comes to using the Engineering plan, that person could help PPMs by telling us how many documents are remaining... In the middle of a project I don't have time to chase down all documents or numbers, and I don't have time to sit down and make good forecasts. Therefore, it would have been better with a professional planner to work with the actual planning and to help us PPMs on a daily basis.»

PPM2 said that the work done prior to a project, like going through scope of supply, should be improved to get a better overview of what items had been delivered earlier and not. He also mentioned that the importance of having control over engineers and to have continuous meetings with the customer could help get as much information and documentation about changes as possible.

PPM3 mentioned a few additional actions that could improve project work:

- Spend more time with customer to make the contract more specific and making sure essential clarifications are included.
- Spend more time detailing contracts with sub-suppliers to improve a common understanding.
- Repeat internal contract review when changing personnel.
- WP2 need more focus and more resources, as WP2s workload is repeatedly underestimated.
- Minimize replacement of staff.

To improve projects and reduce their overrun, SubComp could invest more time and focus on understanding the contract better and thereby challenge the customer more according to PPM5. He further listed three preventive actions:

1. *To increase the budget,* PPM5 suggest being tougher (commercially) towards the end customer, i.e. work harder to get more back.
2. *Efficiency*. SubComp should improve on "doing it right the first time". The quality on SubComp's foundation is, today, relatively low according to PPM5.
3. *Direct communication towards the end customer*. When challenges (or changes) are to be solved, the company tend to work a lot on it. They send ideas back and forth with the customer

and have review rounds concerning documents. Instead, SubComp should sit down with the customer face-to-face and get all comments at once. This could possibly make it easier to quickly find a solution and move forward.

PPM6 suggested that development of new design perhaps should have been done by the product team, so that when projects start up, the design is complete. The product team can however not do this, as they don't have any budget. He also stated that:

"Upgrades could have been made in earlier projects, so that not all updates came in Project E."

PPM6 listed what he regarded as areas of improvement:

1. *The work done in the tender phase* is important. Perhaps sitting down with tender team and base the tender on other projects, making sure the sources of information are as accurate as possible, and involve the appropriate resources as early as possible.
2. *Use enough time on the handover between tender and project.* Go through the work scope to make sure the project knows what it is doing, or if something is not included in the contract - go back to the customer and ask. Having a good handover is important to make sure the tender team and the project team see the same picture.
3. *Delivery team:* having a clear distinction between project and delivery team (designers). Perhaps letting the project control resources as they loose overview of resources used in design or procurement. It is the project who is communicating with the customer, and it could increase the project's sense of ownership.
4. SubComp need to have *enough resources* to do the job, and not wait in line, which often happens with sub-suppliers. SubComp should have fewer managers and more workers, and should make sure they have enough resources to work for a customer, as some areas of work lack a satisfying amount of sub-suppliers.

6. Discussion

In this chapter I will discuss my findings against earlier research and theory. Specifically, the «control loop» will be used to link findings to theory (figure 6). The section is structured into 8 parts. 6.1 to 6.8 discuss the main issues found to be contributors to mhr overruns in construction projects.

I will also answer the six research questions according to the empirical findings from this chapter. Calculations and assumptions in this section are based on raw data collected and empirical data from interviews. Calculations are only based on raw data.

It is my intention that the findings from SubComp's projects and similar studies will assist in the understanding of why overruns on project mhrs occur. By highlighting the most crucial factors influencing project mhrs overrun, I believe it can give companies an incentive to further implement actions to avoid similar issues in future projects.

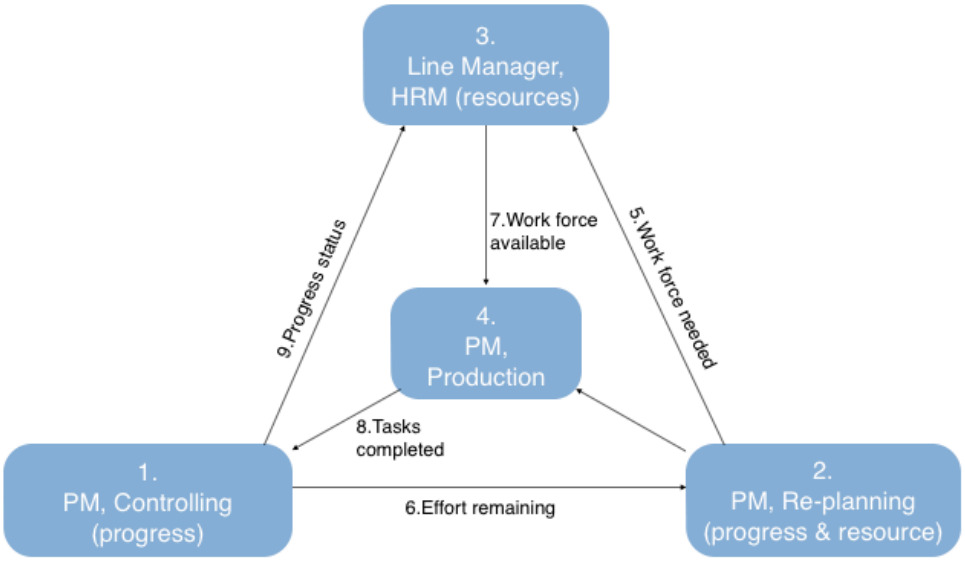

Figure 6: Adapted control loop.

6.1 Budgeting - A Systematic Error

Budgeting for project hours are *systematic errors* as it involves underpricing projects to win contracts. Companies are aware that underestimation of budgets occur, and it is an issue that is difficult to avoid. Eden, Ackermann and Williams (2005) stated in their study of amoebic growth of project costs, that it is common practice to «tamper» with estimated hours (and costs) to strategically win bids. They further mentioned in their article that this «tampering» is forgotten

when the project is in its planning phase, and that plans therefor become unrealistic. This kind of underestimation is a common trigger for escalation of hours and costs.

Husby et al (2003) mentioned that contracts can have a fixed price, which was used in Project A-E. In this setting, SubComp is responsible for completing the project according to negotiated time and cost. If the customer has requirements beyond the negotiated term, this becomes an additional order and SubComp gets paid for the additional work. When SubComp bid to get contracts, as shown earlier in chapter 5.3, they underestimate knowing that they push down the price to win the contract. This is a strategy used to keep customers, win contracts, and secure getting new ones later.

By analyzing Project A, I found that the contract was sold for a much lower price (calculated in hours) than what the project actually used (see diagram 4 above), causing an overrun to occur early in the project. If we look at WP2 in diagram 10, we can see that the WP exceeded its budget in month 20. When the overrun occurred, mhr activity was at its highest, and the project was at only 38% progress. At the same time I found that labour activity is reduced after the overrun occurred, after month 25 to 51 equivalent to 2,2 years.

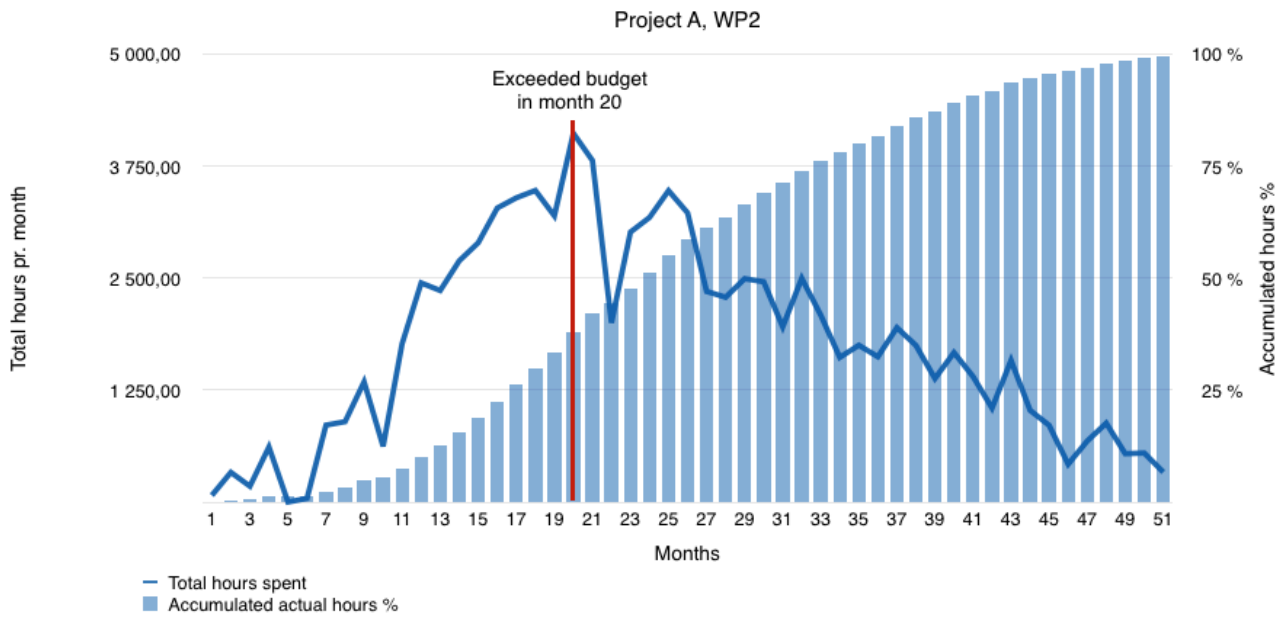

Diagram 10: Showing when the budget was exceeded in Project A, WP2.

Project C did not go over budget by the time I studied the data as shown in diagram 11. However, at 70% progress there is a reduction in mhr activity after month 16 and onwards to month 34,

equivalent to 1,5 years.

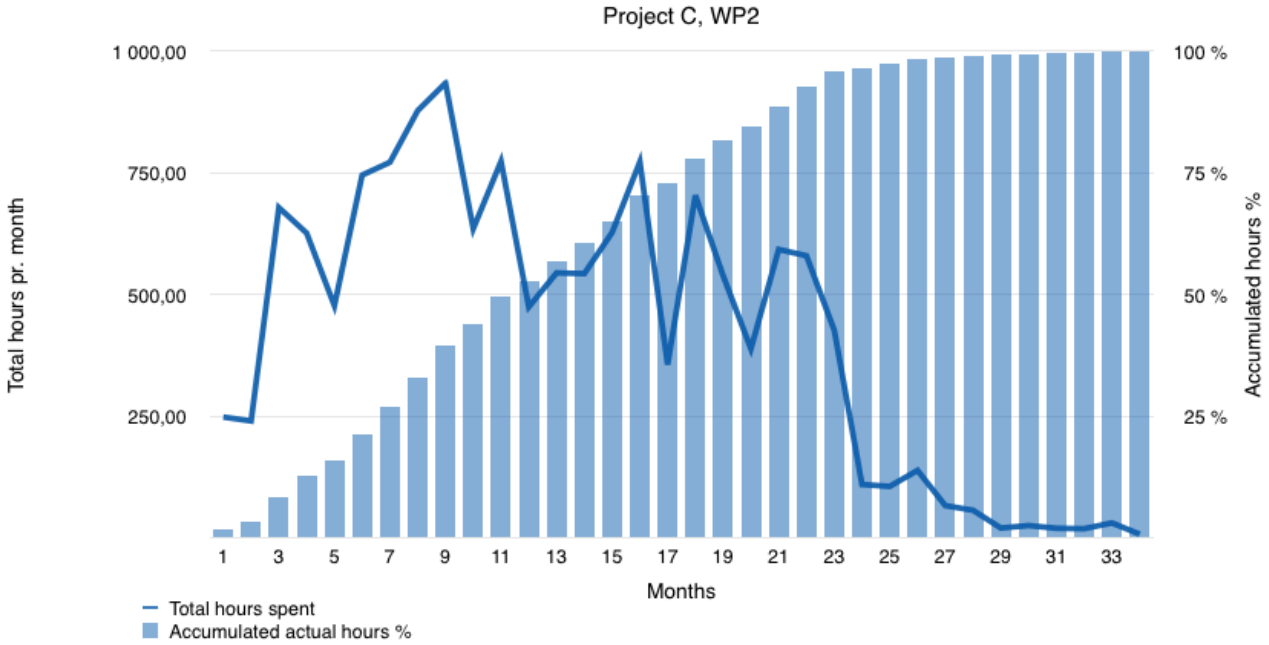

Diagram 11: Showing WP2 in Project C's lifecycle up until December 2013.

In a highly competitive market environment like today, SubComp sometimes need to underestimate and price down their tender to win contracts. However, PPM5 suggested that SubComp could be tougher commercially towards customers. Smaller projects such as Project C, seem to be easier to plan and further estimate more correctly the amount of hours needed, compared to larger projects such as Project A.

If we look at figure 6, HRM (3) delegate resources according to demand. When budgets are highly underestimated, this could give incorrect information to HRM and further affect delegation. When an overrun is noticed through controlling (1), the planning unit (2) need to re-plan and give updated information on workforce needed (5) to HRM. A new need for workforce may not be available due to the fact that projects compete for the same resources (more discussion in 6.3), and it is therefor highly important to report updated information (5 and 6) frequently enough for HRM to better delegate resources among projects. There might be a lacking focus on updating project plans/re-planning which reduce the degree to which a resource budget is realistic, and further create additional deterioration.

In relation to my additional research question 1, this section shows that budgets tend to be underestimated for larger projects. This could be a strategic choice made by SubComp as it is

consciously done to keep customers, win contracts and secure the basis for new contracts in the future.

6.2 Rework

External or internal changes generates uncertainty which implicates projects when occurring (Eden et al, 2005). External factors such as VORs from customers create scope changes. Certification, requirements and environmental factors such as the seabed or the sea depth may create delays and/ or changes. Internal factors can be change of resources, new product development, new product releases, logistic challenges here being subcontractors production flexibility and limited capacity, etc. All these factors generate rework in all parts of the supply chain, such as design, logistics, planning, etc. The number of VO's and scope changes also generate rework. Rework is however *not* dependent on the size of a VO's, as even a small VO will require rework in several parts of the supply chain and thereby create uncertainty and a risk of overrun.
When changes occur, products that will be produced need to be changed in order to meet new requirements. If information about change would have been known in the tender phase, the planning probably would have been different and, in addition, the bidding would have been different as it would have been for a different project (Eden et al, 2005). Reichelt and Lyneis (1999) discussed, in their study of project performance, the issue of rework of design drawings, and said that «understanding what drives quality and rework..., are key to understanding the dynamics of project performance.» The need to carry out rework (e.g. on design drawings) creates long staffing «tails» and/or second peaks, second peaks being due to overstaffing late in projects.

Project D is a good example to visualize both long «tails» at the end of the project, and «second peaks». WP1, shown in diagram 12a, experienced a second peak in month 22, at 62% progress. This occurred two months after the PPM was replaced (see diagram 18) and budget was exceeded. The WP also has a long «tail» of reduced labour activity from month 22 to the end of the project in month 43 (i.e until December 2013), equivalent to 1,75 years.

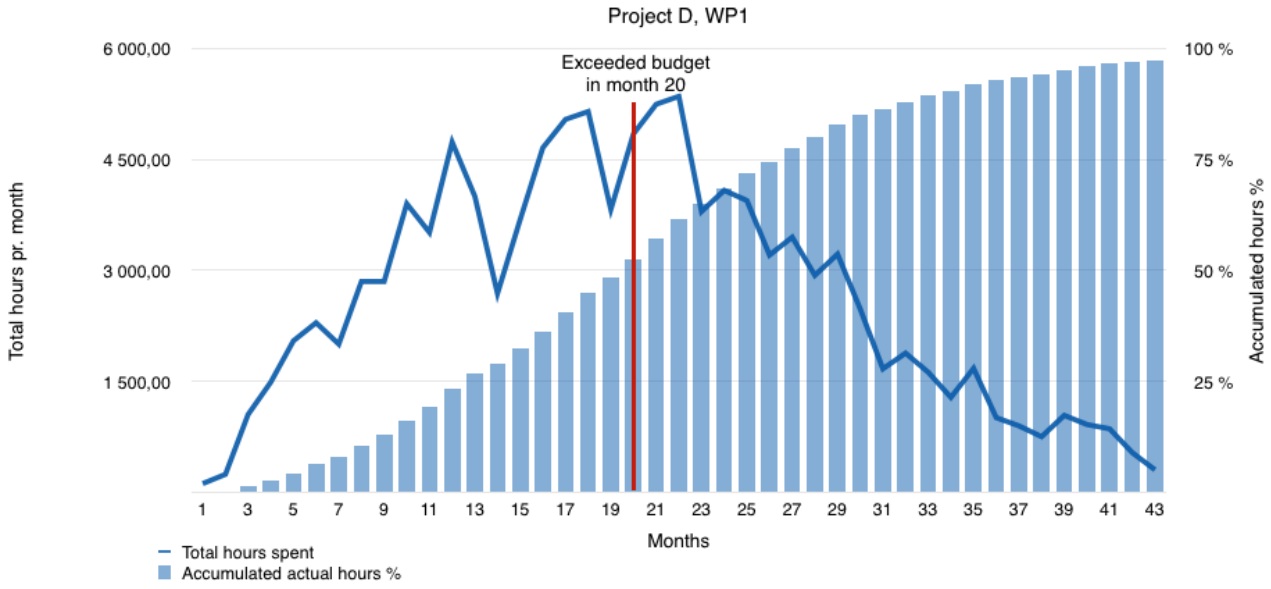

Diagram 12a: Showing a second peak and a long «tail» in Project D, WP1.

Looking at WP2 in Project D, shown in diagram 12b, it also has a second or in fact a third peak occurring in month 27, at 64% progress. This could be due to overstaffing as the budget was exceeded (only) two months earlier. There is reduced activity from month 29 to 43, equivalent to 1,17 years.

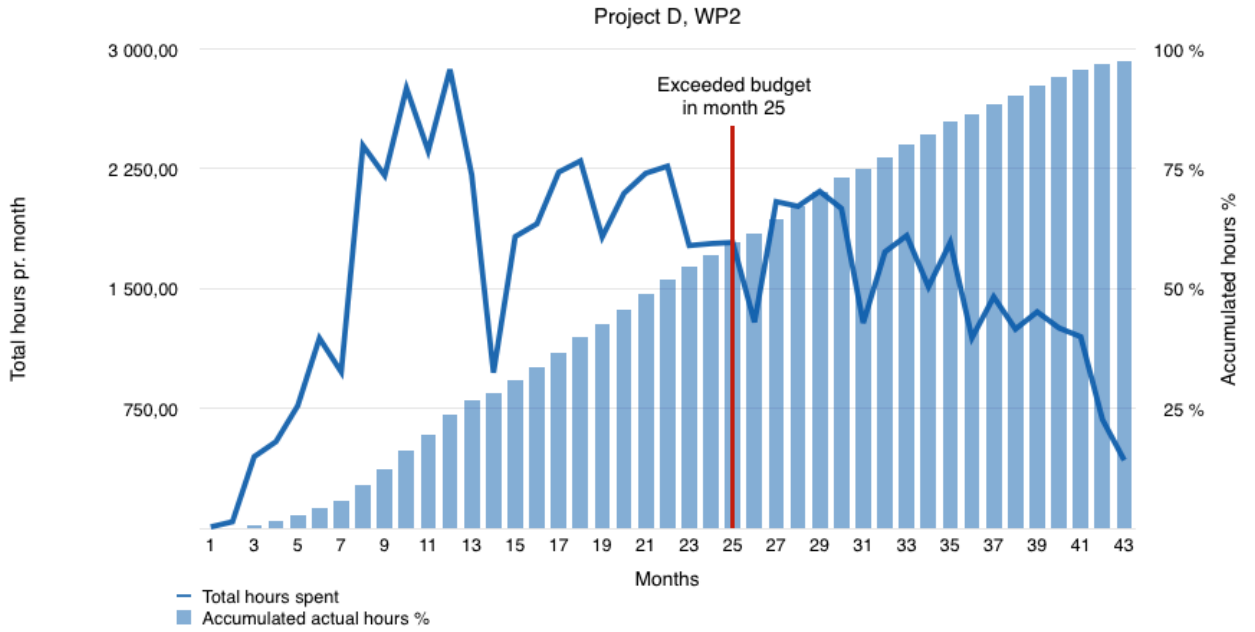

Diagram 12b: Showing a second peak in Project D, WP2.

Project A and B WP1, shown in diagram 13 & 14a, has a similar trend-line to the one I found in WP1, Project D.

WP1 in Project A had a second peak in month 24 (at 72% progress), and a long «tail» of reduced labour activity until the end in month 41, equivalent to 1,4 years. WP2 had a second peak in month 25 (at 55% progress), and from that point on reduced activity (see diagram 10).

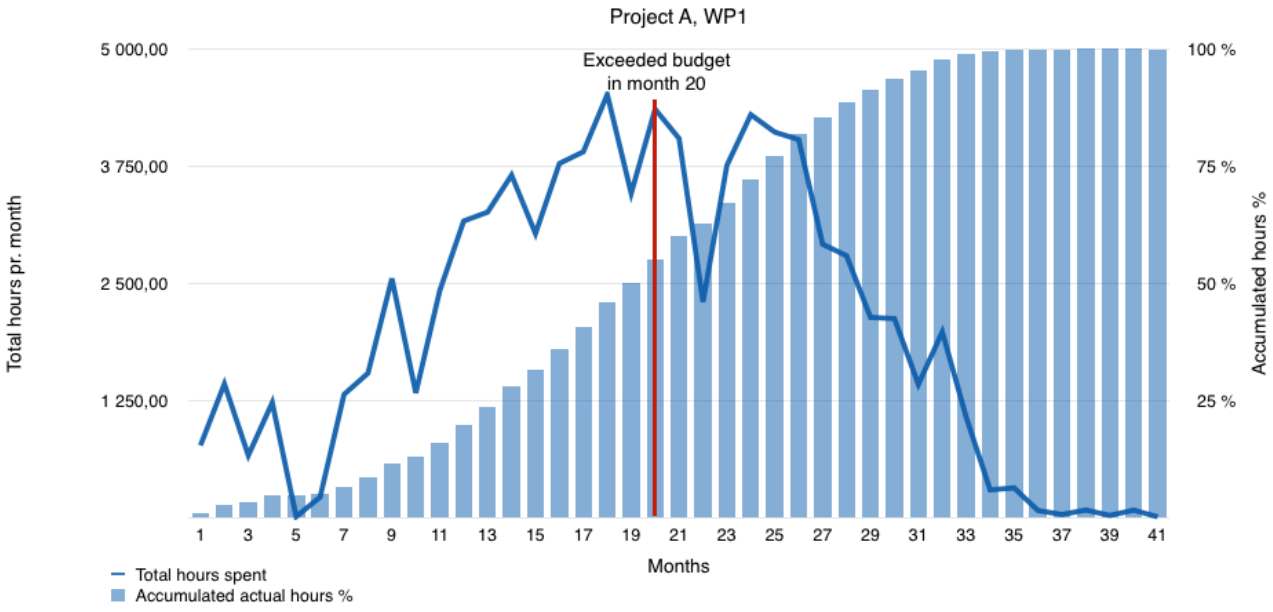

Diagram 13: Showing the trend-line and time of budget exceeded in Project A, WP1.

In Project B WP1 the second peak occurred in month 27 (at 62% progress), and the long «tail» of reduced labour activity continued to the end in month 40 equivalent to 1,1 years.

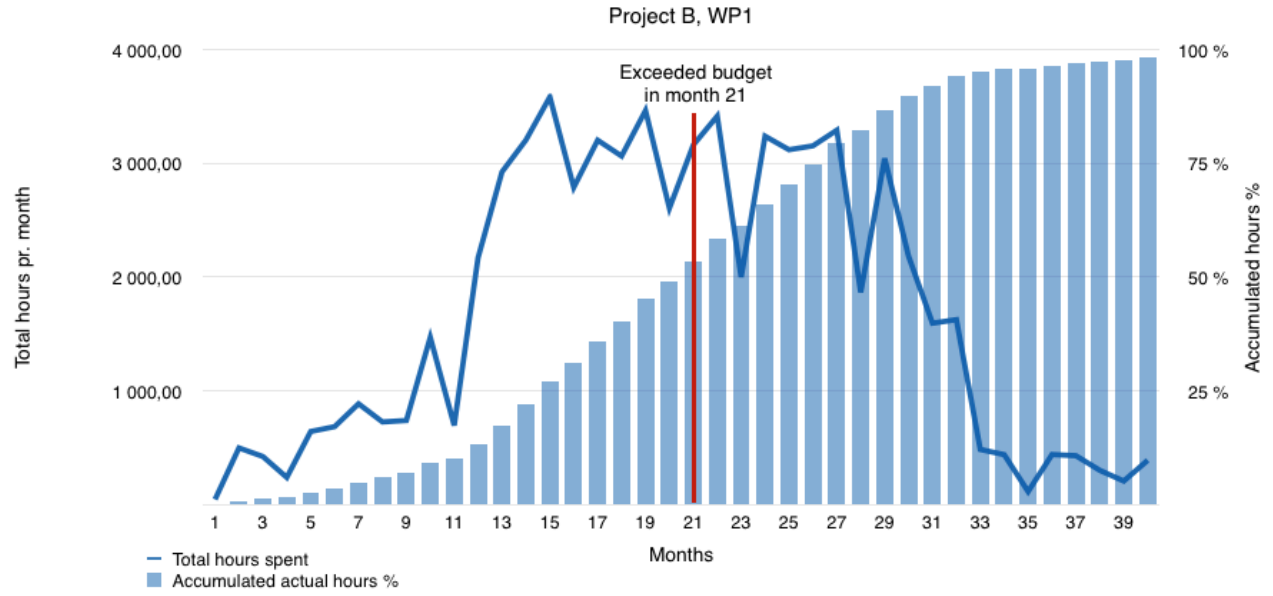

Diagram 14a: Showing the trend-line and time of budget exceeded in Project B, WP1.

Looking at diagram 14b below, WP2 in Project B had a slight peak of labour activity one month after exceeding its budget, in month 28 (at 68% progress). The reduced labour activity continued to month 39, equal to 11 months.

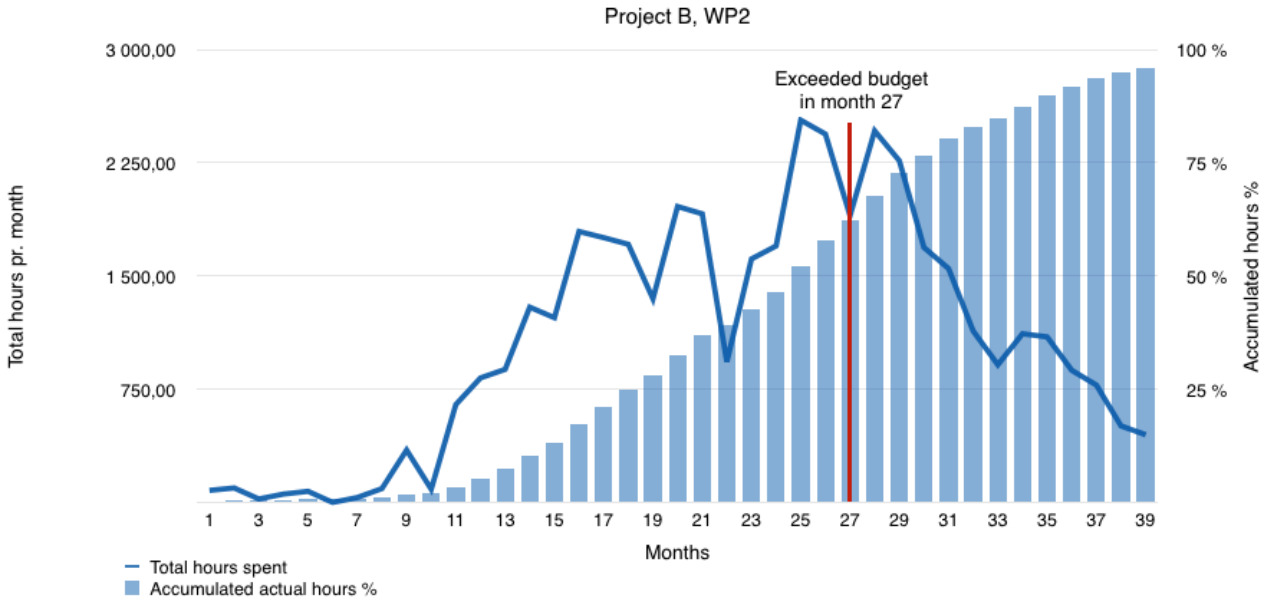

Diagram 14b: Showing when WP2 in Project B exceeded its budget.

I found a clear tendency to increase labour activity for a short time-period after a project exceed its budget. This could be due to rework causing overstaffing late in projects. As testing of equipment happens towards the end of each project, this is where faulty design and errors will be discovered and rework is needed. After this second peak of activity I see a clear reduction in the level of activity which again reduces progress. The reduction creates a long «tail» of labour activity, several months or years, and unnecessary long delays on original delivery-date. The reduction in labour activity take place in the last months or years of the projects lifecycle and might be mainly due to resource constraints or a lacking focus. On average, reduced activity lasts for 1,1 years at the end of projects in WP1, and 1,5 years in WP2.

In relation to figure 6, when the need for rework is detected in the production phase (4), tasks completed (8) can decrease, and repeated controlling (1) is important to further be able to re-plan (2) and report what workforce is needed (5) to HRM (3). If tasks completed or rework is not reported frequently enough, re-planning and production will suffer. As rework seem to be discovered late in projects, controlling and re-planning is highly important in this phase to report correct information to HRM and to get the necessary workforce to execute rework as quickly and efficiently as possible.

To answer my additional research question 2, overruns in larger projects occur in WP1 on average in month 20 or at 53% progress. In WP2 budgets are exceeded on average in month 24 or at 53% progress.

In relation to research question 3, rework due to additional orders or mistakes is a potential contributor to labour hour overrun as changes increase the use of mhrs and cause delays.

6.3 Replacing Resources

According to Reichelt and Lyneis (1999) the amount of resources in projects should increase smoothly to a (planned) peak, and then decrease smoothly towards completion, if things go according to plan. However, this does not happen in real life. In real life, plans may be inadequate as there may be an inconsistency between scope, cost (budget) and time (schedule), and changes may occur. If projects fall behind schedule due to unexpected changes or inadequate planning, they may apply more resources. When resources are added to a project, it can have a positive effect on accomplishing goals, but also have a negative effect on quality and productivity, according to Reichelt and Lyneis (1999). They stated that the average experience level decrease when additional resources are brought into projects, and that less experienced people make more mistakes and work slower than experienced people. By adding more resources, communication channels are in addition re-established as the size of the project increase, which can reduce productivity and quality.

PPM1 stated in chapter 5.7 that the focus in projects drift off towards the end of projects. The efficiency and productivity is therefor naturally affected negatively, and could be an effect on the long «tails» projects have which in addition affect the degree of delivery delays. Diagram 15 shows that PPM1 came into WP2 in project A, in month 11. This was at a relatively early stage of the project, and we see an increase in activity for some time after the replacement was done.

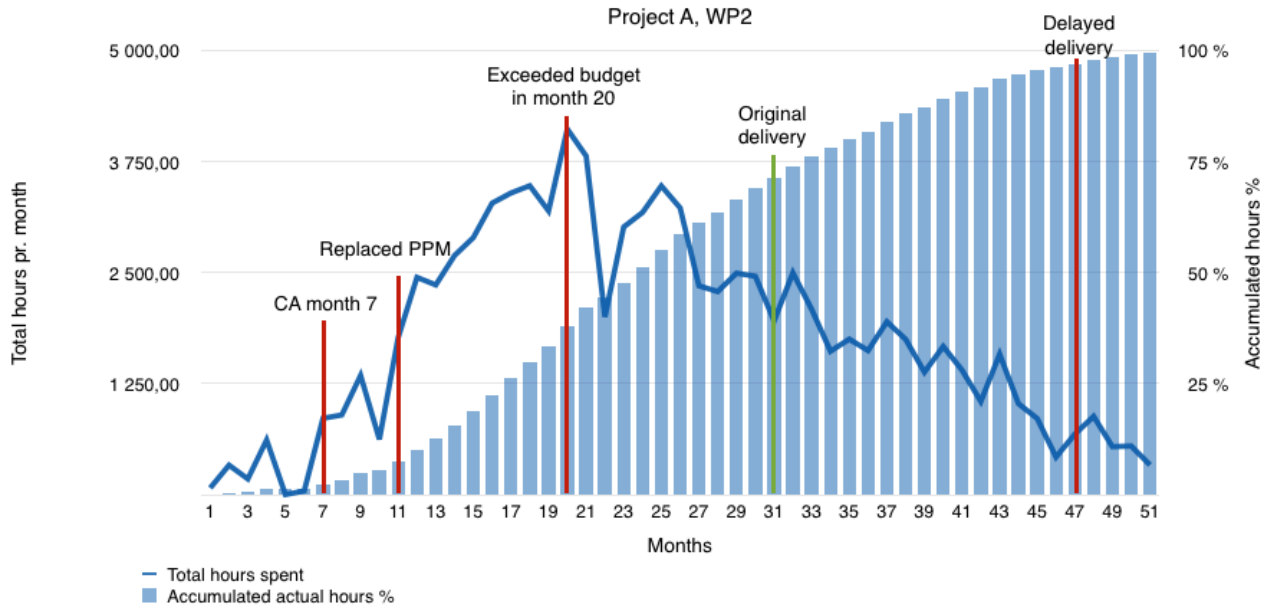

Diagram 15: Showing when the PPM was replaced, delay on one activity, and contract award in Project A, WP2.

Diagram 16 shows that PPM2 came into WP1 in Project B, in month 37. The replacement was done at a late time (end phase) where activity was very low and decreasing. PPM2 stated that the prior PPMs had been stable within Project B.

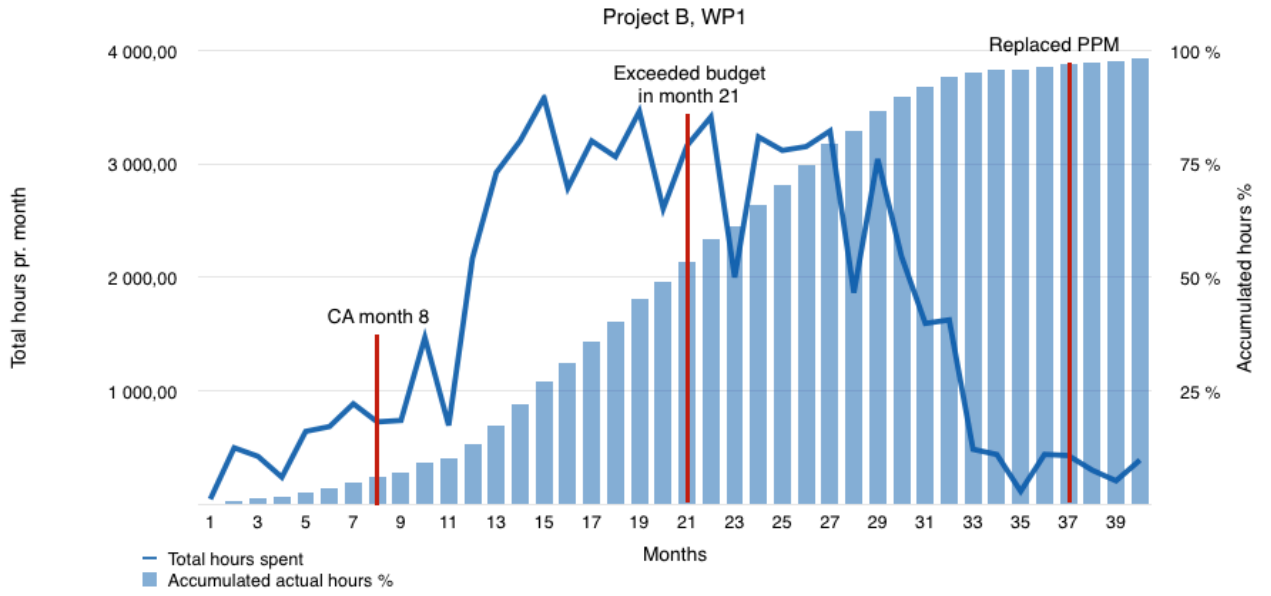

Diagram 16: Showing when the PPM was replaced and contract award in Project B, WP1.

In Project C, PPM3 was the third PPM in the project and he stated that many hours are used on getting a hold of the history of the project and what the (work) scope is. Looking at diagram 17a and 17b, we can see that there is a short-time increase in labour activity after the replacement of PPM occurs.

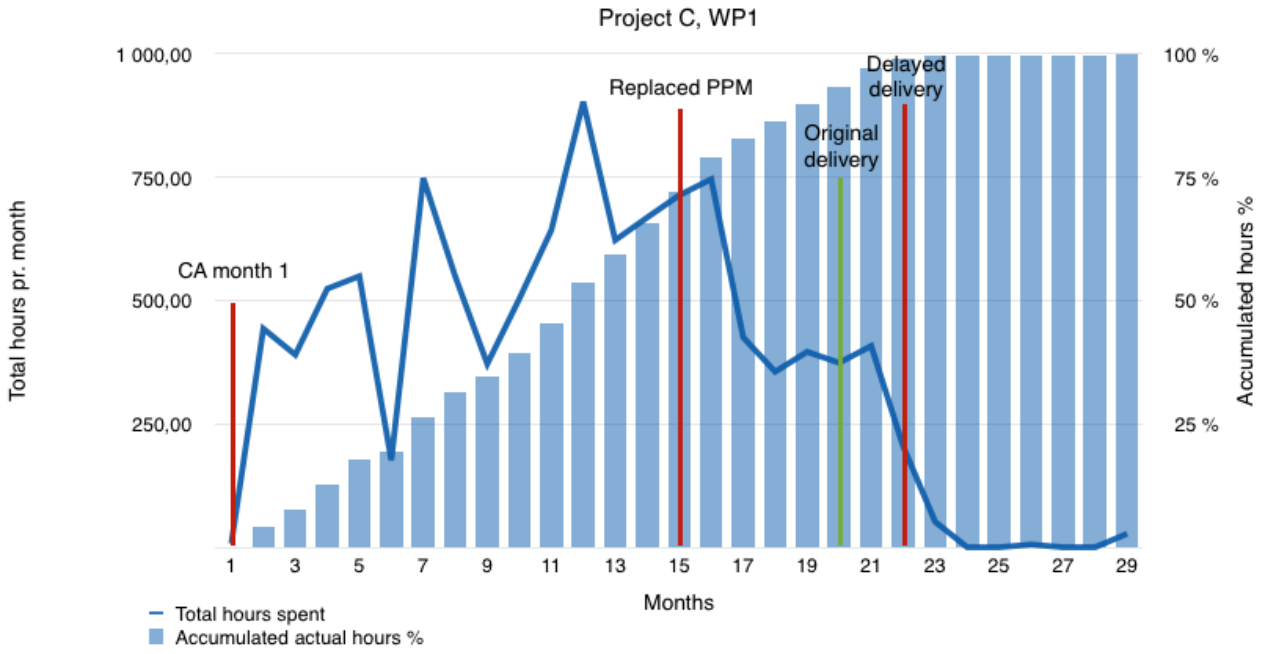

Diagram 17a: Showing an increase in labour activity after replacement of PPM in Project C, WP1.

In WP2, CA occurred one month before work started, which explains why it is not shown in diagram 17b. The same goes for diagram 18, 19a and 19b.

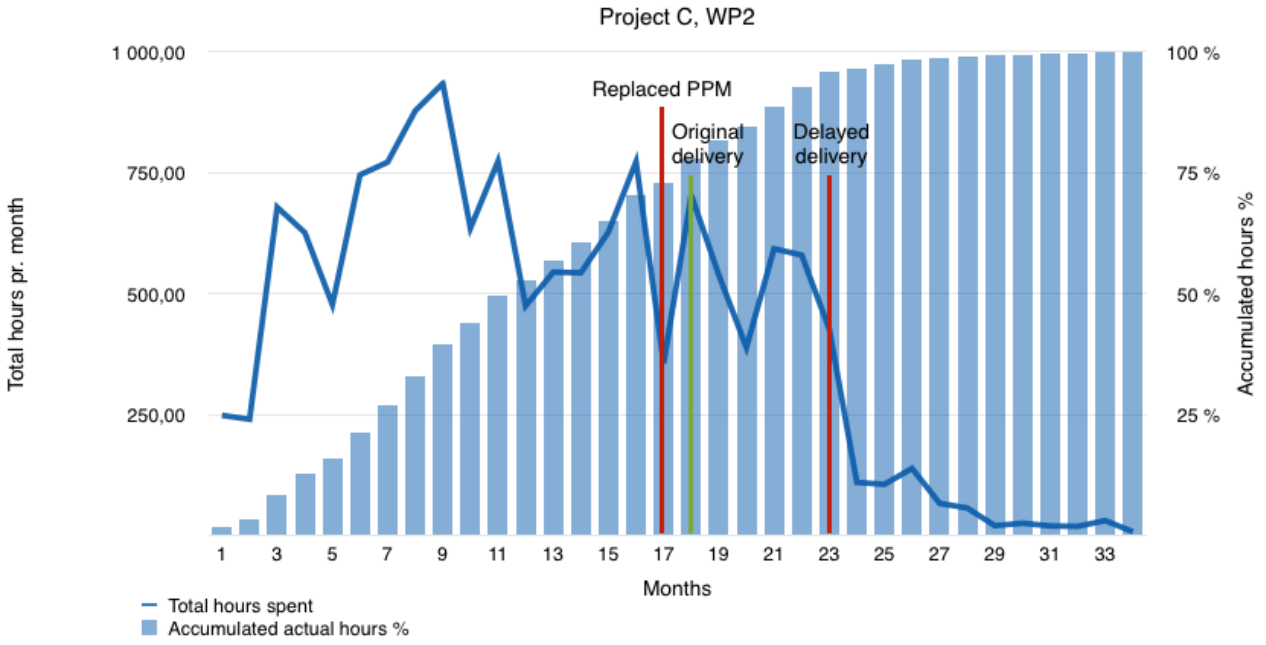

Diagram 17b: Showing an increase in labour activity after replacement of PPM in Project C, WP2.

PPM5 stated that after being appointed to Project D he used the first two months to get an overview of the project. When new personnel is delegated to projects, it may be necessary to get help from others to get a hold of the workload and a projects history. This way it is not just the PPM who use

additional hours, but other personnel as well which may decrease productivity. In diagram 18 we see an increase in labour activity in month 20-22 likely to be related to PPM5's statement.

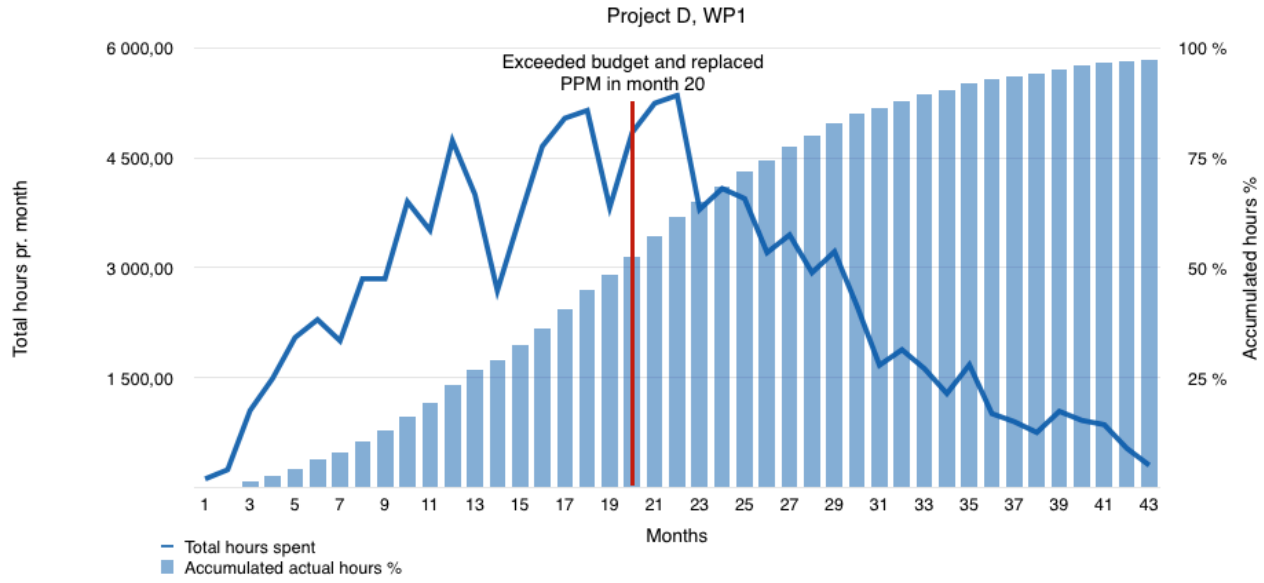

Diagram 18: Showing an increase in labour activity after replacement of PPM, in Project D.

Diagram 19a show that in Project E, WP1, PPM6 at an early stage replaced his predecessor (in month 3). The diagram shows an increase in mhr activity for several months after the replacement was done, until a peak in month 12. The same goes for WP2 in Project E (diagram 19b). The replacement occurred in month 3 as well, and an increase in activity thereafter until a peak in month 13.

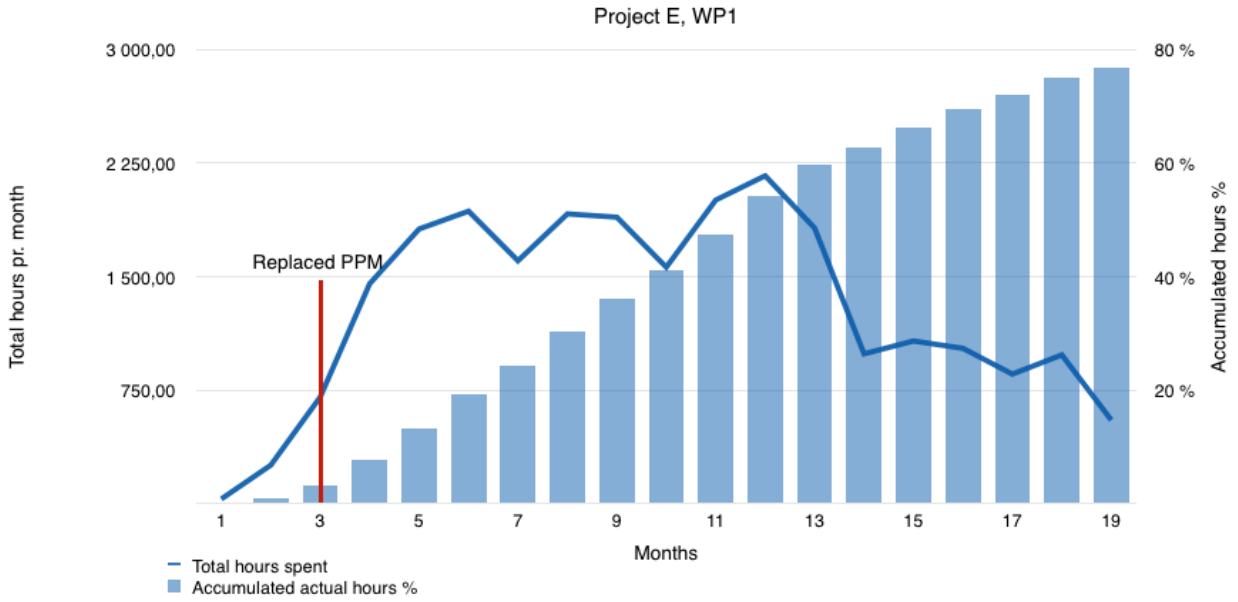

Diagram 19a: Showing an early replacement of PPM6 in Project E, WP1.

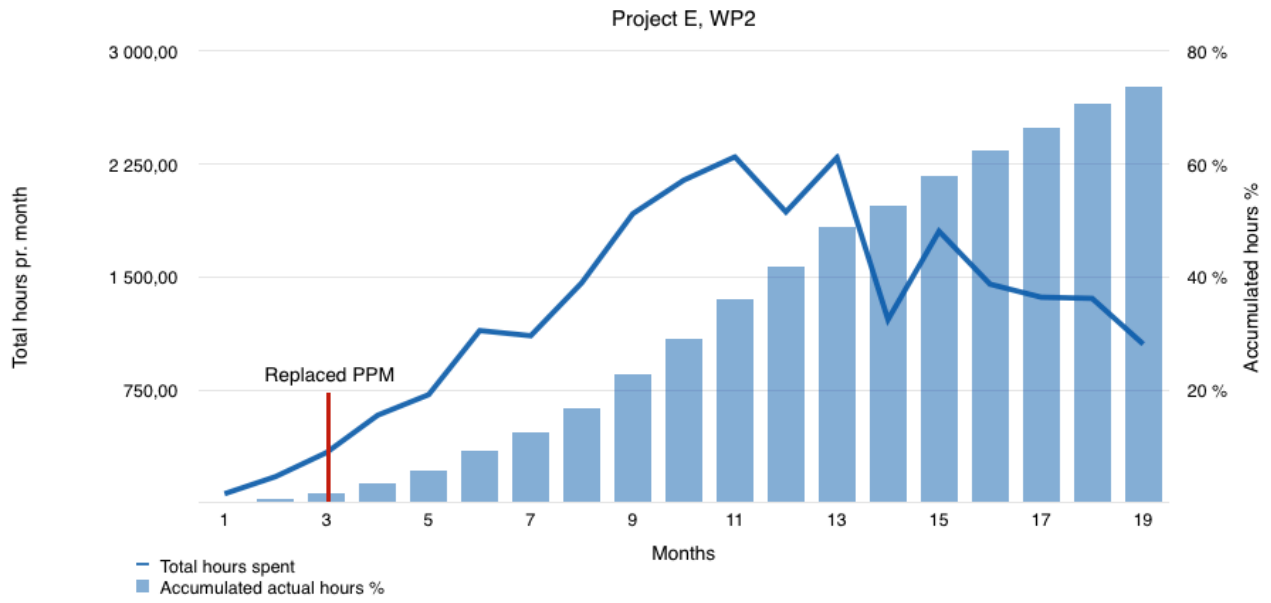

Diagram 19b: Showing an early replacement of PPM6 in Project E, WP2.

Payne et al (in Laslo, 2010) stated that projects consists of individuals being grouped together for a limited period of time to execute a job. When a project is finished the individuals are set to work in new projects. However, Cusumano & Nobeoka (1988; in Laslo, 2010) mentioned that projects compete for resources in *multi-project environments*, and Platje et al (in Laslo, 2010) stated that it exist competition between projects to get experts and skilled resources to achieve goals with optimal use of resources. In multi-project environments there is an issue of unavailable resources (Pich et al, 2002, Williams, 1999; in Laslo, 2010) which complicates the task of scheduling and planning projects and their need for resources.

SubComp is a company with a multi-project environment where projects clearly compete for expert individuals, and replace resources during the projects lifecycle. When resources are replaced, new staff need to use time to get an overview of the project and its work scope. PPM3 said that by repeating internal contract review with new personnel when replacements occur, could be one mitigating action. This way, the time new PPMs use on reviewing projects to get an overview could be reduced, and could again decrease the level of overrun on mhrs. In addition, PPM1 suggested that PPMs should work on a project from the start, as to assess the budget, to know the scope, and to understand what he is working with.

There is a tendency to have increased labour activity for a short period of time after replacements are done, then drop drastically to the end of the project. However, if replacements occur early in projects, as we have seen in diagram 15, 19a and b, there might be a tendency to have a higher increase in labour activity for a longer period of time. One reason for this increase could be that the number of new personnel delegated to projects is high in the beginning, and that new personnel need to get an overview of the project, its history and its work scope.

In relation to figure 6, each individual project plan (2) with desired amount of hours (5), which can be higher than the amount available (7). The line-organization own resources, and HRM (3) have to delegate resources according to demand. Often projects may plan to use the same resources, which can create a deviation between the project plan and available workforce due to competition. If re-planning of resources at stage 2, according to effort remaining (6), is not done frequently enough, it may affect the information going up to HRM, the delegation of workforce between projects, and further the production phase (4).

To answer research question 4, resource constraints are likely to be a contributing factor to labour overrun in larger projects. As SubComp deals with multi-project environments, management needs to allocate resources according to demand. This creates a need to replace resources over time, and further increase mhrs used as explained above. This relates to research question 5 as well. Hours used by new staff to get an overview of a project could indicate low productivity as it is not directly adding value to the project or its overall progress.

6.4 Monitoring and Controlling

Rolstadås (2011) stated that it is important to establish what the critical path for projects is. In what order activities should be executed is determined by what they are dependent on and their duration. The fact that certain activities have to be complete before others can start, is an important factor to take into account, according to Conde (2009).

Project A had delays in activities which provoked a delay in the overall project. As shown in diagram 15, one main delivery in WP2 was delayed for 16 months. Duration and completion time could however, be reduced by adding more resources (Yang, 2007). This would be done at an

additional cost which SubComp would bear. Göçken (2012) mentioned that uncertainty in the environment and changes can influence activities, their duration, their cost etc., and further influence activities execution sequence. As was mentioned by PPM1, Project A had a delay due to new data from the seabed, which required new design and the project had to redo their engineering work. For large projects like Project A, delays seem to have a bigger impact on the overall progress and delivery, compared to smaller projects like Project C. Looking at diagram 17a and b, Project C had delays, but did however not not go over budget.

Looking at figure 6, production (4) report what tasks are completed (8) to the controlling unit (1). If delays on activities occur, effort remaining (6) could be higher and re-planning (2) would have to occur to give a viable estimate of workforce needed (5) to HRM (3). Smaller projects are naturally easier to monitor and control, which ease the impact of delays as re-planning and necessary information given to HRM is more easily assessed.

In relation to research question 6, continuous monitoring and control is necessary as progress and workforce needed is reported to HRM who delegate resources based on reports from each project. If a project lacks monitoring and control, HRM may be given inadequate information, which would further implicate the delegation of resources and possibly generate additional delays.

6.5 Knowledge Sharing

Reichelt and Lyneis (1999) stated that rework can be reduced if things are done right the first time. They suggested some mitigating actions that could contribute to this; have an experienced project team as possible from the start; execute work in an optimal order; try to find rework after each phase of the project; and avoid continuous overtime. Morris (1990) said in his paper on cost and time overrun in public sector projects in India, that learning by doing is a cost which is passed on to user firms as delays of delivery or faulty design. Eden et al (2005) noted that if additional workforce is needed, they have to be trained which creates learning inefficiency if the new workforce is put into a project at a late point in time. In addition, Reichelt and Lyneis (1999) mentioned that the idea of every project being unique implicates systematic learning across projects.

PPM2 said that doing things right the first time will contribute projects to reduce problems, save time, frustration and money. PPM3 noted that in WP2, the LE was less experienced than expected

and needed help from others. In relation to this, he also mentioned that people are not always good at asking for help, and may see it as a defeat. This he said is a challenge. Looking at figure 17b we can see an increase in mhrs in month 9 which could be an effect of the less experienced LE. In addition, WP2 came much closer to an overrun than WP1, which could also be a result of less experienced staff members. PPM1 mentioned that learning from others that are more experienced is key. He also mentioned the issue of «blueberries». When «blueberries» are assigned to projects they require training in order to learn. This can create inefficiency as other project members need to train them, and additional hours are spent in the project. In this regard, PPM6 noted that the ones delegating resources have to communicate with each other to find out how many unexperienced resources a project can handle.

There is a common understanding between all PPMs that getting things right the first time is essential to save time and cost. The challenge of making employees ask for help I interpret as something that, if neglected, could reduce the chance of getting things right the first time. By making it clear for employees that it is important to ask for help could decrease the time related to learning by doing. It could also be a prevailing action related to avoiding overruns and delays in SubComp's future projects. In addition, clearly sharing experience through the activity Lessons Learned, and from experienced personnel to new employees could save time in relation to learning, and further decrease the risk of an overrun on mhrs as personnel would more quickly become productive.

In relation to figure 6, if experience is not successfully or sufficiently shared between employees and projects, production (4) could be affected negatively as less experienced personnel use more time to complete tasks and make more mistakes. Tasks (8) may therefor take longer to complete, causing mhr overruns and possibly delays. Re-planning (2) and frequently reporting workforce needed (5) to HRM (3) is necessary to get the best mix of resources to handle unexperienced team members, and to have time to share knowledge and help each other out.

6.6 Communicating Change Orders

Eden et al (2005) stated that creating a system for logging all changes and the reason for change is essential, as change orders usually impact projects more than expected. Kumaraswamy and Chan (1998) discussed, in their paper on contributors to construction delays in Hong Kong, the importance of non-scope contributors such as project participants priorities and relationships, and

effective communication. These factors could affect project duration, either directly, or indirectly through the factors' effect on the level of productivity. The lack of effective communication between consultant and contractor, and delays in information regarding design was noted as being two important factors contributing to construction delays.

PPM2 stated that having continuous meetings and spend more time with the customer could increase the chance of collecting as much information and changes as possible. PPM3 also expressed that spending more time with customers on clarifying contracts could improve the overall project work. PPM5 noted that one mitigating action could be through direct communication with the customer, and PPM6 said if something was discovered to not be included in the contract, SubComp should go back to the customer and clarify the contractual understanding.

There is a consistent agreement between all the PPMs that an increased communicative relationship and continuous meetings with customers would reduce the time spent on discussion of contracts and change orders, and more quickly resolve disagreements and uncertainty. This could relate to the controlling phase (1) in figure 6. By having an increased communicative relationship with customers, reported progress (9) and effort remaining (6) could be more exact. Re-planning (2) could be executed more quickly, and further give HRM (3) an increased amount of sufficient information.

6.7 Forecasting Issues and Re-planning

Porter et al (2011) stated that it is naive to assume that things will occur in the same way in the future, as it did in the past. As the world is quickly changing, concerning technology and environment, forecasting becomes more challenging.

The lack of time available to make good forecasts, and the lack supporting tools to do so is an issue for PPMs. When hours are registered incorrectly by employees as discussed in chapter 5.9, it gives an inaccurate status of how many hours are used in projects. This is an issue which implicates the use of historical data for estimation purposes. Forecasting in SubComp is therefor highly based on project status, estimated remaining hours and experience. Porter et al (2011) mentioned that forecasts are supposed to give management schedule information to evaluate risk and further control it. If forecasts are uncertain and highly based on experience and individually created forecasting systems, there is an issue of giving managers incorrect or insufficient information.

As shown in figure 6, re-planning (2) communicates to HRM (3) what workforce is needed (5), and as HRM is not an integrated system, meaning that it is separate from project planning, inaccurate forecasting and planning can easily create a mismatch between planned hours/workforce needed in a project and actual available workforce (7) in the HRM-database.

6.8 Standardization

Teller et al (2012) suggested that formalization in both Single Project Management (SPM) and Project Portfolio Management could increase the level of project performance. Transparency as an effect of formalization could improve managements allocation of resources, and therefor reduce the level of competition between projects and improve project cooperation in portfolios. Formalization of tools, standards, processes and procedures could in addition increase the willingness to assist other PMs and project teams.

Standardization of routines, methods and tools could be an influencing factor on how to get things done right the first time. PPM1 requested a sufficient tool to be able to have an overview of what resources are needed in projects and to easier see the amount of remaining documents. This could be something similar to the tool PPM4 created himself and has been using in his projects. His tool was an Excel sheet detailing all elements in the project such as administration, engineering, document control, and accumulated mhrs, showing a complete overview of mhrs in a project. However, it may seem as each individual project use their own knowledge and experience to create forecasts, rather than a standard tool. SubComp use an Engineering plan and a resource-planning system for forecasting, but perhaps an additional standardized tool based on «Best Practices» would be helpful for PPMs to make better forecasts internally in each project. This could be a «low hanging fruit» based on the idea of agile methods for implementing standardization's.

PPM3 stated that WP2 require more focus than other WP’s, as the workload is higher in WP2 and continuously underestimated. The need for more specified roles is prominent. PPM1 noted that PPMs do a lot of non-value creating work, such as searching for documents and underlying figures to be able to make good forecasts. The need for a document planner or professional planner to handle the Engineering plan could assist PPMs on a daily basis. To allocate responsibility and roles so that the workload of PPMs is reduced, could decrease the amount of mhrs used on administrative non-value creating work.

In addition to forecasting and documentation work, PPMs have the full responsibility of approving all hours registered on the different activities in a project. There is a tendency among employees to register hours on incorrect activities or projects. This imprecise registration of hours give a wrong picture of actual hours in a project than what is reality. Further, it indicates a higher overrun than it should. When work is hectic there is less time available for the PPM to control all the hours registered on the project. If parts of the PPM's role would be allocated to others there would be more time available for him to follow up hours and weed out incorrect registered hours. This could make SubComp have a more optimal use of their resources.

Some activities do not have a budget as some activities are created at a later time to have a better overview of what corrections may have cost. It could also be due to the fact that people register their hours on incorrect accounts, and as an action PPMs create new accounts to avoid misuse. There is a need for a better control system to plan, monitor and follow up hours to make it easier for PPMs to control hours, reduce their workload, and reduce the risk of misuse of activity accounts.

In figure 6, controlling (1) affect re-planning (2) through effort remaining (6), and further what resources are delegated to production (4). Effort remaining may be determined by how many documents are remaining, and if PPM's workload influences his ability to control and determine the number of documents remaining, it will affect re-planning of workforce needed. If incorrect information is reported to HRM (3) due to lacking time accessible to correctly determine effort remaining, production will be affected as an insufficient number of workforce will be delegated. Implementing standardizations could ease PPMs workload and further give them sufficient time to execute re-planning and new forecasts, and report more correct information to HRM.

7. Conclusion and Recommendations

This chapter summarize the findings in a conclusion, discuss how the research can be used and highlights recommendations for further studies on the subject.

7.1 Conclusion

The research was carried out for a case organization and the goal was to find what main factors contribute to mhr overruns in projects. To get the necessary information to perform the analysis, and to get insight into how project management is today, empirical findings were based on PM's knowledge through personnel interviews, and raw data. The raw data was collected from an internal database, starting from 2009 until December 2013. I have tried to find trends among projects and WP's that could support the problem definition and my additional research questions.

There are several factors that contributes to mhr overruns in larger projects. Through my discussion and analysis I found that underestimation of budgets, rework and delays, replacement of resources, low level or lack of knowledge sharing across projects and between employees had an impact on mhr overruns. Potential lack of direct and frequent communication with customer to collect as much information as possible in order to discover changes was an important factor I found. Lack of sufficient forecasting and re-planning due to time-constraints and a heavy workload for PPMs, lack of standardization of project roles, tools and processes affecting the optimal use of resources also had a critical impact on productivity and therefor mhr overruns, particularly in *larger* projects.

One of my observations were a clear tendency to increase labour activity for a short-time period after a project exceed its budget, which could be due to rework causing overstaffing late in projects. After this increase, there is a significant reduction in the level of activity which again reduces progress. It also creates a long «tail» of labour activity (several months or more than a year) and unnecessary long delays on delivery-date. The decrease of activity seems to be due to resource constraints and/or lack of focus among employees towards the end of a project's life-cycle.

There is a tendency to increase labour activity for a period of time shortly after replacement of key personnel, especially PPMs. This could be due to the fact that PPMs and project team use time to get an overview of the project and its workload. When new personnel is delegated to projects, they

may need assistance from others, which generate additional use of hours and affect the overall productivity in a project. Replacements also generate hours if new hires are assigned to projects. New hires require initial training and follow-up from experienced and already established personnel. Communication channels are in addition re-established as the size of the project changes which may create confusion among employees as i.e whom to report. This can reduce productivity and the quality of work.

The administrative time required for PPMs to make sufficient forecasts, approve all hours, carefully review documents etc., may be restricted as their workload in general seems to be fairly high. If PPMs have a time-constraint they need to prioritize, which will affect the quality of the overall execution of project work. A time constraint indicates a lack of optimal use of resources.

7.2 Recommendations for Improvement

There is a consistent agreement among PPMs that an increased communicative relationship and having continuous meetings with customers would reduce the time spent on discussion of contracts, requirements and change orders, and more quickly resolve disagreements and reduce uncertainty. To get things done right the first time may be improved if project experience is clearly communicated through an active use of Lessons Learned, and by having consistent and careful training of new employees.

Implementation of standardized procedures and tools is highly recommended to ensure getting things right the first time. When things are performed in a standardized way it is likely to create synergy within the project organization. I recommend the use of successfully established and existing procedures, tools and routines based on «Best Practices».

Reducing PPMs workload through delegating roles to i.e. planners, could help improve productivity and efficiency in projects and the overall quality of work executed. It would certainly make it easier for PPMs to follow up and control their project. The issue of wrongly reported hours by employees could be avoided if a standardized system for reporting actual hours was implemented. i.e. restricting access to project accounts.

Human Resource Management should become an integrated part of the planning system and they should strive to allocate resources more accurately. The planned need for resources in projects should «match» actual available resources within the organization. A defined resource allocation routine would help match «supply and demand» for resources.

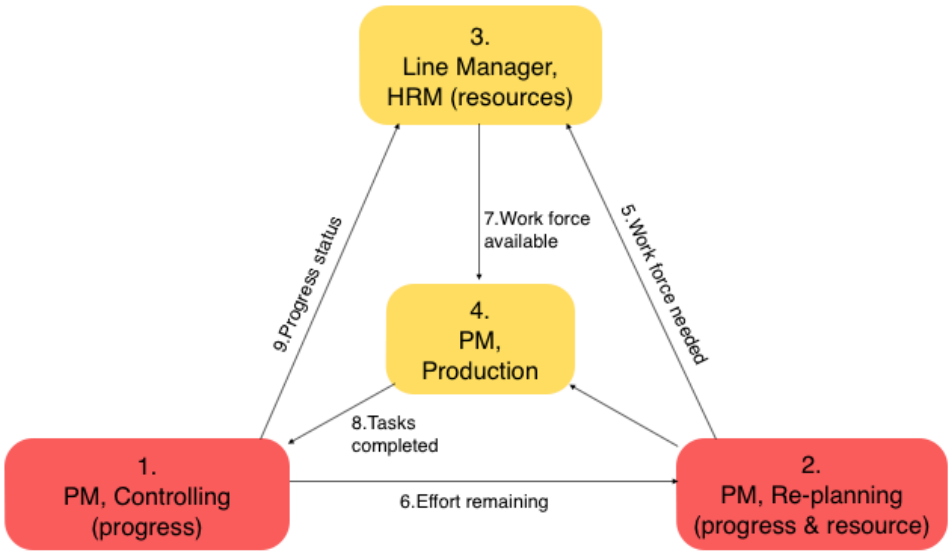

Figure 7: Control loop showing criticality of the different units.

In figure 7 above *Red* indicates a great potential or need for improvement, and *Yellow* represent a less severe need for improvement.

The issue of mhr overruns seem to be highly connected to both the controlling and re-planning units shown in figure 7 above. If there is a low level of control in a project, it affects the quality and ability to re-plan. If re-planning is not performed by PM's on a regular basis it present the Line Manager with false and imprecise information. As the Line Manager allocate workforce based on this underlying information, it influences the delegation of workforce and further the quality of the production unit.

7.3 Application of Research

The research is an important documentation of facts and figures. It can give organizations valuable input on what the main contributors to overrun on mhrs are in large construction projects, and further give organizations an idea of where to take action to reduce overruns and delays. Hopefully the result can help PPM's to improve their forecasting, resulting in a more precise estimation, and improve overall execution of Project Management in future projects. The findings from my study can be helpful if there is a willingness to increase focus on standardization. The use of «Best Practices» and standardizing roles, procedures and tools, improved communication towards employees and customers, reduced workload for key personnel, and careful knowledge sharing can have a positive impact on individual incentives for improvement in organizations.

It is my opinion that any research within an organization, like SubComp, even as a fairly limited study, is both useful and valuable for organizational management. By taking the time and effort to analyze data is crucial for organizational management to be able to prioritize which improvement efforts to implement.

7.4 Further Research

This research has focused on mhrs in projects. Future research could incorporate a study of hardware costs in construction projects. It is likely that hardware is linked to mhrs and it could therefor give a more detailed picture of where and why overruns occur. Projects often experience cost overruns in addition to mhr overruns.

In this research I was able to study and analyze five different projects and interviewed six different PPMs in total. This gave a limited, but useful selection of information to be able to say what the main contributors to mhr overruns are.

Future research should study a higher number of projects, interview accordingly more PPMs, perhaps interview Line Managers at different levels within an organization, and interview management in the HR-department regarding resource allocation. Additional research like this would secure a more reliable and valid result. It could be interesting to try to find if there are any trends among customers, or between WPs. Further research could look into how project complexity affects overruns, as its discussion was limited in this study.

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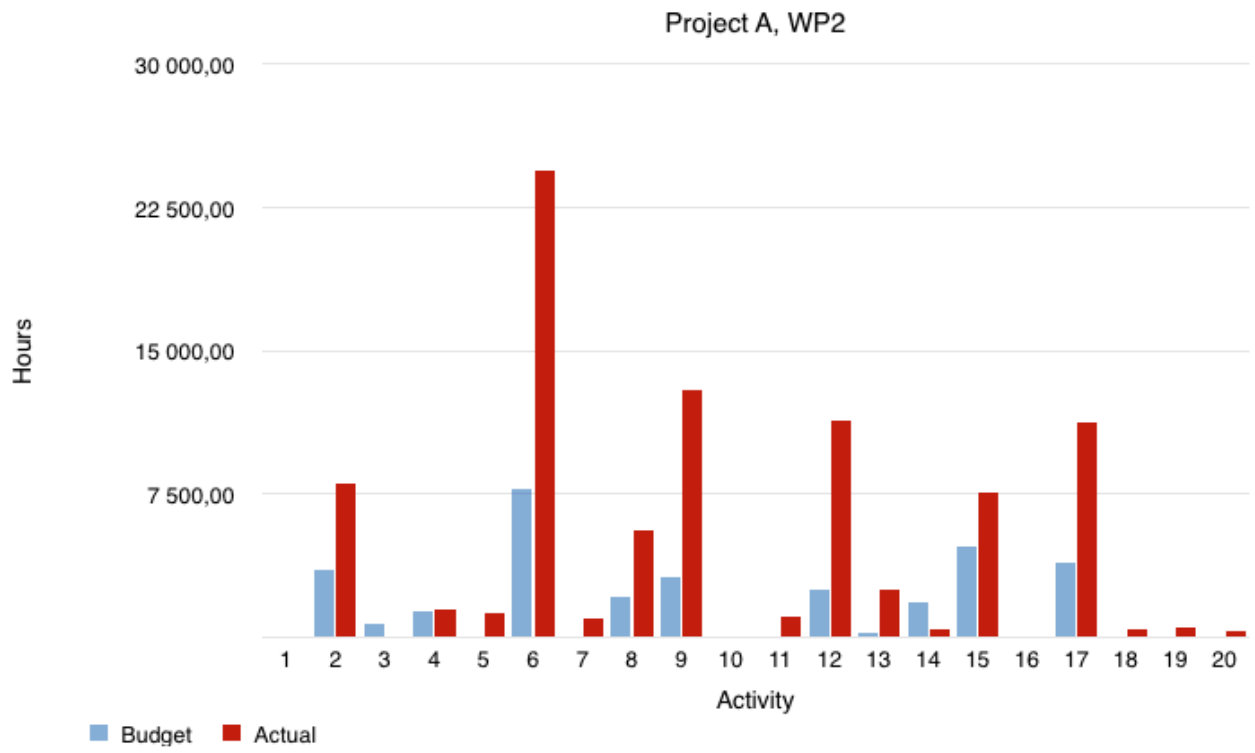
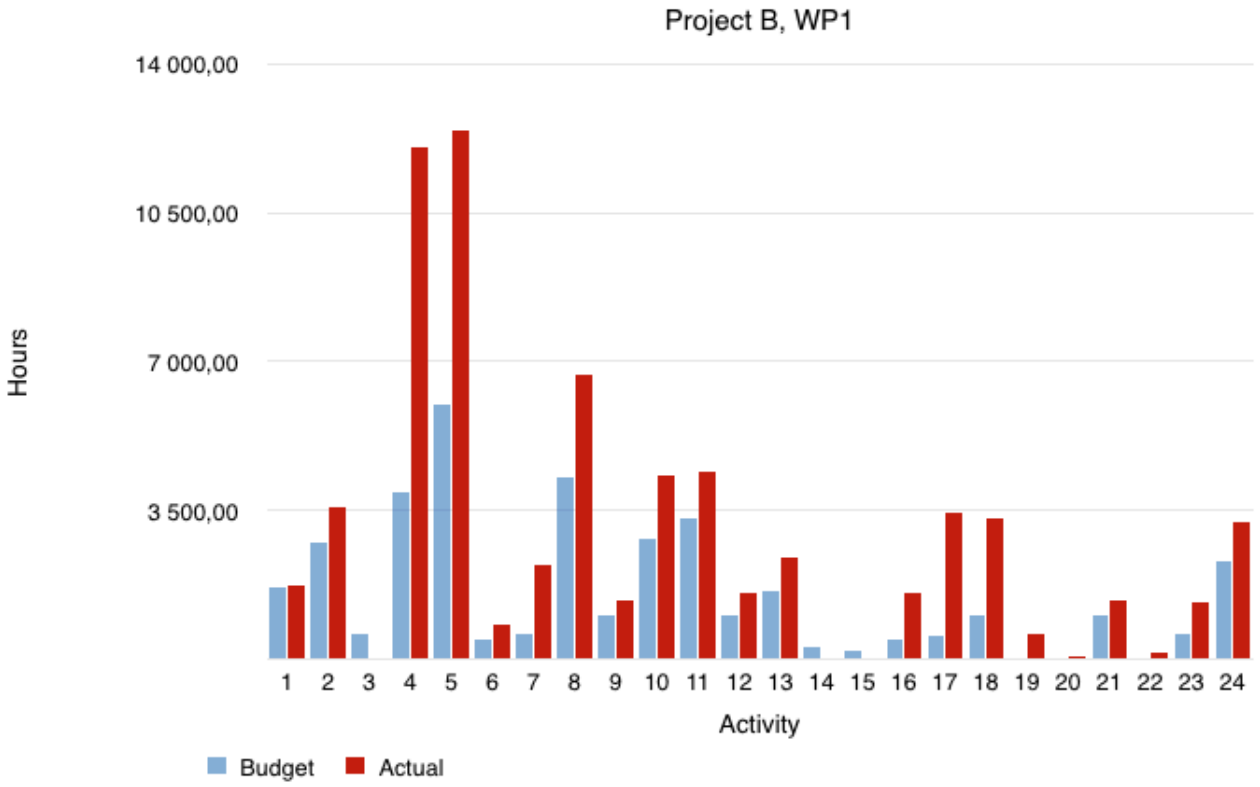
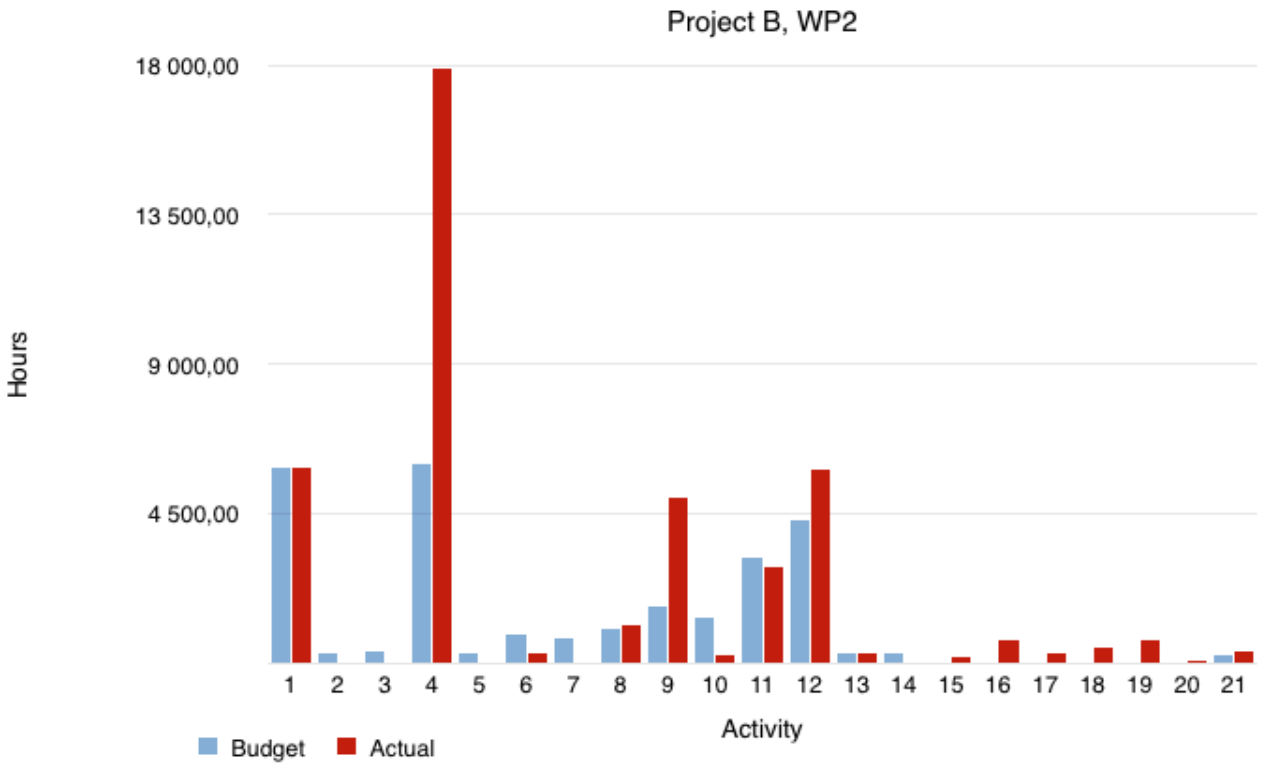
Appendix

Diagrams



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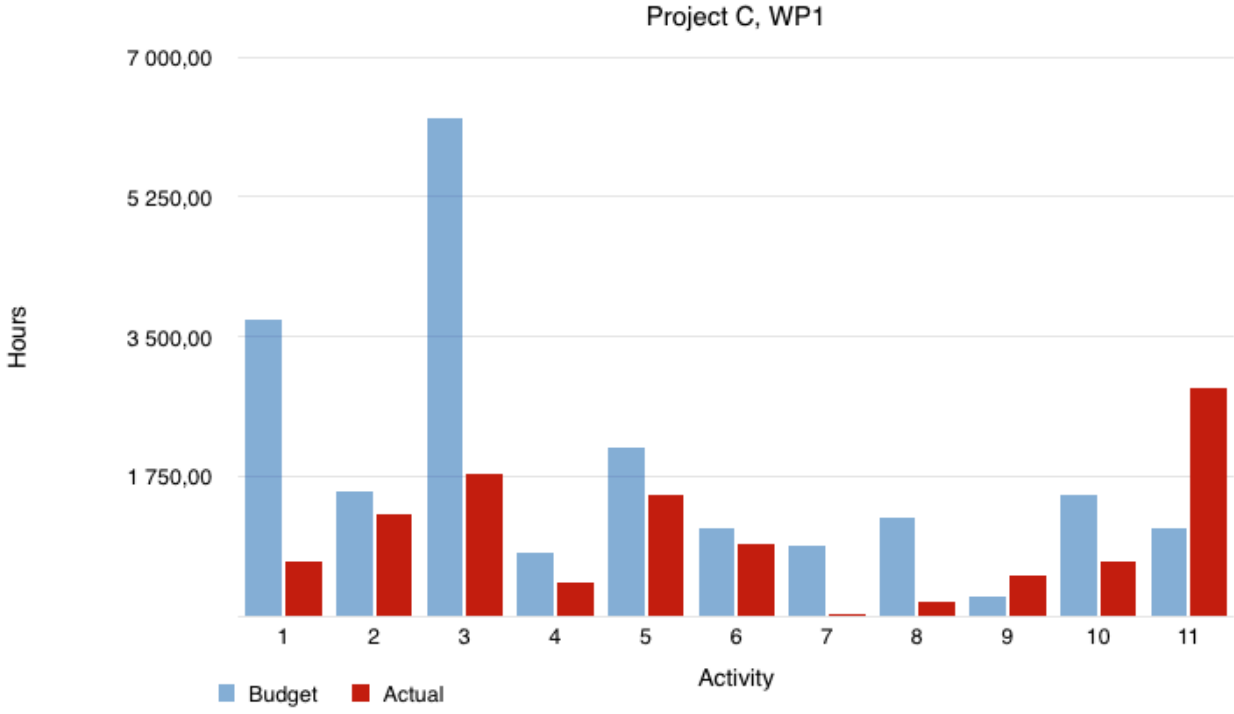
13 500,00
9 000,00
4 500,00
Hours
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21
Activity
Budget
Actual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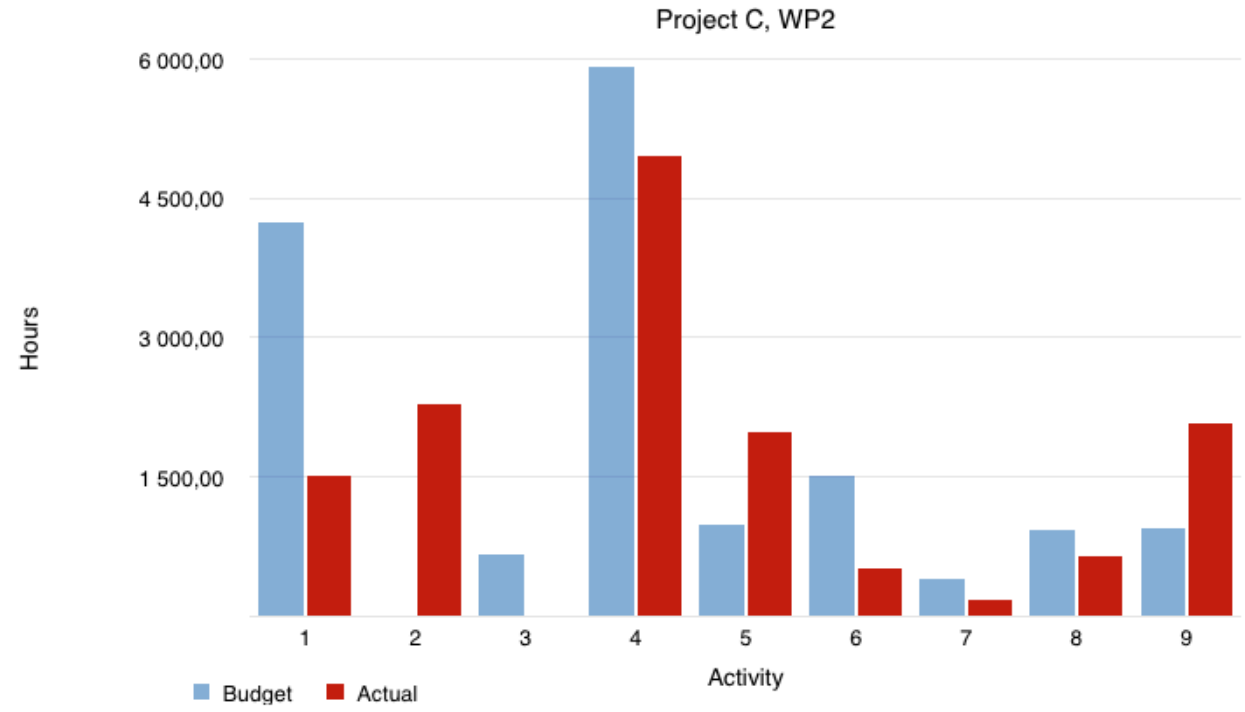
3 500,00
1 750,00
Hours
1 2 3 4 5 6 7 8 9 10 11
Activity
Budget
Actual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Hours
1
2
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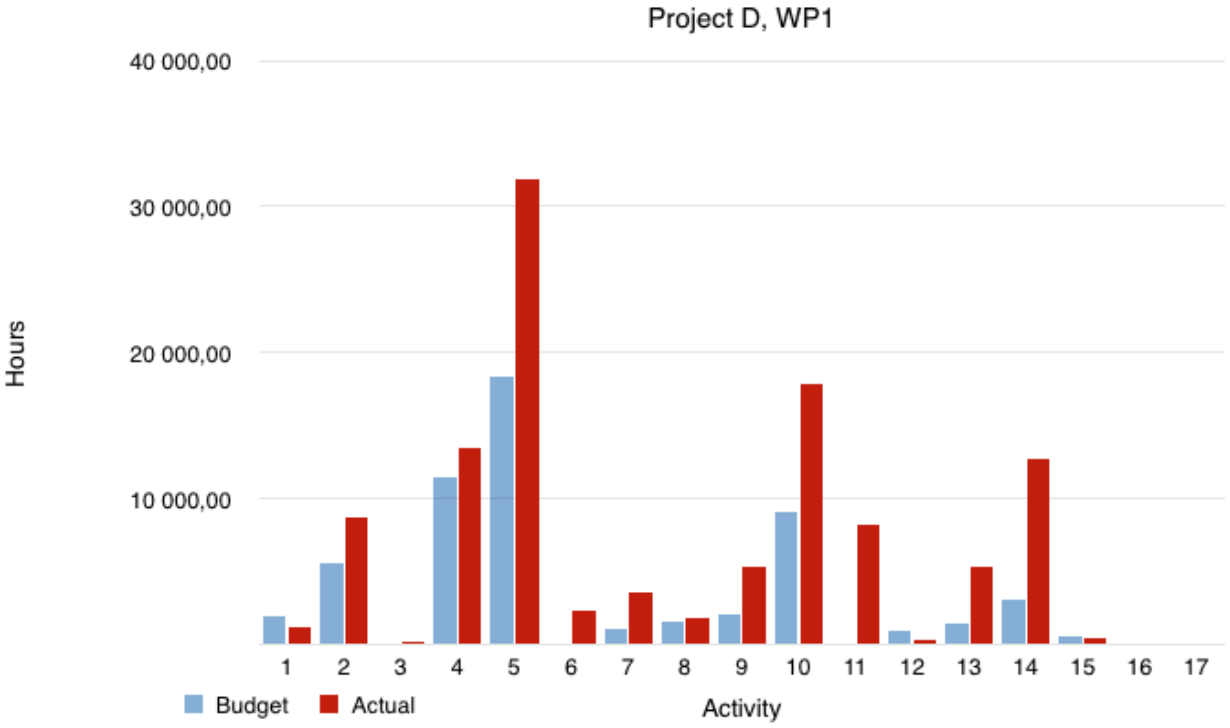
Activity
Budget
Actual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30 000,00
20 000,00
10 000,00
Hours
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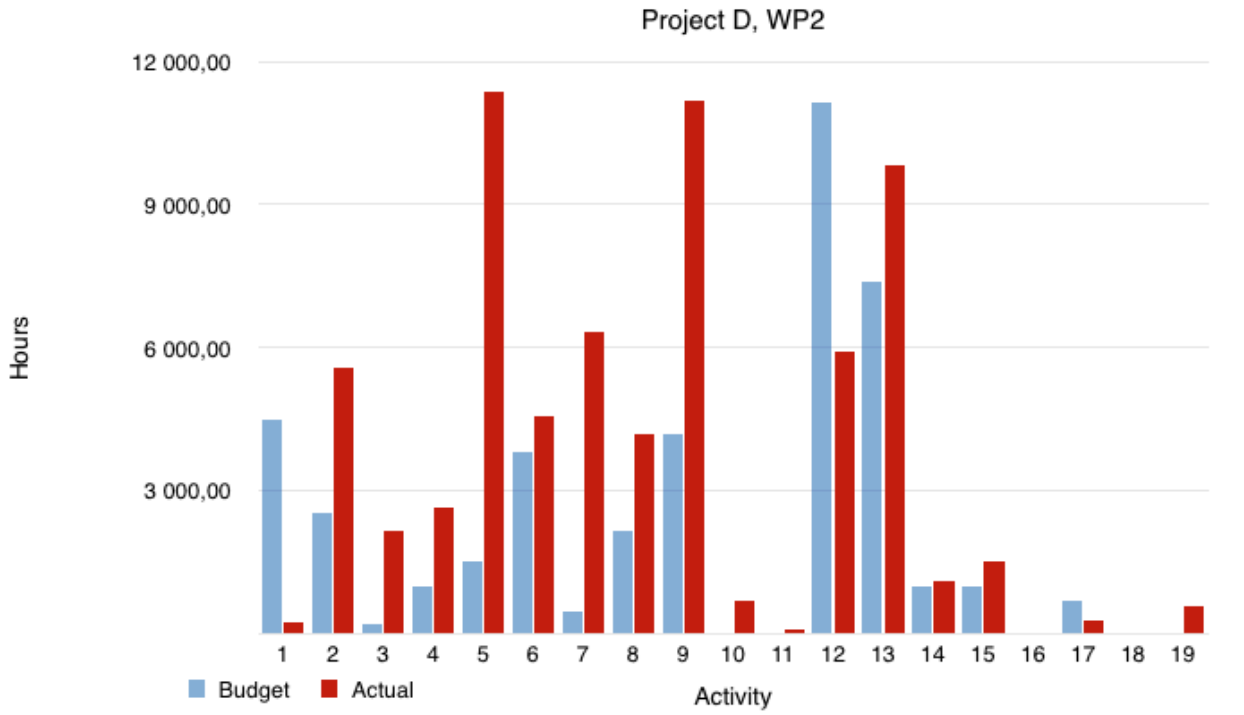
Activity
Budget
Actual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Hours
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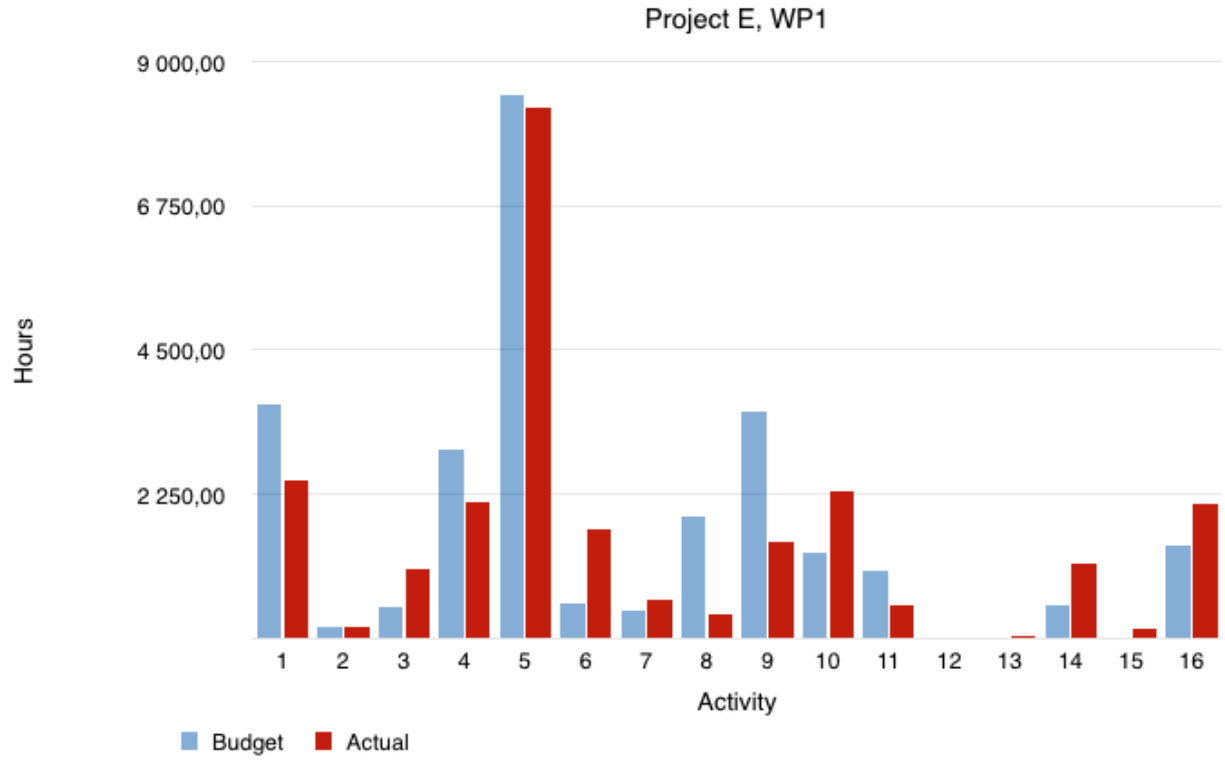
Activity
Budget
Actual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Hours
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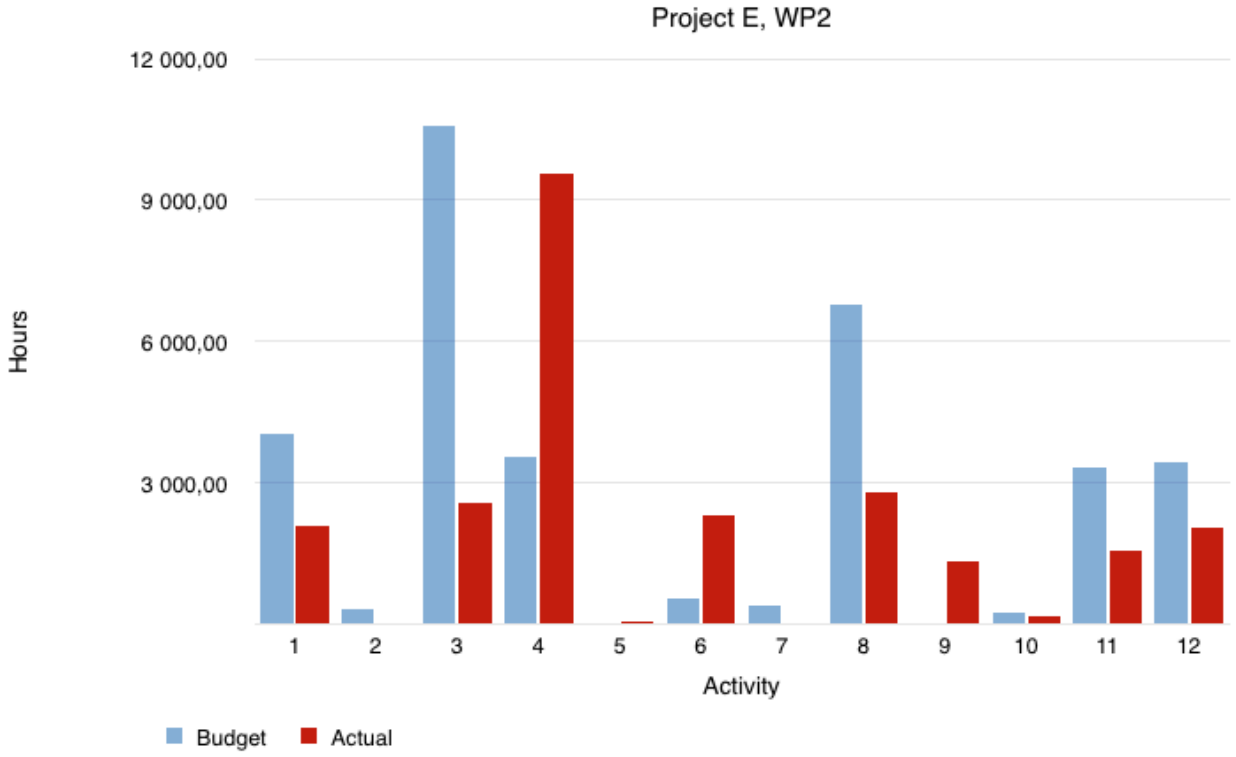
Activity
Budget
Actual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3 000,00
Hours
1
2
3
4
5
6
7
8
9
10
11
12
Activity
Budget
Actual

Interview Guide

Interview guide on manhour overruns:

I have been looking at manhours spent in projects up until December 2013, and based on the data, I have tried to find trends that could answer my problem definition; «What are the main contributors to labour overruns in projects?». However, the need for further and more detailed information is neccessary. I have therefore listed a number of questions that I find relevant.

What kind of «rules» do you use for progress measurements? e.g. to find earned value?

Do you have a set of standards within the company, or rules specified for each project?

"Value creation" is being implemented as a tool in one of your projects, but the company has not used this kind of analysis before. What have they used instead?

In a project, is a plan and critical path used and followed?

How often do you update a project plan?

When was Contract Award and project end?

Are hours registered after projects are closed? If yes, why?

Are hours registered before contract award? If yes, why?

What was the main source of supply?

Any implications/difficulties with the type of supply?

Did you have any difficulties in terms of the customer?

How do you plan to handle changes? Any guidelines the firm uses?

Did any specific changes occur and when? If yes, what and why?

What happened at peaks? (more detailed questions while looking at graphs)

What actions did you take when unexpected changes occurred?

What have you done to try to prevent the same mistakes?

Did any changes have a major impact on the budget (hours, costs, supply, customer, delivery-date)?

- Where changes formalized as an additional order to an increased budget?

How would you say the quality of the forecast is?

Who creates the forecasts? Are they experienced?

What do they base forecasts on?

How do you ensure that the forecast is realistic?

What do you base the budget on?

How do you budget for activities, changes, delivery-date?

Why is there no budget for some activities?

When (and how) do you usually notice if hours/the project has gone over budget?

What actions do you plan to take when you notice an overrun?

Are actions implemented in time?

How would you say the status of the project is today?

How would you say the productivity has been/is in the project?

Do you manage that employees register hours in the correct account/activity/project?

Are employees experienced with the work they do?

Can you come up with three actions to prevent overruns and improve project planning?

Additional questions sent by email:

Has there been replacements of staff in your project? If yes, how often (month, year, when needed), and which positions (designers, engineers, PPMs etc).

- And why, would you say, was the reason for replacement?

When did the main customer delivery in your project (WP1 and WP2) have its original milestone, and actual milestone?

- If the delivery consist(ed) of many items, please pick the first and last. I need to understand how many days (average days late) it was delayed from original milestone.