In control: monitoring the costs of projects at Enexis E&P

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In control: monitoring the costs of projects at Enexis E&P

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Preface

This thesis is the final assignment for my degree in Business Administration, and therefore also marks the end of my student days. A friend of mine recommended a vacancy at Enexis B.V., for it related to me and my field of study quite well. Enexis offered an internship to research if, and in what way, the existing applications used by Enexis can be used to create a more efficient and reliable process for the projects carried out by Enexis E&P.

In June 2013, I started at Enexis E&P in Zwolle with my research. After consulting with my supervisor Thijs Derksen at Enexis, it was decided to focus on cost monitoring and control for project management, and review which preconditions such a control system should meet. This was decided in order to keep the scope of this thesis manageable, and to avoid focusing too much on software issues. Furthermore, it was decided to focus on cost control, for it is one of the main issues that the E&P department was struggling with at that time.

Personally, I am very happy with the progress made in this research over the last months. It took me a while to find the right direction to take, and the right scope for the research. If I had to do it all by myself, it would have definitely taken me much longer. I would therefore like to thank in the first place Henk Kroon, for giving me advice and asking those critical questions that have made me think twice about which direction to take, and to stay focused on the core research, instead of going into too much detail. It was very helpful, and also kept me motivated. I would also like to thank Thijs Derksen for his support, helping me on my way in a new and complex organization, and reading my work into detail to give clear advise, despite his busy schedule. Also, I would like to thank Peter Schuur for giving me useful feedback during the last stages of this research.

Perhaps even more so, I would like to thank all employees at Enexis E&P, in the first place for making me feel welcome and helping me understand the projects and the organization. Even more, I would like to thank everyone for making time available for me to interview them. Everyone was very open and helpful, and without it the results of this thesis would be meaningless. I have learned so many new and interesting things in a relatively short time, which has been a great experience.

Last but not least, I would like to thank my family and friends, for always being there for me. Alex, for always being an optimist and making me smile, even after a bad day. Most of all, I would like to thank my parents, who have always been there for me, and always will be. It is a great feeling to have people in your life who will love and support you unconditionally.

Ellen Groothuis

Management Summary

This master thesis aims to review cost control for projects more in-depth. The research is carried out at Enexis E&P; the department Engineering and Projects is responsible for carrying out large projects at medium voltage power stations, that are part of the power grid that Enexis controls.

The main reason for carrying out this research is the wish from both project managers and higher management to be able to monitor the progress of projects more closely, and to get a better grip on project costs. The department E&P currently makes use of different systems to control and monitor projects. The objective of this research is therefore to assess which preconditions there are for proper project cost control. In order to do so, control aspects are derived from literature: what is good project cost control? These aspects are reviewed: by carrying out interviews at Enexis E&P and reviewing the current processes, it is assessed which of these aspects are already in place, and for which aspects gaps remain between the desired or recommended situation, and the current situation. Based on these results, recommendations are made to improve the current project control structure: what is needed to improve the monitoring of costs, to acquire better control on project costs.

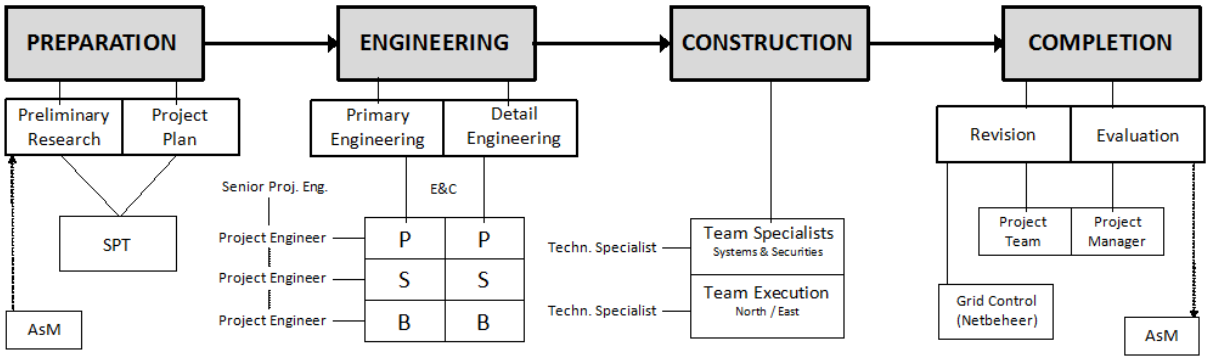
The main research question for this thesis is therefore: *Analyzing the current project control system for the department Engineering & Projects at Enexis, focusing on budgeting: what opportunities are there to improve the monitoring and control of project costs?*

In order to answer this main question, the following sub questions are defined:

- *What is the process of a project at Enexis E&P, and who are involved throughout that process?*
- *What is project management, and how can good project management be achieved according to literature, focusing on cost management?*
- *Which control aspects, that describe the conditions for proper project cost control, can be derived from theoretical concepts?*
- *Are the aspects of control, derived from literature, already in place at Enexis E&P?*
- *What features should an ideal project control system have, and what information should it provide, according to employees?*
- *What improvements can be recommended to the current processes for projects, in order to improve the monitoring and control of project costs?*

These research questions are answered throughout the report, their main findings are now described per research question.

What is the process of a project at Enexis E&P, and who are involved throughout that process?
Projects at Enexis E&P are initiated by Asset Management, the department responsible for the utility of Enexis' infrastructures, and for managing risks and problems with capacity, reliability and safety of the power grid. After a preliminary research, the project enters the *engineering phase,* in which the engineering department draws the plans for the project and orders materials. This is followed by the *construction phase,* in which the O&S department and third parties carry out the physical work at the location. In the *completion phase*, the project is revised and evaluated.
The project plan and estimates are the responsible of the Small Project Team, under authority of the project manager. The following figure gives a detailed overview of the project phases, and the persons/teams responsible for the work during that phase.



What is project management, and how can good project management be achieved according to literature, focusing on cost management?

Project management is defined as the "planning, organizing, directing and controlling of company resources for a relatively short-term objective that has been established to complete specific goals and objectives" (Kerzner, 2001). A project is defined as having the following characteristics: a specific objective or goal, a defined beginning and end, uses diverse resources, is unique, and has limited funding. An important factor of project management is the friction between the functional organization and the project organization: successful project management is dependent on coordinating and integrating activities throughout both the horizontal and vertical organization.

In order to acquire good project control, five theories on project monitoring and control are reviewed: the iron triangle, life cycle theory, the work breakdown structure (WBS), the critical path method, and earned value management (EVM). Because the focus of this thesis is on *cost* control, the iron triangle, WBS and EVM are regarded as the most useful methods for project cost monitoring and control.

- The Iron Triangle describes one of the basic concepts of project management: projects deal with competing constraints of time, cost and quality. These constraints are mutually dependent, and project managers should strive for the right balance between all three. This results in the *trade-off theory:* which constraint is considered most important? Or which constraint is fixed, making the other two less important? The theory will help, for this thesis, to look at the priorities that different actors/departments place on the constraints of a project, and on the effects that this may have on the controlling of a project.
- The Work Breakdown Structure (WBS) focuses on breaking down the work needed for projects into smaller steps, which are increasingly detailed for each lower level in the WBS. Its main advantages are dividing the project into *manageable* components, that are *measurable* in terms of progress, *controllable* due to a clear definition of the work needed and the WBS will make it easier to have an *overview* of the project as a whole. Work Packages are the most important elements of the WBS, and describe the activities of the project for the level at which the project is managed. They are preferably comparable in size and have a defined beginning and end, as well as a defined deliverable, or *milestone*. The milestone planning shows how the deliverables build towards the final objectives of the project.
- Earned Value Management (EVM) is a way of performing cost control. An important part of cost control is not only monitoring the progress of a project through costs and time, but also measure performance: how much of the work is actually done. This will ensure that correc-

tive action can be taken in time. EVM is a method for making a prognosis for the final costs of a project. Different variances can be calculated, such as the Budgeted Costs of Work Performed (BCWP), which takes into account the work performed, as well as the *work-in-progress*. In order to do so, the WBS needs to be properly in place, to be able to review the status of the work per activity or work package. Ultimately, the budget at completion and estimate at completion are used to determine the variance at completion. By doing this, EVM is considered a crude estimate, but will help to identify trends concerning the status of specific WBS elements, to answer the essential questions "where are we today?" and "where will we end up?".

Which control aspects, that describe the conditions for proper project cost control, can be derived from theoretical concepts?

Aspects of control are derived from these three main theories in order to review which preconditions need to be in place in order for project cost control to be carried out properly according to literature. The aspects are determined by looking at overlapping elements, mentioned by more than one author. For the *iron triangle,* no specific aspects are determined, for it can be used to review priorities rather than it describes aspects needed to use it. For the iron triangle, the three constraints (time – cost – quality) are presented to project personnel and management, to review which element they find most important, and on which element they are evaluated or controlled.

For WBS and EVM, more describing aspects of control are defined from reviewing literature. The aspects describe what needs to be in place in order for WBS and EVM to work properly:

WBS	EVM
1. The WBS should be structured in the same way as the work will be performed, and thus should reflect the way in which project costs and data will be summarized and reported.	1. A control system incorporates schedule, performance and costs. To control costs the actual expenditure must be compared not to its schedule, but to some measure of the value of work actually done.
2. Each element in the WBS should have an activity code, these code numbers relate the WBS to costs	2. A proper WBS structure should be in place, providing the input data to the cost control system.
3. By providing an increasing level of detail, the WBS makes sure that each major and minor activity is accounted for; each item should be clearly and completely defined.	3. Meaningful cost estimates are needed, to provide a measure against which to control costs. These estimates need to be quite detailed, and also explained in terms of work definition, the basis for the estimates and a range of possible outcomes.
4. Work packages should show a natural subdivision of cost accounts and effort planned. They must have a definable deliverable that must be generated for the task to be complete.	4. Centralized authority and control over projects are the responsibility of project management. All personnel in the project team that are responsible for incurring costs, also have to perform cost control; and project staff needs to understand the total flow of financial and cost information.
5. Work packages should be relatively short, so that little or no assessment of work-in-progress is needed. They are comparable in terms of size, with a defined duration.	5. Project teams must have regular team meetings, with a formalized agenda.
6. The amount of levels should fit the project: too many levels means too much time is spent on control, while too few levels make it hard to act timely in case of cost	6. The actual performance to date should constantly be compared to the estimated performance: is there a (large) variance? The percentage of work done, including work in progress, has to be assessed, and a forecast

	overruns		of cost at completion can be made by using the earned value and cost variance so far.
7.	Higher levels of the WBS are controlled by the project managers, and can be reused if they are standardized. Lower levels should be more project-specific, and responsibility over the work needed for those levels should be clearly assigned and communicated	7.	Periodic re-estimation of time and costs is needed: if there is a variance, it should be assessed whether corrective action needs to be taken, and when such changes are authorized.
		8.	Value should be recorded as early as possible, and all value has to be reported properly (materials and labor hours separately). Reports on project control are short, use defined criteria, and are made at defined intervals.

Results

In order to find results on whether or not these aspects of control are currently in place at Enexis E&P, interviews are carried out with project personnel. The persons interviewed include management, (assistant) project managers, (team) managers for the engineering, Asset Management, and Maintenance & Outages (O&S) departments, senior project engineers, and supporting personnel. In these interviews, questions are asked about the process of projects and the way of working, the constraints in the iron triangle and the way they are valued by personnel, and the control aspects. The aspects of control are presented in the interviews and discussed (shortly, or more in-depth, depending on the degree of involvement).

Some aspects of control cause more problems than others. From the interviews, some main results can be derived, which are described in success factors and main issues.

Conclusion and recommendations

The results are described in the report for each aspect of control. The most overall findings are now described as the conclusion.

Success factors:

- Project teams have **regular team meetings**.
- The current **project plans** describe the main phases and –deliverables of the project, and include a milestone schedule.
- The most important **milestones** are always defined in projects, and are usually met. The **planning** of projects is going well.
- The current WBS shows a **natural subdivision** of the work that needs to be done. Although it does not go into detail for all activities, the main structure follows the way the work is performed.

Main Issues:

- The control system is **not incorporated.** Planning, costs, and work finished are assessed separately and compared to get an idea on the status of projects. It would be better if there is one overview of booked costs, working hours, planning and schedule. The tools to have such an overview are currently not in place, although the budget reporting tool that project management is starting to work with is a good start. There is a wish for more functions (to build

projects, and assign activities) in the current SAP system, and more knowledge and training on how to use them.

- The activities in projects are **not properly defined**, and the complete **structure of projects is not clear**, or poorly communicated. The steps in the current WBS are too large to make the work properly manageable, and activities are under-defined in terms of what they entail, and which budgets and activity codes are used. There is no uniform way of structuring projects. Well-defined activities are needed, not only to be the input for the incorporated control system discussed before, but also to be able to apply Earned Value Management and variance analyses, as well as planning methods. Detailing of the work is however hard to do up front, when a lot of information on the project is still unknown.
- **Responsibilities** over activities (and their costs) need to be defined more properly; project managers are held responsible for all costs of a project, while they cannot control all costs. Especially the role of the project engineer and the Small Project Team are currently not properly formalized.
- **Estimates** need to be more uniform and formalized. It is not always clear where the estimates are based on, and it is hard to assess how effective they are in hindsight. Also, people estimating the costs of work needed on a project are not always the ones held accountable for those costs. Estimates are currently custom-made for each project, but this makes them hard to compare to each other, while they take up a lot of time and resources. A more standard VoCa would be better, but then the margin of error for the ultimate costs need to be broader, for it is now unrealistic.
- **Value needs to be recorded properly**. It is not always clear which costs should be booked to which activity codes, or costs are booked too late. The deliverables of a project are therefore not always measurable at this point. There is also no appraisal of costs per category, making it hard to make comparisons among projects, or to know if work was done efficiently.
- There is friction between the **functional organization and project organization.** Evaluation of project personnel is done by the team managers for the departments working on a project, and working hours booked on projects are only approved by team managers, not project managers.

It is derived from these issues, that the main problems concern the lack of a formal project structure and activities, undetermined responsibility over the activities and over the estimates, and a non-integrated project control system, that is not always used properly either. These issues lead to other problems as well: the lack of defined criteria for the project activities and estimates also makes it hard to compare projects to each other, and therefore hard to establish whether the project was efficient, and to establish 'lessons learned' for future projects. Also, to be able to carry out project control methods like defining work in progress, and with it Earned Value management or variance analyses, it is essential that these problems are resolved first.

Transport South

This research is carried out at E&P with Transport North, located in Zwolle. However, there is also an E&P department at Transport South. Since management also strives after a more uniform way of working, and since E&P South deals with the same kind of problems concerning project control, a short evaluation of this department was also included in the research. This department has held a brainstorm session to tackle the problems concerning forecasting, and making their prognoses more

reliable. The most important outcomes of the session were decisions to have budget holders for each discipline, who are held accountable for the budget of their part of the project, describing the project process more clearly including roles and responsibilities, and making everyone in the organization aware of the importance of the finance of projects. Also, risks need to be taken into account in the VoCa, and in the long term, the SAP-system should become more user-friendly and also incorporate the budget (VoCa) of projects.

Recommendations

The following recommendations are done to solve the current problems concerning project cost control:

- **The process of projects needs to be formalized more in-depth.**
- **Start using a formalized, standard WBS for all projects (the project manager is responsible for designing this WBS) –** Each item in the WBS should be clearly and completely described
- **The upper three levels of the WBS should be controlled by the project manager, work packages should be filled out by the person delegated to the respective lower level work element –** The project manager should provide technical direction *through* the line managers
- **Activities should have defined cost account numbers**
- **Perfect the current budget reporting tool –** Meeting with Transport South to look at which information the ideal, combined control tool should provide.
- **VoCa's (estimates) need to be more standardized and uniform –** the current error margin of 5-10 % is unrealistic.
- **The role of project engineers needs to be clearly defined –** Project engineers need to have the tools to be able to monitor and control their budget
- **The role of the Small Project Team needs to be reviewed –** The SPT may play a larger role in evaluating a project, and project personnel.
- **Value needs to be recorded properly:**
    - Who is allowed to book costs (should be prescribed in the WBS elements)
    - To which activity codes should costs be booked
    - Working hours need to be filled out in time.
    - Materials and hours spent should be recorded and monitored separately.

Table of contents

Preface 8
Management Summary 9
Table of contents 10
SECTION I – INTRODUCTION 14
1. Introduction and Research Plan 14
1.1. Enexis: Company Profile 14
1.1.1. Company History 14
1.1.2. The market in which Enexis operates 14
1.1.3. Organizational Structure 15
1.1.1. The department E&P 16
1.1.2. Project 18
1.2. Problem description 20
1.2.1. Cause 20
1.2.2. Practical problem description 20
1.2.3. Main Research Question 21
1.3. Objectives 21
1.3.1. Research Questions 21
1.4. Plan of Approach 22
1.4.1. Research Methods 22
1.4.2. Scope 25
1.4.3. Outline of the report 26
SECTION II – THEORETICAL FRAMEWORK 27
2. Process of a Project at Enexis E&P 27
2.1. Project phases 27
2.1.1. Preparing phase 27
2.1.2. Engineering phase 29
2.1.3. Construction Phase 30
2.1.4. Completion phase: revision and evaluation 30

2.2. Project teams 31
2.2.1. SPT and Project Team 31
2.3. Project phases & personnel 32
3. Literature Review 33
3.1. Project: 33
3.2. Project Management: 34
3.3. Different theories on Project Control 34
3.3.1. Iron Triangle 35
3.3.2. Life Cycle Theory 36
3.3.3. Work Breakdown Structure 37
3.3.4. Critical Path Method (CPM) and PERT 40
3.3.5. Cost Control: the Earned Value method. 40
3.4. Three main theories 43
4. Aspects of Control 44
4.1 Iron Triangle trade-off aspects 44
4.2 WBS aspects 44
4.3. Aspects for the Earned Value method. 47
4.4. An overview of the Control Aspects 50
SECTION III - RESULTS 51
5. Results: The control aspects for Enexis E&P 51
5.1. Iron Triangle 51
5.1.1. Asset Management 51
5.1.2. Project Management 52
5.1.3. Engineering 53
5.1.4. O&S (Construction) 53
5.1.5. Conclusion 54
5.2. WBS 54
5.2.1. WBS: Results per control aspect 55
5.2.2. WBS: Main Issues 58
5.3. EVM 58
5.3.1. Results per control aspect for Enexis E&P 59
5.3.2. EVM: Main Issues 61
5.3.3. Wishes of Project Personnel 61

5.4. Successes 63
5.5. Main Issues: overall 63
6. Analyzing the Results 65
6.1. E&P Transport South 65
6.2. Discussion 68
6.2.1. Incorporating system 68
6.2.2. Project structure 69
6.2.3. Responsibility and Accountability 71
6.2.4. Estimating 72
6.2.5. Recording value 74
6.2.6. Project organization vs. Functional organization 76
7. Conclusion & Recommendations 78
7.1. Research Question 78
7.2. Recommendations 81
Formalization 81
WBS 81
An integrating system 82
Estimating 83
Responsibility: 83
Recording Value 84
Forecasting 84
7.3. Recommendations concluded 84
7.4. Strengths and limitations 86
7.5. Further Research 86
References 88
APPENDICES 92
APPENDIX I: Glossary 92
APPENDIX II: Shareholders of Enexis NV 94
APPENDIX III: High Voltage power stations for Transport Noord. 95
APPENDIX IV: Variance Analysis for the EVM 96
APPENDIX V: Aspects of the WBS 98
APPENDIX VI: Aspects of control for EVM 100
APPENDIX VII: Interview Slides 102

APPENDIX VIII: Results: control aspects at Enexis E&P 104
VI.I. WBS 104
VI.II. Earned Value – Cost Control 111

SECTION I – INTRODUCTION

1. Introduction and Research Plan

The aim of this chapter is to introduce the subject of this thesis, and define the goals of this research. This chapter starts with an introduction of Enexis and the department E&P, in order to understand the outline of the organization and the settings important to fully comprehend the problem definition. Following the background information, the problem description will help to define the research questions and objectives. Next, the plan of approach for this thesis is described.

1.1. Enexis: Company Profile

Enexis is a Dutch grid operator, which manages the energy grid in (parts of) the North, East and South of the Netherlands. The company is responsible for transporting gas and electricity from energy supplying companies to the end user. Enexis is therefore responsible for the construction, maintenance and control of its transportation and distribution grid for gas and electricity, in order to minimize outages. All together, the organization brings gas and electricity to about 2.6 million customers each day. For electricity, Enexis manages the power grid in (large parts of) the provinces Groningen, Drenthe, Overijssel, Noord-Brabant and Limburg, as well as the city Leeuwarden in Friesland.

1.1.1. Company History

Enexis as an organization originated from the merging of several municipal public utility companies into Essent, an integrated energy company. In 2006, the Wet Onafhankelijk Netbeheer (WON, "Law Independent Grid Operating") was initiated. This law put integrated energy companies under the obligation to split their activities into three separate parts for production, transmission and distribution, in order to guarantee the independence of the gas- and power grid in the Netherlands. All transmission activities became under control of TenneT, the company which is responsible for the high voltage electricity grid in the whole country. Essent had to split off their network company Essent Netwerk. Starting January 2009, this organization started operating independently as Enexis.

1.1.2. The market in which Enexis operates

In the electricity market in the Netherlands, the grid operator (netbeheerder) is responsible, as a utility company, for the physical transport of electricity. In the Netherlands, he is a *monopolist* for his region, and is ordered to apply a tariff which is set by the government. The tariff is revised each three years to make sure it is still enough to ensure continuity in the power supply. So the price is regulated, and therefore Enexis has limitations on the amount of money they can spend. If they reach their targets as a company, for example keep a limited amount of outages, Enexis can be rewarded by the Chamber of Energy by being allowed to ask a higher price from its customers. Last year, Enexis was allowed to raise their price by ten percent, but decided not to do so, for Enexis aspires to raise their prices with no more than the inflation rate.

The **Chamber of Energy** (Energiekamer) is part of the Nederlandse Mededingingsautoriteit (Dutch competitor authority). The Chamber of Energy is responsible for the supervision of the compliance of the 'Elektriciteitswet 1998' (the law for electricity), and acts by order of the Ministry of Economics.

Since 2009, the overall covering organization Enexis Holding NV is a public limited company. Its shares are owned by Dutch provinces and municipalities. An overview of the shareholders and their percentage in shares can be found in Appendix II.

1.1.3. Organizational Structure

Enexis BV (owned by Enexis Holding NV) as the main organization is subdivided into three main departments, which describe the company's *core activities:*

- **Asset Management (AsM):** AsM focuses on realizing and maintaining the company's cable and piping infrastructure. This department is responsible for developing effective policy and control, which aims to reach all targets at the lowest costs possible. AsM decides which infrastructure projects are necessary.
- **Infra Services (IS):** IS is the executing division of Enexis. This department takes care of effectively and efficiently carrying out the decisions made by AsM, and realizes the work.
- **Customer Relations (KR, KlantRelaties):** KR provides for contact with customers of Enexis, and is responsible for meter inspection, invoicing, settling complaints, rate-fixing based on regulation by the Chamber of Energy (Energiekantoor), and connections/terminations.

These three divisions are supported by staff departments (like HR, Facilities, Finance, et cetera).

Asset Management

'Asset Management' is not only the name of a department for Enexis. The term Asset Management is also used for an organizational structure typically used in capital-intensive organizations: there is a distinction between the roles (and sometimes departments) **asset owner**, **asset manager** and **service provider** (de Croon, 2011). Enexis also uses this structure. The *asset owner* is responsible for giving the long term vision for the organization. They decide the goals that are achieved by using the assets, and make the proper (financial) resources available. The *asset manager* is responsible for developing the policy under which the goals set by the asset owner can be achieved, and for adequately outsourcing the work to the service provider. The *service provider* is responsible for effectively and efficiently carrying out the measures that are developed by the asset manager, and agreed upon by the asset owner (v/d Steeg, Enexis, 2010).

Within Enexis, the role of asset owner belongs to upper management, the role of asset manager to the AsM department, and the role of service provider to the Infra Services department (to which Transport North, and subsequently E&P belong). The most important reason for subdividing these roles is to be able to realize optimal efficiency and effectiveness: by separating the formulating of the policy and the execution of that policy, it can be prevented that departments will generate their 'own work', or adapt their goals to the actual developments (v/d Steeg, Enexis, 2010).

Infra Services

Up to now, the organizational structure of the department IS at Enexis looked as follows:

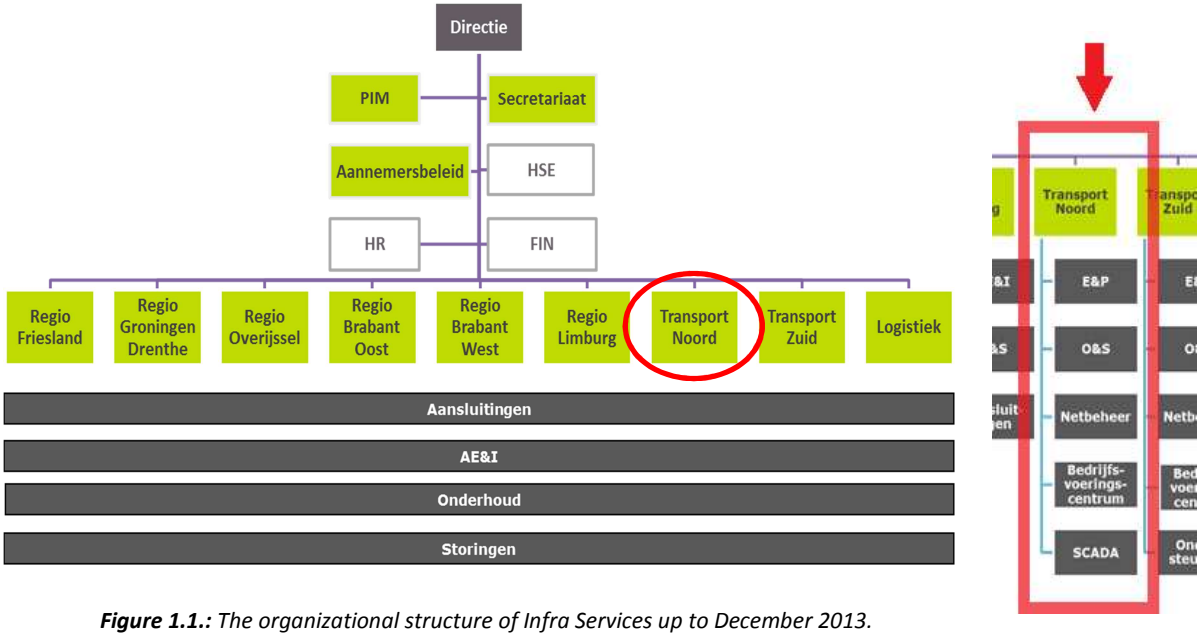


Figure 1.1.: *The organizational structure of Infra Services up to December 2013.*

In the organizational structure at Enexis, there are nine different locations throughout the Netherlands: six regional offices (Friesland, Groningen-Drenthe, Overijssel, Brabant Oost, Brabant West, Limburg), two locations for Transport (North and South) and one Logistics department.

Transport North (TP-N) is located in Zwolle, and is responsible for realizing and controlling the infrastructure in the main power stations, the operational conduct of business for the medium voltage power grid, and the responsibility of the operational installation for the complete infrastructure. The focus of the Transport department is on activities that require specific knowledge and which cross regional borders. The department is subdivided into five business departments: Engineering & Projects (E&P), Maintenance & Outages (O&S, Onderhoud & Storingen), Grid Control (Netbeheer), Business Conduct Center (BVC, Bedrijfsvoeringscentrum), and SCADA (Supervisory Control and Data Acquisition).

1.1.1. The department E&P

The department E&P is responsible for new construction, replacement, and maintenance projects for business resources in the main HS/MS (high voltage/medium voltage) power stations of Enexis. The department E&P with Transport North is responsible for the project management and engineering of existing and new connections to the Enexis North network. The large projects carried out by the department, take place at the high voltage transformer stations in control of Transport North. Appendix III shows a map of these stations. There is a team of project managers and assistant (junior) project managers, and a team of engineers and consultants, who together form E&P. Figure 1.2 shows the structure of the department, as well as the three different disciplines within the Engineering & Consultants group.

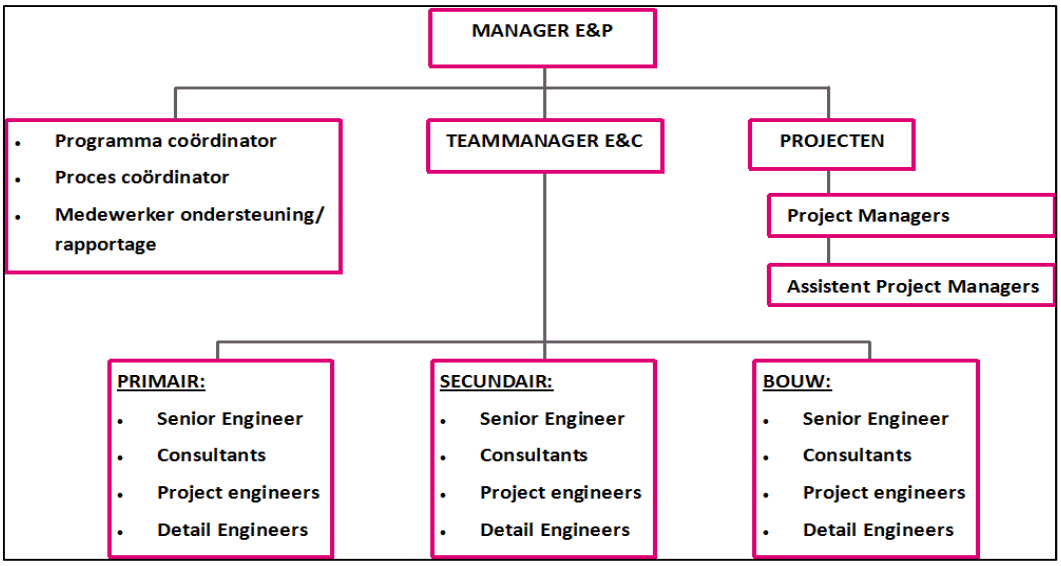


Fig 1.2.: *The organizational structure of the E&P department.*

Impact of the Reorganization

This research started at the department E&P with Transport North, which is the department that is responsible for carrying out projects. However, during the research, a reorganization has taken place. The organizational structure has changed significantly as of December 2013. Instead of the 9 departments that currently exist for IS, a new organizational structure will be set up, dividing IS into six new departments: Processes, Projects and Information Management, Production North, Production South, EBS, and Logistics. The regional offices will now become sub departments of Production North and South, and Processes is an entirely new department. In addition, each department will be supported by a Workforce Management division and a RAK (Reporting, Analyzing and Quality) division.

Most significant for this report, is that the current division Transport (North and South) is renamed into EBS, which stands for Expertise, Business Conduct and Stations (expertise, bedrijfsvoering en stations). The layout of this new department is as follows:

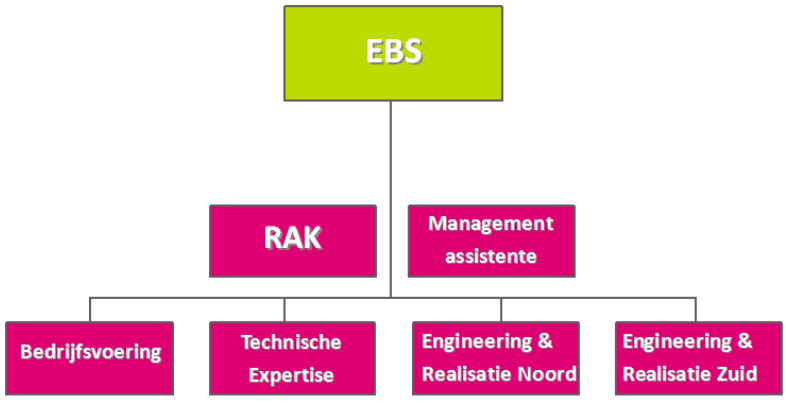


Figure 1.3.: *The new EBS department*

So, instead of two departments for Transport (North and South), the one department EBS will now be subdivided into two E&R locations: North and South. These departments include the former departments E&P as well as O&S, but the structure will be very different from before:

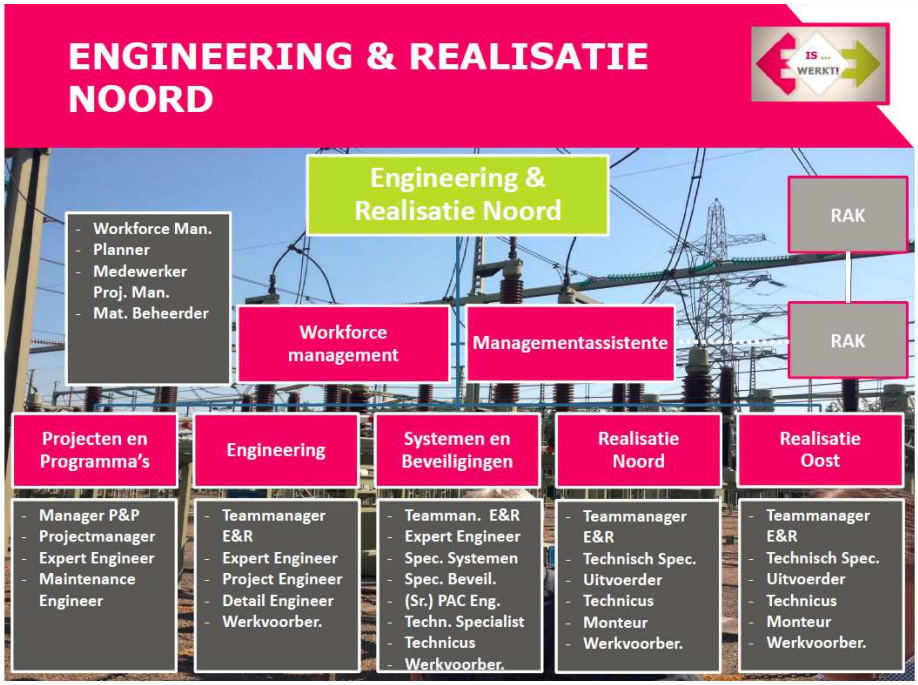


Figure 1.4.: *The new E&R department*

The department E&P will seize to exist, and projects will now be carried out by the department Projects & Programs (P&P). This department will include the project managers, the expert engineers (which are the former consultants of the engineering group), and maintenance engineers (engineers for the current department O&S). Engineering will become a separate team. The three teams for O&S (two executing teams, one team Systems and Securities) will remain largely the same.

As a logical consequence, this reorganization will have a big impact in the way of working at the department. However, for the process surrounding projects it is impossible to say at this point which implications it will have. At the time of the research, the process of working was still according to the 'old' organizational structure, which is why this report is based on the department Transport and its sub department E&P. The reorganization with its new departments will be mentioned in giving recommendations for the future, using the current knowledge on how it may affect the way of working.

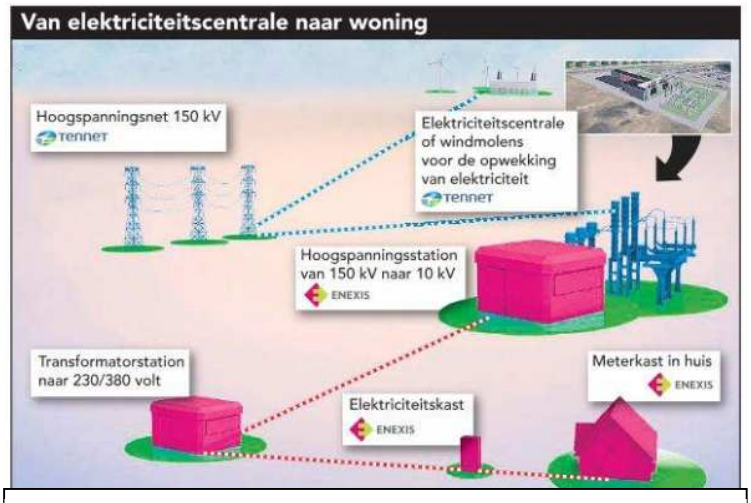


Figure 1.5.: *The "hoogspanningsstation" (High Voltage station) in this figure is where the projects are carried out.*

1.1.2. Project

The high voltage transformer stations in the utility area of Enexis (as can be seen in Appendix III) are partly in control of Enexis (transforming from high to medium voltage, in order to reach the end user) and partly in control of TenneT, the only national operator of the high voltage electricity grid in the Netherlands. In simple terms: all com-

ponents up to the HS/MS station are in control of TenneT, and from there on (including most of the station itself) all components up to the end user are in control of Enexis. The most important electrical components at such a station are the transformer between the high- and medium voltage grid (the HS/MS-transformator), the medium voltage switch installation (MS-schakelinstallatie), and the connection between these two components, the transformer connection.

One of the main tasks of the division Asset Management (AsM) is to review these crucial stations and their components by drawing up KCD's: Kwaliteits- en Capaciteitsdocument, or Quality and Capacity Documents, in which the bottlenecks in the current power grid are reviewed. The required transport capacity is constantly influenced by economic, societal and technological developments. If the economy is growing, the demand for electricity is growing as well, but another example that influences the capacity demanded may be an increasing amount of energy generated through windmills and solar cells. The expected changes in future capacity are translated into projects and described in the planning for the coming year: the JOB, or Year Order Book.

The projects carried out by the department E&P can be projects in one of five different work flows: net extensions, net improvements, replacement investments, custom made connections and reconstructions. The size of the JOB for 2013 for Transport North was 20.5 million euros. The table shows how this money was distributed over the five work flows in 2013.

Work Flow	Amount
Custom Made Connections	€ 341.500
Net Extensions	€ 1.796.500
Net Improvements	€ 12.558.200
Replacements	€ 5.851.400
Reconstructions	€ 0
Total	**€ 20.547.600**

The workflows custom-made connections, net extensions and reconstructions can be determined customer-driven activities; Enexis does not have an influence on these activities, their volume is hard to predict and may fluctuate notably from one year to another. Enexis can only influence the activities that they initiate themselves, like replacements and maintenance. The KCD's and JOB are therefore flexible regarding the amount of replacement activities. Replacements can be postponed, to still be executed if there is little customer-driven work. The current recession has halted the growing demand for electricity, which is why the department E&P currently focuses a lot on improvements and replacements for their power stations.

1.2. Problem description

In this section, the reason for carrying out this research will be explained, followed by the practical problem description. This results in the main research question, which describes the main problem.

1.2.1. Cause

In order to monitor the projects carried out by the department E&P, Enexis makes use of different systems to control the projects and its processes. This makes it hard for the responsible project managers and overall management to assess the progress of projects (in both time and money). The division IS is also looking for more uniformity within the organization; making it important to look for a more efficient and clear way of monitoring their large projects.

1.2.2. Practical problem description

The department E&P is using separate systems in order to monitor the financial and logistic progress of projects. In the future, the want for a more integrated system should be fulfilled, in order to monitor and report faster, more accurate and more efficiently. But what is good project monitoring and control? Which preconditions should such a system satisfy, and to what extent are vital features of project control already existent in the current situation?

The aim of this thesis is to address those questions. In project control, there are three important constraints on a project: time, cost, and quality (or scope). At Enexis, cost awareness is becoming more and more important. However, projects are still prone to go over budget, and it is not always clear to the project managers and overall managers why there is a deviation from budget. According to Oberlender (2000) "…a project manager must develop an integrated cost/schedule/work system which provides meaningful feedback *during* the project rather than *afterwards*". This is one of the main problems with the current project control system at Enexis E&P: project managers are not always able determine the current status of a project, making it hard to act accordingly. It should be possible to monitor and control projects more efficiently, instead of merely evaluating projects in hindsight.

The project managers have an error margin of ten percent for the estimates they make for their projects (or five percent for larger projects). For a large project, with a corresponding large budget, the total amount of variance can be substantial. Also, while the deviation margin for individual projects is ten percent, the overall margin for the *sum* of the projects for the department, reported through the year order book, is only one percent. So overall, there is a wish to get a better grip on the costs of projects: from management, as well as the project managers and project personnel.

Since projects are prone to go over budget, and management wants to focus more on cost awareness, the focus of this report will be on *cost control.* However, it will become apparent from literature review that cost control has a strong relationship with planning (time) and work to be done (scope). For the sake of good and complete control, taking them into account is inevitable. However, all theories handled focus first and foremost on monitoring and controlling project *costs*.

1.2.3. Main Research Question

The problem description has led to the following main research question:

Analyzing the current project control system for the department Engineering & Projects at Enexis, focusing on budgeting: what opportunities are there to improve the monitoring and control of project costs?

In order to answer this question, the current situation has to be reviewed, and compared to recommendations that are taken from important literature on project management.

1.3. Objectives

The key objectives of this thesis can be summarized into the following points:

- Describe the current process for carrying out a project at Enexis E&P.
- Find out how project costs should be monitored and controlled, according to literature on project management.
- Define control aspects, deducted from the most important concepts found in literature on project control: what preconditions should a proper project cost control system meet?
- Describe if and how these aspects are currently in place at Enexis E&P.
- Make an analysis of the current way of monitoring and controlling project costs: which aspects are missing?
- Analyze the opportunities that are still un- or underexploited in the current project control system: is there room for improvement?
- Give recommendations for a better control of project costs in the future.

Ultimately, this thesis leads to a clear overview of control aspects that are needed according to literature, and an observation of whether or not these aspects are already in place. The gaps between the current situation and the wished/recommended situation are described, followed by recommendations on how to 'fill' those gaps.

1.3.1. Research Questions

In order to reach these objectives, and to be able to answer the main research question, the following sub questions have been defined:

- *What is the process of a project at Enexis E&P, and who are involved throughout that process?*
- *What is project management, and how can good project management be achieved according to literature, focusing on cost management?*
- *Which control aspects, that describe the conditions for proper project cost control, can be derived from theoretical concepts?*
- *Are the aspects of control, derived from literature, already in place at Enexis E&P?*
- *What improvements can be recommended to the current processes for projects, in order to improve the monitoring and control of project costs?*

1.4. Plan of Approach

The plan of approach will explain how the research questions will be answered, in order to ultimately draw conclusions about the main problem definition. Also, the outline of the report will be reviewed: which steps are taken to reach the final conclusion.

The research questions, described in section 1.3.1., are answered by using the following methods:

1. **What is the process of a project at Enexis E&P, and who are involved throughout that process?**
    - Preliminary conversations with employees involved in the process of projects
    - Read internal documents for the E&P department: project plans, process reports, calculations.
    - Attending project management meetings
2. **What is project management, and how can good project management be achieved according to literature, focusing on cost management?**
    - Literature review
3. **Which control aspects, that describe the conditions for proper project cost control, can be derived from theoretical concepts?**
    - Literature Review: which are the most important concepts, and which aspects of control are mentioned as important (by multiple authors) for these concepts
4. **Are the aspects of control, derived from literature, already in place at Enexis E&P?**
    - Interviews
    - Visiting Transport South: comparing the results found on aspects of control for Transport North, to the situation at the same department in the South.
5. **What improvements can be recommended to the current processes for projects, in order to improve the monitoring and control of project costs?**
    - Recommendations are based on the conclusions drawn from the interviews

1.4.1. Research Methods

This research is based on qualitative research methods. According to Babbie (2007), a qualitative analysis entails “the non-numerical examination and interpretation of observations, for the purpose of discovering underlying meanings and patterns of relationships”. Rather than using statistics to describe a larger population, this research aims to draw conclusions from in-depth interviews. These interviews are based on theories derived from literature. The process of carrying out the complete research is described in the following section.

Theoretical Framework

Section II, the theoretical framework, consists of a description of the *project process*, based on preliminary conversations with employees, in order to assess the process of projects carried out by the E&P department, and of a *literature review* defining the main concepts on which this report will focus. Ultimately, the theoretical framework is used to derive aspects of control that can be examined more in-depth.

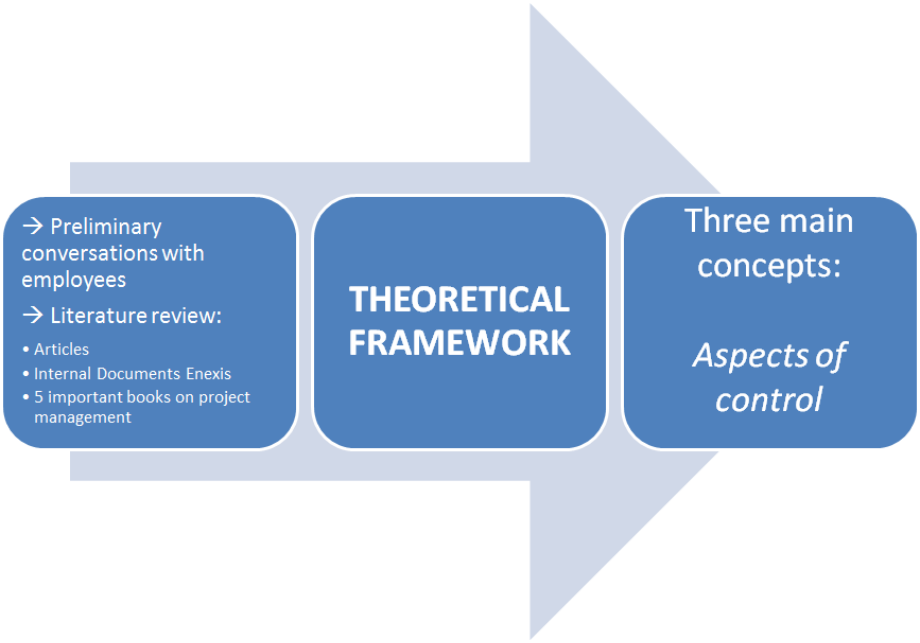


Figure 1.6.: *The theoretical framework is based on preliminary conversations and the literature review. The theoretical framework ultimately leads to defined aspects of control for three main concepts.*

Literature review

A literature study is used, in order to set up the theoretical framework on which this research is based. More specifically, the literature review is performed in order to answer research questions 2 and 3. Figure 1.6 shows which literature is reviewed.

A starting point is made by reviewing many different articles, focusing on project control and project management. From these articles, five important theories on project management are described that are mentioned by different authors. At the same time, definitions of projects and project management are derived from literature, and internal documents at Enexis E&P are reviewed, in order to be able to understand the projects carried out by E&P, and describing its project phases and process.

From the five theories, or concepts, mentioned in the articles, those concepts specifically important for *cost control* are chosen to review more in-depth. Ultimately, these theories will lead to aspects of control: important aspects that need to be in place, in order to use the concepts mentioned for proper project monitoring and control.

Interviews

In order to collect the results for this research, interviews are carried out.

Introductory interviews

In the starting phase of this research, introductory interviews or conversations have been carried out for orientation. These conversations are carried out with different persons within the E&P organization: the manager of the overall Transport North department, the manager with E&P, the team manager for the engineers, the planner for E&P, the program coordinator, and two persons (a project- and program manager) with the Asset Management department. These conversations were used to gain more understanding about the process concerning projects at Enexis E&P. The project managers are not interviewed at this beginning stage with a reason: to avoid bias, or make sure that not only

those concepts are included that project managers view as most important or problematic. By doing this, the research has started with a more unattached starting point.

Semi-structured interviews

To gather results, more in-depth interviews are carried out with those involved in projects. The most important focus group for these interviews was the project managers, since they are the ones first and foremost responsible for monitoring and controlling projects. Besides them, members of the Small Project Teams (experts in their discipline) have been interviewed, and team managers for departments included in the execution of projects. The total group that is interviewed:

- 4 project managers
- 3 assistant (or junior) project managers
- The team manager for the Engineering & Consultants
- 2 senior project engineers
- The program coordinator for E&P
- 2 team managers for the O&S department
- 2 managers for the Asset Management department
- 1 controller for the Finance department

The interviews carried out were semi-structured, or 'qualitative interviews' (Babbie, 2007). In this form of interviewing the interviewer "has a general plan of inquiry, including the topics to be covered, but not a set of questions that must be asked with particular words and in a particular order" (Babbie, 2007, p. 306). In this case, the interviews (or conversations) were semi-structured in the sense that there were open questions based on the aspects derived from the literature. The control aspects have been presented in the interviews by some PowerPoint slides presenting the most important aspects as a guideline, to make sure that all relevant subjects are discussed. An overview of these interview slides can be found in Appendix V.

The interviews started with some general and open questions about the way of working, and about the process of projects and project teams. The finishing questions were questions like "do you feel that you completely control a project with the way you work?" or "what would make your work easier?". The aspects of control functioned as a main thread for the interviews, leaving room for further questions and explanations. This approach was used most strictly for the project managers in covering all aspects. For other functions or disciplines concerning projects, some aspects are left out of consideration, or discussed more in-depth, to focus more on those elements relevant to their field of work. All interviews are audio-taped and transcribed.

Transport South

This research is carried out for the E&P department for Transport North. The same department exists for Transport South, carrying out the same type of projects in the Enexis' field of activity in the South of the Netherlands. In broad lines, they deal with the same problems concerning the monitoring and control of costs. Therefore, it was decided that it is useful to review this department shortly as well, also since the new division Enexis EBS strives for more uniformity.

At Transport South, they have started tackling the same type of issues by having a brainstorm session focusing on improvements for the reliability and quality of financial prognoses. The documents re-

sulting from this session are reviewed and compared to the situation in Zwolle. In order to gather more information on the way of working in Transport South, and further explanation on the problems they run into, an in-depth interview is held with one of their project managers closely involved in the improvement process.

1.4.2. Scope

This research focuses on the *managing* of the overall projects at E&P. Since the main goal is to achieve better project cost control, project management is the main focus of this report. Interviews with all disciplines (engineering, execution, management, finance) are needed to assess the overall conduct of work, and the complete process. The conclusions made in this report focus on *project management,* but the process of managing projects has implications for the entire project team, for they are all included in carrying out projects.

Based on the first exploratory talks with persons (higher management and team managers) involved with project control at Enexis E&P, the scope for this thesis was defined. In all these interviews, the SAP system, which is the ERP (Enterprise Resource Planning) system for the entire Enexis organization, was mentioned as an important factor concerning the problems with project control. However, in agreement with supervisors and considering the complexity of this software system, as well as my own limited knowledge on ERP systems, it was decided that the research should not focus merely on the software system in use. Rather, this research looks at what preconditions *any* control system needs to satisfy for proper project cost control.

Also, the focus on *cost control* is an important restriction to this research. As stated before in the problem description, costs are indissoluble related to time and quality (scope) in project management. The chosen literature focuses a lot on integrating project information for complete project control. Since costs are so dependent on the other factors concerning a project, it is impossible to focus solely on costs, but the concepts chosen to verify the results are those most significant for monitoring and controlling costs.

Finally, the qualification of Enexis as having a monopolist has some implications for the scope. Since there are not many organizations carrying out the same activities, there is only a small frame of reference, making it hard to compare the efficiency of the work carried out by E&P. It is one of the goals of the new organization (starting December 2013) to create a more *uniform* organization, and as part of this wish for comparison, they are carrying out a benchmark between projects done by Transport North and South. The wish for more uniformity is the main reason that this research included a visit to Transport South, to briefly review and compare their situation to the results obtained at Transport North.

1.4.3. Outline of the report

The outline of this report looks as follows:

Now that the situation of Enexis is described, and the main research objective is explained, the next chapters will describe how these objectives are reached.

- Chapter 2 describes the process of a project at Enexis E&P: which project phases are there, and who is involved.
- Chapter 3 covers the literature review, in which different methods for cost control are described and explained. Three main theories are chosen, from which control aspects will be defined.
- Chapter 4 defines the aspects of control, deducted from literature on the main theories. These aspects of control describe the preconditions that are needed to be able to use the methods described in Chapter 3. The results are based on these control aspects.
- Chapter 5 describes the results that are based on the interviews that are carried out. The results are described per control aspect.
- Chapter 6 discusses the results: the main issues are reviewed more in-depth, including possible solutions and examples. The recommendations are based on this discussion.
- Chapter 7 describes the overall conclusion of the thesis. It is followed by recommendations that can be done for Enexis E&P, showing opportunities for improving the current situation. It is followed by a section reflecting on the report, describing the strengths and limitations of the research, and stating possibilities for future research.

SECTION II – THEORETICAL FRAMEWORK

2. Process of a Project at Enexis E&P

In this chapter, the process of how a project is carried out at the E&P department is described. The process model as described by Enexis is shown in Figure 2.1, paragraph 2.1. The phases described in this model are explained, including who is responsible for those phases. The project personnel will be further described in paragraph 2.2, explaining the project team and the Small Project Team used for projects, including the responsibilities of all involved.

Question

The goal of this chapter is to answer the question: *What is the process of a project at Enexis E&P, and who are involved throughout that process?*

The information in this chapter is deducted from the interviews with all persons involved throughout the process.

2.1. Project phases

In this paragraph, the project phases that are also shown in the process figure 2.1 are described. A subdivision is made between the preparing, engineering, construction and completion phase.

2.1.1. Preparing phase

Initiation

As shown in the flow chart, Asset Management (AsM) is the initiator (or internal customer) of a project. It is the department that is in charge of the utility of Enexis' infrastructures, and manages risks and problems with capacity, reliability and safety of the power grid.

Research on the capacity of the power grid is done by the SCADA department, who determines critical points in the grid (like a transformer cable in need of replacement). This capacity defines the projects: which (parts of a) station(s) are in need of extension or replacement. A request by AsM is sent to E&P asking for a solution. This is usually a short text, two or three lines, describing the problem and usually some direction for the desired solution.

Preliminary Research

Sometimes, E&P needs to start the project with a preliminary research, if there are still many unknowns. When completed, the report of the research is delivered to AsM. The report will contain the cause of, and solution to the problem. However, such an in-depth research is not needed for most of the projects, for AsM usually has a plan how to handle the project already. The solution for the problem, and the work that needs to be carried out is therefore reviewed, and described in a project plan.

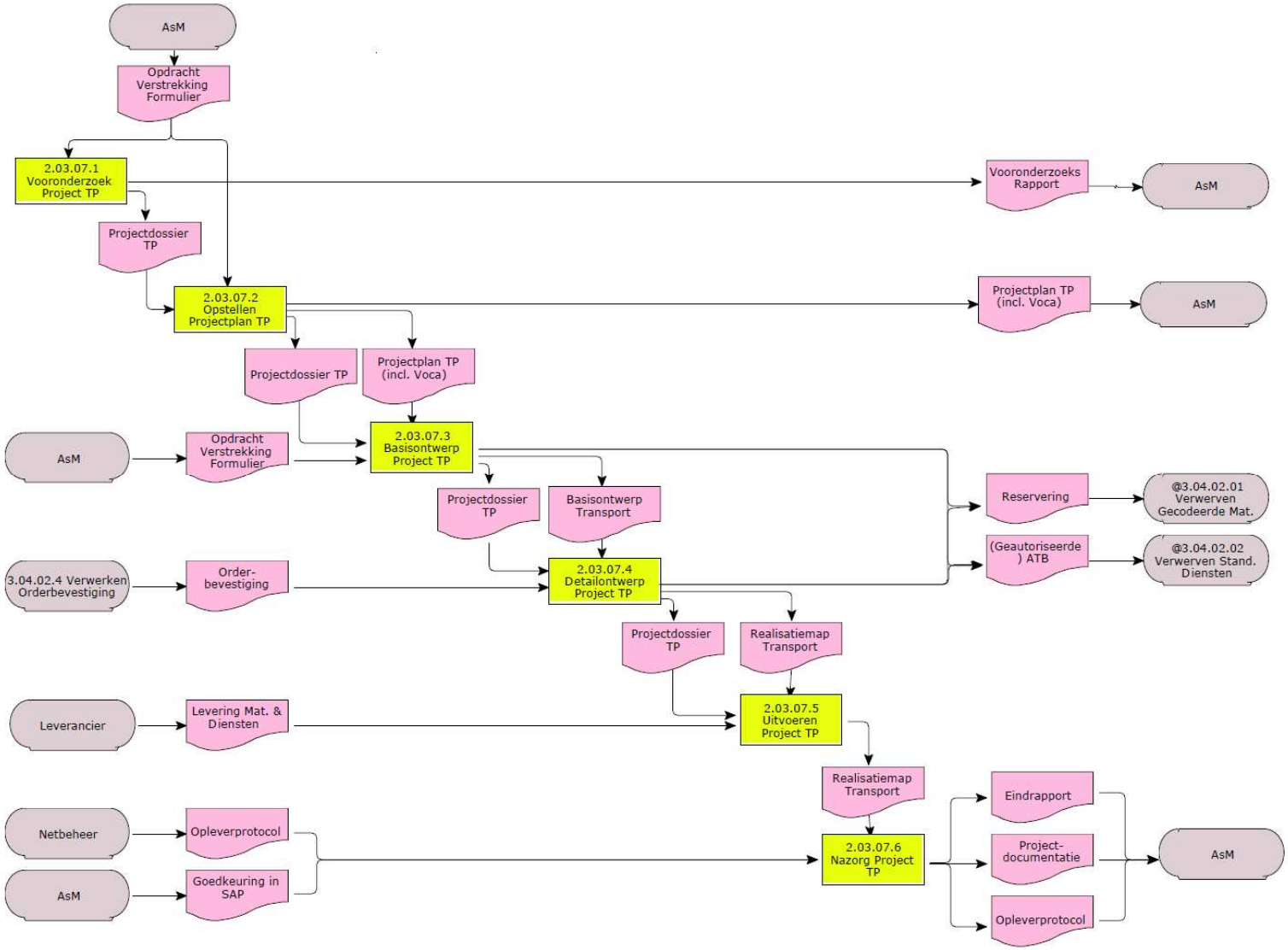


Figure 2.1: *Business Process Report "Realizing Infrastructures Transport" (Source: Enexis, 2013)*

The project plan and review of the work to be done is the task of the Small Project Team, SPT. This is a team of experts from the different disciplines that have a lot of experience which can help to assess the work needed. The goal of the SPT is to translate the assignment by AsM into a realistic plan, with attached to that plan an estimate of the costs: called a VoCa (voorcalculatie, 'pre-estimate'). Who writes the project plan depends on the project manager: some of them write it themselves, others leave it to the disciplines, who write their part of the plan. The project plan describes the work that is needed. Next, the SPT delegates the plan to their departments: the persons that will work on the project are asked to draw up their part of the VoCa (for their discipline), including working hours needed. These parts are delivered to and approved by the SPT members. The project manager then bundles these smaller parts to one overall VoCa.

The project plan and VoCa are delivered to AsM. When they are approved, the project manager needs to draw up the project planning. He will request capacity for the project, because he knows from the VoCa how many hours are needed per discipline.

Next, a kick-off meeting is planned with the project team, which will start the work on the project. The project team is made up of the persons assigned to the project from the request for capacity.

2.1.2. Engineering phase

So, the engineering phase starts with the kick-off meeting. In this meeting the project team members are taken on board, and are showed the project plan, goals and schedule. The kick-off meeting is planned to transfer the project from SPT to the project team, which includes the engineers and executers doing the work. If there are any questions by project team members, the experts can explain and address them immediately.

In the engineering phase, the drawings for all the work that needs to be done are made. At the same time, components needed for the project are ordered by the engineers.

Basic design vs. detailed design

For engineering, there are three different disciplines: *primary, secondary,* and *construction* (see Figure 1.2). The basic (primary) design is focused on the main components, the smaller components are built around it. In the basic design, the changes for the building and its drawings is done by construction engineers, the primary installations (transformers, MS-installation, cables) are described by the primary engineers. The secondary engineers describe what is needed to control and secure the primary installation.

When the basic design is finished, the project needs to be detailed out further: every wire, clamp and other precision parts need to be drawn out in detail. This is done by the detail engineers, also subdivided for each discipline (although detail engineering mainly entails secondary engineering work). Detail engineering is usually contracted out. The reason for this outsourcing is that the outside firms function as a flexible shell: without them, E&P would require much more in-house personnel, while there may not always be enough work for them to carry out.

When detail engineering is finished, the set of drawings goes to the O&S team, for inspection (schouwing). All the drawings are reviewed: how do they look, what work needs to be done; the exe-

cuting personnel (technicians) can comment on them. After this inspection, the comments are processed by modifying the drawings. Next, the set of plans is transferred to execution (O&S).

2.1.3. Construction Phase

So, while the kick-off indicates the point from preparation to engineering, the inspection indicates the moment in which the engineering phase is finished, and the execution of the actual work can begin. This entails the physical work at the project location, and is usually the longest phase of a project. The O&S department is responsible for executing the work. For Transport North, O&S is subdivided in three divisions: Execution North and East (Uitvoering noord/oost) and specialists systems & securities (Specialisten – systemen en beveiligingen). The teams North and East, are the teams responsible for executing the work (and thus divided per working area). These teams are made up of mechanics, executers (uitvoerder) and job preperators (werkvoorbereiders). The team 'specialists' is made up of security specialists and systems specialists. An important part of their job is designing and building the software needed to control and secure the power stations.

The project is, for the teams East or North delegated to a site manager (uitvoerder), who is responsible for the execution part of the project, and for safe working conditions. The foreman (ploegleider) is responsible for the daily conduct of business, like guiding the team of mechanics, and the progress of activities. For Systems and Securities, two specialists are made responsible for the project and take part in the project team.

The execution of the work is finished when the power station goes into operation (in-bedrijf-stelling, IB). When everything is working, the completion phase starts.

2.1.4. Completion phase: revision and evaluation

When a project is completed, the department ‘grid operation’ (Netbeheer) will test and review the quality of the work. The project is delivered to Netbeheer and the SCADA department, who is responsible for making sure the station’s operating systems can be remote controlled. There are protocols and testing documents that are required to be filled out for every project.

Revision

For the revision, all data is processed, in order to make all systems ‘as built’ again. This means that all information in Enexis’ systems is up to date: the drawings, materials used, etc. in the systems needs to correspond with the real (new) situation at the station. This phase of the project is important, since in case of an outage Enexis will need those drawings of a station; if they are not up to date, this will cost more (unnecessary) time. Every component and part of a station is described in Enexis’ systems: from floor plans, drawing, to the serial numbers for the smallest components.

Evaluation

Project management draws up a final report for AsM. In this report the highlights and lowlights of the project are described: what went well, what can be done better next time, possible exceptional situations are described. The final costs are clarified and possible Contract Extras (meerwerk) explained.

2.2. Project teams

In this section, some further explanation will be given on the Small Project Team as well as the overall project team. Ultimately, the personnel involved in projects are linked to the project phases to show a clearer image of who is involved in which steps of the process.

2.2.1. SPT and Project Team

The following figure (2.2.) shows how both an SPT (Small Project Team), responsible for the project plan, and the project team responsible for carrying out the work, are compiled.

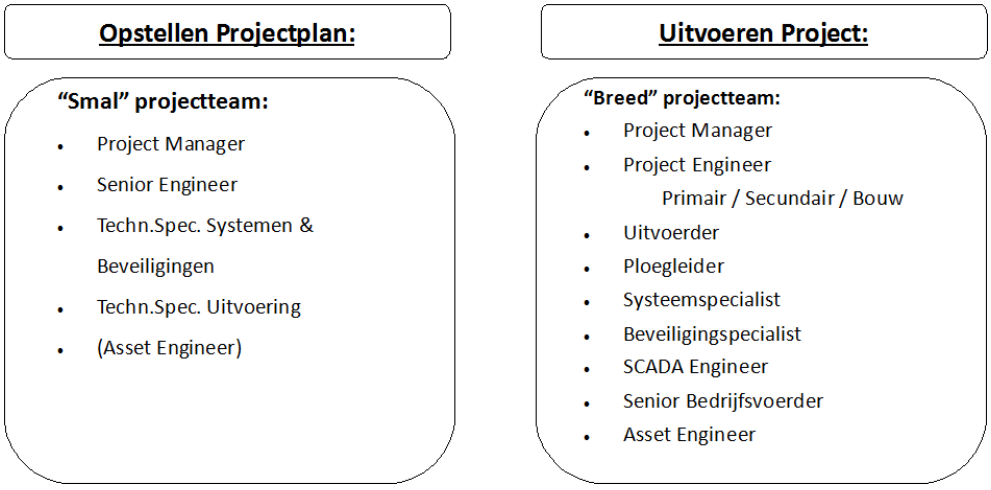


Figure 2.2.: *the roles in a Small Project Team and project team (Source: Enexis, November 2011)*

Small Project Team

The image gives an idea of the roles in project teams. The process of a project starts with the request made by AsM, and E&P will then start assessing the project by appointing a Small Project Team (SPT). An SPT is a team containing representatives for each department involved in the project: first of all, the **project manager** that is assigned to the project, and responsible for the project as a whole. Besides him, there is one **senior (project) engineer** for the engineering department, and **technical specialists** for the department O&S: one for Systems and Securities (systemen en beveiligingen), and one for Execution (uitvoering). Since the assignment for the project comes from Asset Management, an **Asset Engineer** may also be part of the SPT.

The SPT is responsible for making the project plan and calculations.

Project Team

The project team are those people actually delegated to, and working on the project. In fact, everyone working on the project (including for example mechanics, or detail engineers) is part of the project team. However, the roles described in the figure are those delegating the work for their respective disciplines, and are the persons coming together for project meetings. It should be noted that not all persons have an active role throughout the whole project: a foreman (ploegleider) for example, will probably not attend all project meetings when the project is still in its engineering stage. Project team members are involved in the meetings, when they are needed.

2.3. Project phases & personnel

In order to give a clear overall view of the process of a project, and the personnel that is involved in each stage, the following figure (2.3.) is designed. It shows each consecutive phase in a project (and its sub-phases), followed by the persons (teams) involved in those phases.

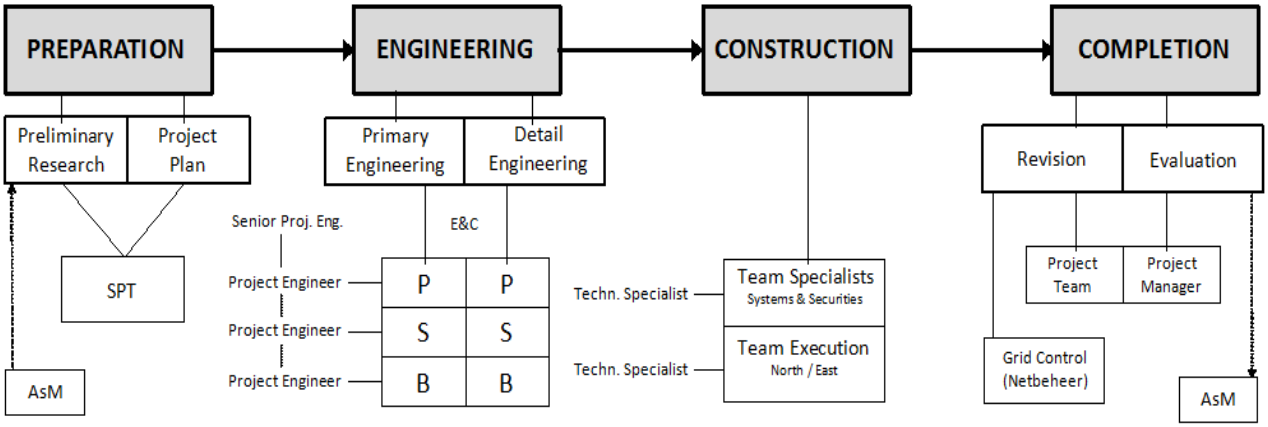


Figure 2.3.: *The process of a project, including the people (teams) involved for each consecutive step.*

The figure shows the SPT responsible for the preparation phase (including the preliminary research, which may be initiated or already carried out by AsM as principal). The engineering phase is subdivided in primary and detailed engineering. For both, there is a team subdivided in disciplines, in the figure showed as P/S/B. These letters represent the disciplines Primary, Secondary, and Construction (Primair-Secundair-Bouw), with a project engineer for each discipline. The senior project engineer (who is also part of the SPT) is responsible for guiding the project engineers. The construction phase is carried out by the two O&S teams: Systems & Securities and Execution. For the completion phase, revision is the task of the whole project team, but testing and revision of the components is also done by the Grid Control department. An evaluation report is the task of the project manager, who ultimately reports about the project to the principal, AsM.

3. Literature Review

In this chapter, literature on project management is reviewed. First of all, a 'project' and 'project management' are defined, followed by important theories on project management and control.

For this chapter, and for this study overall, five books on project management have been found most useful. The authors (Heinze, 1996; Kerzner, 2001; Oberlender, 2000; PMI, 2000; Turner, 1993) have written extensively about project management, sometimes specifically based on engineering projects. They are referenced by many other authors on project management, and their work can be considered the 'red line' for this chapter.

Research Question

This chapter aims to answer the second research question: *What is project management, and how can good project management be achieved according to literature, focusing on cost management?*

To answer the main research question for this report, it is important to review what proper project cost control really is, and how it can be achieved. Reviewing the literature on project (cost) control, will help to review theories that can be used to assess the current functioning of project monitoring and control at Enexis E&P.

3.1. Project:

How a project is defined differs for all five main authors. Their definitions can be found in table 3.1. There are however some attributes that these definitions have in common. A project (1) has a specific objective or goal, (2) has a defined beginning and end (or is temporary), (3) uses diverse resources, (4) is unique, and (5) has limited funding.

Author	**Definition of a project:**
Turner (1993)	*An endeavor in which human, material and financial resources (3) are organized in a novel way (4), to undertake a unique (4) scope of work, or given specification, within constraints of cost and time (2/5), so as to achieve beneficial change defined by quantitative and qualitative objectives (1)*
PMI (2000)	*A project is a temporary (2) endeavor undertaken to create a unique (4) product or service.*
Oberlender (2000)	*A project is an endeavor that is undertaken to produce the results that are expected from the requesting party.*
Heinze (1996)	A project: • Has a beginning and an end (2) • Has an objective (1) • Is distinct from other projects (4) • Uses multiple diverse resources (3) • Requires a project leader and competent associates • Must be planned and its progress monitored • Its performance must be reviewed continuously • It is affected by internal and external forces.
Kerzner (2001)	A project can be considered any series of activities/tasks that: • Have a specific objective to be completed within specific specifications (1) • Have defined start and end dates (2) • Have funding limits (5) • Consume human and nonhuman resources (3) • Be multifunctional

Table 3.1.: *The definition of a project, according to five main authors*

A project is therefore defined as "*a unique endeavor with a clear start and end date, in which diverse resources are used to complete a specific goal, within a defined budget*", for this definition includes all five important attributes of a project.

3.2. Project Management:

Kerzner (2001) defines project management as "the planning, organizing, directing, and controlling of company resources for a relatively short-term objective that has been established to complete specific goals and objectives. Furthermore, project management utilizes the systems approach management by having functional personnel (the vertical hierarchy) assigned to a specific project (the horizontal hierarchy)". The definition shows the interaction between the project organization and the line organization. While the project manager has the right to request specific resources, the final decision of those resources rests with the line managers. Successful project management is therefore dependent on a good working relationship between the project manager and the line managers, and the ability of employees to report vertically to their line manager, as well as horizontally to their project manager at the same time (Kerzner, 2001).

The friction between the functional organization and the project organization is underlined by Heinze (1996) and Oberlender (2000) as an important factor of project management. They emphasize the need for good communication skills for a project manager, since the work that is required often involves people that do not report to the project manager directly. Coordinating and integrating activities performed by functional organizations over which the project manager has no authority makes his task very difficult (Heinze, 1996; Oberlender, 2000).

3.3. Different theories on Project Control

Project control has been reviewed from many different angles. Many articles reviewed for this research were very broad about project excellence as a whole. However, when focusing on the monitoring and control of projects, regarding project costs in particular, some theories are very prominent, and the next table (3.2.) shows which articles mention which recurring theory.

Concept	Articles:
Iron triangle	*Atkinson (1999); Bowen, Hall, Edwards, Pearl & Cattell (2002); Babu & Suresh (1996); Ebbesen & Hope (2013); Gardiner & Stewart (2000); Ireland (1985); Jugdev & Müller (2005); Khang & Myint (1999); Koskela & Howell (2002); Westerveld (2003)*
EVM Earned Value Management	*Al-Jibouri (2001); Fleming & Koppelman (1999); Pajares & López-Parades (2011); Vandevoorde & Vanhoucke (2006); Zwikael & Globerson (2000)*
Life Cycle Theory	*Crawford (2004); Jaafari (2001); Jugdev & Müller (2005); Morris (2000)*
CPM and PERT Critical Path Method Program Evaluation and Review Technique	*Babu & Suresh (1996); Crowston & Thompson (1967); Khang & Myint (1999); McKim, Hegazy, & Attalla (2000)*
WBS Work Breakdown Structure	*Fleming & Koppelman (1999); Globerson & Zwikael (2002); Koskela & Howell (2002); McKim, Hegazy & Attalla (2000); Thiry (2002); Turner & Speiser (1992); Vandevoorde & Vanhoucke (2006)*

Table 3.2.: *Five important theories on project control, and the authors mentioning them.*

The following section will explain these theories and why, or why not, they will be reviewed to assess the situation at Enexis E&P.

3.3.1. Iron Triangle

The 'Iron Triangle' or 'time-cost-quality triangle' is mentioned in almost all literature on project management, though some authors emphasize more on it than others. Its main concept is the idea that projects deal with competing constraints of time, cost, and performance. The three constraints are mutually dependent: increasing quality will increase the amount of time needed, which will also lead to higher costs. It is an interesting theory to review more in-depth.

The 'iron triangle' of project management is depicted in figure 3.1. This figure shows the triangle as described by Atkinson (1999), with the three constraints time, cost, and quality. Other authors, like Kerzner (2001) use the constraint performance or scope instead of quality. Oberlender (2000) defines a project as follows: "A project is an endeavor that is undertaken to produce the results that are expected from the requesting party. (…) A project consists of three components: scope, budget and schedule". This 'triangle' of scope, budget and schedule, is also depicted in figure 3.1. Comparing the two, it is noticed that Oberlender (2000) has replaced 'time' with 'schedule', and 'cost' with 'budget'. Scope is mentioned as the third factor, and 'quality' is instead of a separate factor in the triangle, defined as the integral part of the three components: "Quality is an element that is integrated into and between all parts of a project (…). An attitude of achieving quality must be instilled in everyone and perpetuate throughout the work environment"

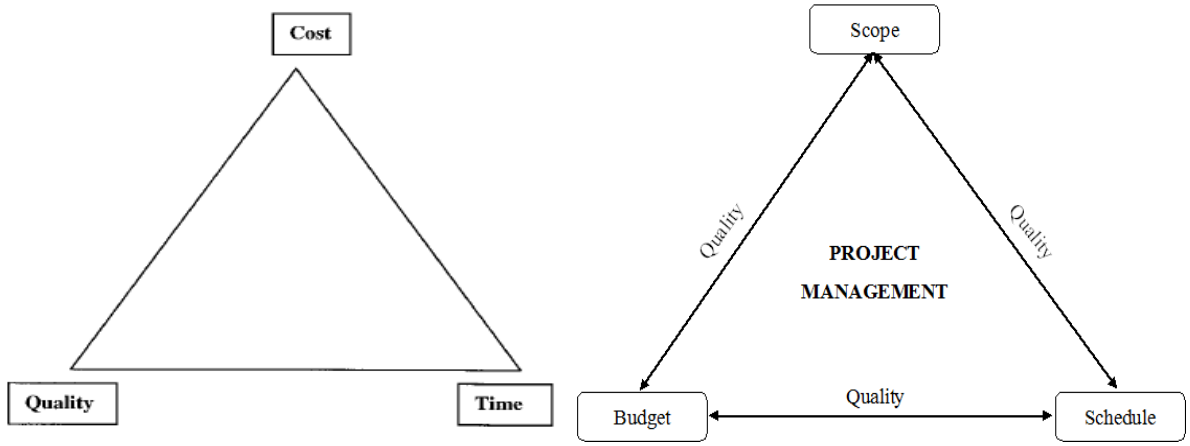


Figure 3.1: *The "Iron Triangle" of control (Atkinson, 1999; Kerzner, 2001) vs. Oberlender (2000).*

Since 'scope' is viewed by many as mainly concerned with what is or is not included in the project, the focus of this term is too much on quantity/amount of work. Since almost all authors use the term 'quality' instead of scope, it will also be the constraint used throughout this report, the iron triangle used is therefore not the redefined version of Oberlender (2000), but the classic 'iron triangle' of cost – time – quality (performance), as described by Atkinson (1999) and Kerzner (2001).

A lot of authors mention the fact that the iron triangle is somewhat outdated as a concept of project management. In modern organizations new constraints are sometimes viewed as just as important: aspects like functionality, sustainability, or organization (Atkinson, 1999; PMI, 2000). Still, there is no consent on a new definition of the classic iron triangle, and since most authors do agree on the strength of this classic concept, it will be used for this report as well.

Trade-off analysis

Kerzner (2001) calls the time-cost-performance (he mentions performance, instead of quality) triangle the "magic combination" which is always strived after by a project manager throughout the life cycle of a project. He calls the balance between the three elements 'delicate', and emphasizes that most projects struggle to achieve the desired performance within the set time and costs. Trade-offs have to be made: either time, cost or performance have to be sacrificed, and it is not always possible to sacrifice one of the items without impacting another.

It is important to know which constraints have priority. Some companies may have a policy like 'never compromise performance', and in order to make the right decisions, priorities for time, cost, and performance (quality) have to be determined. Kerzner (2001) describes four situations for which different paths of action are determined: (1) Performance is held constant, (2) Cost is fixed, (3) Time is fixed, and (4) No constraints are fixed. In each situation one constraint is fixed or held constant (or none of them), and it shows that there may be constraints that are most important to an organization. This is the essence of trade-off theory: which constraint is 'sacrificed' first when the project is not going according to plan.

Iron Triangle for projects at Enexis

In the case of the projects at Enexis E&P it may be useful to assess which constraints are most important to management, and whether this is in accordance with the project teams. There are several disciplines involved in the process of carrying out a project, and while management may want to strive after more cost awareness, different actors within the organization and project teams may attach different levels of importance to the three aspects of control. It is interesting to review this more in-depth, and to see whether there may be friction between constraints, and the importance different actors place on them.

3.3.2. Life Cycle Theory

Just like the product life cycle, that is used to describe the different stages in developing new products and their accompanying difficulties, there is also a project life cycle. Concerning projects, Turner (1993) names four stages: Germination, Growth, Maturity and Death. For engineering projects in particular, these stages are represented by the project phases of conceptual design (germination), detailed design and procurement (growth), construction (maturity), and handover and close-out (death) (Turner, 1993). It is interesting to see how these stages mirror the project phases of the project process at Enexis E&P. The stages of the project life cycle are also mentioned by Jugdev & Muller (2005), who name them conceptualization, planning, execution, and termination.

Most theory on project life cycle describe the difficulties in the different stages of a project, and how to deal with them. This makes the theory rather describing, and not very focused on costs. There are however authors (Jugdev & Muller, 2005; Jaafari, 2001) that take the project life cycle as the base for *strategic project management.* Its main concept is that since project managers usually have to manage multiple projects at various stages of their life cycles, and have to balance different objectives and competing priorities all the time, there should be a shift from activity based approaches to a strategy-based style. Risk and uncertainty management should be at the core of such a system.

Life Cycle Theory for Enexis E&P

This theory may not be very useful for evaluating the project process at Enexis, reason being that it is mainly focused on commercial processes. *Because* the project life cycle is described as being so similar to a product life cycle, life cycle theory is very focused on innovation and designing new products. Jugdev and Muller (2005) use project life cycles also used by the PMI (2000): four different life cycles for construction, pharmaceutics, defense acquisition and software development. It is noteworthy that all of them start with phases like 'discovery' or 'concept exploration', and their main stages include production or development. Since the projects at Enexis are not based on new products, or commercial success, the definitions of stakeholders or project success/failure do not match.

Its strategy-based approach should make sure that instead of looking at cost, time, and quality, the broader objectives of the end users should be looked at throughout the project life cycle. However, Enexis always has the same end user (AsM) that will become owner of the assets. So, while the project stages at Enexis clearly match with life cycle theory, its main ideas are too much based on commercial projects for it to be relevant for this research.

3.3.3. Work Breakdown Structure

The purpose of a Work Breakdown Structure, or WBS, is breaking the work that needs to be done for a project into manageable steps, which contain a defined deliverable. The PMBOK (PMI, 2000) defines a WBS as follows: "A *deliverable* oriented grouping of project *elements* that organizes and defines the total work *scope* of the project. Each descending level represents an increasingly detailed definition of the project work". The WBS is a hierarchical breakdown of work. By subdividing the project into smaller, manageable steps, it makes sure that everyone knows their responsibilities, and costs can be controlled better due to the smaller units of control (Heinze, 1996).

Advantages of the WBS

Oberlender (2000) describes the WBS as the cornerstone of the project plan: "in order to manage a whole project, one must manage and control each of its parts". The five main authors on project management for this report mention the following advantages of using a WBS:

Author	Advantages of WBS:
Turner (1993)	• It provides better control of work definition (3) • It allows work to be delegated in coherent packages (1) • It allows work to be defined at an appropriate level for estimating and control for the current stage (3) • It allows risk to be contained within the WBS
PMI (2000, PMBOK)	• Defines the scope of the project • Provides structure for a hierarchical summation of costs and resources (2) • Smaller, more manageable components (1) • Identifies the project deliverables and processes that will need resources (3)
Oberlender (2000)	• Divides the project into identifiable parts that can be managed (1) • The WBS is the cornerstone of the project work plan (4) • Defines the work to be performed, identifies the needed expertise, assists in selection of the project team, and establishes a base for project scheduling and control (3)
Heinze (1996)	• Will help to plan, organize and control any project, large or small (3) • Allows the project to be broken down into manageable portions (1)
Kerzner (2001)	A WBS structures the work into small elements that are:

- Manageable: specific authority and responsibility can be assigned (1)
- Independent, or with minimum interfacing with and dependence on other ongoing elements (3)
- Integretable so that the total package can be seen (4)
- Measurable in terms of progress (2)

Table 3.3: *The advantages of a WBS, according to five main authors.*

From this overview, some main advantages of a WBS have been composed, by putting the work of all five main authors together:

1. The WBS allows the project to be divided into smaller, *manageable* components; each with their own authority and responsibilities.
2. The work is defined by project deliverables that are *measurable* in terms of progress. Estimating and controlling is possible through a hierarchical summation of costs and resources.
3. The project becomes *controllable* by clearer work definition, and smaller steps that can be reviewed and controlled independently.
4. It becomes easier to have an *overview* of the project as a whole, with different elements that are independent, but form coherent packages that make up the whole.

Levels of the WBS

The WBS should essentially break the work down into project elements to which costs will be allocated. However, different sources of literature about WBS disagree on the amount of levels in which a WBS should be subdivided. A small example:

LEVELS OF THE WORK BREAKDOWN STRUCTURE					
Kerzner (2001)			Turner (1993)	Sullivan et al. (2009)	
Managerial levels	1	Program	Program	1	Project
	2	Project	Project	2	Major work elements
	3	Task	Areas of Work	3	
Technical Levels	4	Subtask	Work Package	4	
	5	Work Package	Activity		
	6	Level of Effort	Task		
			Item		
			Step		

Table 3.4.: *Levels of the WBS, according to Kerzner (2001), Turner (1993), and Sullivan et al. (2009)*

Kerzner (2001) mentions the six-level structure as shown above as the most common structure. Level 1 is the total program, composed of a set of projects, and these are subdivided further among two types of levels: the managerial and technical levels. The upper three (managerial) levels are described by Kerzner as summarizing levels for reporting purposes, not related to one specific department. The lower levels are usually for in-house control, and effort required by departments or sections is defined here, in subtasks and work packages.

Turner (1993) gives an overview of WBS levels that can be considered an example. In the example, eight levels of work elements are mentioned, but Turner emphasizes that “there is no universal agreement on the terms to be used for the work elements and their deliverables”. Activities can be

subdivided into tasks, or the other way around. Sullivan et al. (2009, p.97) have a similar approach: a project is subdivided into its major work elements, and then further developed into "successive levels of detail". More important than the amount of levels in a WBS, are the work packages they contain. They are explained in the following paragraph.

Work Packages

Although there is no consent on the levels of elements in a WBS, there is consent in most literature on one thing: *work packages* describe the critical level of managing a WBS and are the most important elements of the WBS. Some authors describe them as the items at the lowest level (Oberlender, 2000; PMI, 2000). Looking at table 3.4, this does not correspond with the levels as described by Kerzner or Turner. However, it can be explained by the PMI and Oberlender: the work package is the smallest unit in the WBS, and must be defined in sufficient detail. They can in turn be further decomposed into a *subproject* WBS. Usually, the project manager will then assign a scope of work to another organization or department that must plan and manage the scope of work at a more detailed level than the project manager in the main project (PMI, 2000; Oberlender, 2000). Kerzner (2001) describes the work package level as "the level at which the project is managed", and states that in his overview, the work package can exist at any level below level 1 (see table 3.4).

Work packages should be designed in a way that cost account managers and work package supervisors can clearly distinguish one package from another. In order to do so, they are ideally short-termed. But that short-term wish should not lead to forced cutoff points; work packages are natural subdivisions of effort planned according to the way the work will be done. The reason for them having to be short-termed is that if they are, little assessment of work-in-progress is needed, and evaluating the status of the project can be done mainly by looking at which work packages are completed. The longer they take, the more difficult and subjective it becomes to assess how far the work has come along in terms of time and budget (Kerzner, 2001).

Heinze (1996) defines three basic rules for work packages: all work packages at a given level should be *comparable* in terms of completion time and costs, they must have a *definable output* and a *specific product* that must be generated for the task to be complete, and every work package must have a *definable beginning and end.* The definable output/specific product rule is in accordance with the view of Turner (1993) and the PMI (2000) that projects should focus on results through the WBS, and that the WBS should be *deliverable*-oriented.

Milestone planning

The focus on deliverables resembles Turner's (1993) focus on results. The *milestone planning* as described by Turner (1993), is related strongly to the WBS: milestones are the *deliverables* of work packages. Turner states that it is common in developing a project plan to define the packages of work first and then define the deliverable that results from them; however, it is better to define the deliverables, or *milestones* first. Focusing on the deliverables can help delegate work to subproject teams: they can plan their own work to deliver that milestone by a certain date independently of the rest of the project team. The milestone plan will, as a result, show the logical sequence of the conditions that a project must pass through to achieve its final objectives (Turner, 1993).

3.3.4. Critical Path Method (CPM) and PERT

The Critical Path Method (CPM) is used to develop the overall project schedule from the WBS by integrating and sequencing the work in accordance with the work packages. It shows the sequencing of activities identified in the WBS, and all activities that may influence the completion date of the project should be represented (Oberlender, 2000). By doing this, CPM can determine the minimum time that is needed to complete the project (Babu & Suresh, 1996).

PERT

A technique closely linked to CPM is Program Evaluation and Review Technique, PERT. It is different from CPM in the sense that for CPM scheduling of projects, there is usually a rather certain estimation of the duration of an activity. PERT is applicable to projects where there is a higher degree of uncertainty about how long activities take to complete (Oberlender, 2000). Kerzner (2001) also mentions its completeness as an advantage: the effect of changes in the program, and determining the probability that deadlines are met can be determined by using PERT.
PERT uses three time estimates to derive the expected time. An optimistic, most likely, and pessimistic estimate are used to calculate a weighted average of those three times to find the overall project duration, by using the following formula: $a + 4m + b$ divided by 6. a being the most optimistic time, b the most pessimistic, and m the most likely duration (which therefore has a higher weight). The optimistic time and pessimistic time may not deviate the same amount from the most likely time, PERT therefore also includes the degree of uncertainty by calculating a standard deviation, on how large the variation may be (Kerzner, 2001; Oberlender, 2000).
Disadvantages of PERT are that it is very time and labor intensive, and the need for too much detail may exist.

PERT and CPM for Enexis E&P

CPM and PERT can be used to analyze the cost/time tradeoff, but they do not include performance or a measurement of work done. CPM (and PERT) is therefore mainly used as a *schedule control* technique, used for planning the project, which is why it will be left mostly out of consideration for the purpose of this report (which focuses on *cost* control).

However, Oberlender (2000) describes the CPM as a way to link the WBS of a project to its costs and organization. Oberlender (2000) and other authors are in agreement on the fact that CPM can help to see how deviations from planning may influence the costs of the project. Critical tasks (that need to be finished for the project to move along) that are delayed will lead to (significant) higher total costs. Kerzner (2001) also mentions several times how, in order to use PERT or CPM, the project needs to be divided into work packages and clearly identified activities, by means of a WBS. So, in order to be able to use PERT/CPM at all, a proper WBS needs to be in place. Also, all authors on PERT and CPM mention the high amount of time it takes, and the detailed information that is needed. For these reasons, and since planning of the projects at Enexis E&P time-wise is rather good, the focus of control aspects will be on WBS, rather than CPM or PERT.

3.3.5. Cost Control: the Earned Value method.

PMI (2000) gives a description on cost control that summarizes its most important elements short and clearly: “Cost control is concerned with monitoring cost performance to detect and understand

variances from plan". The goal or outcome of cost control are revised cost estimates, budget updates, and corrective action.

Cost control is not only about monitoring the costs and recording data; a very important part of cost control is also analyzing the data and taking corrective action before it is too late (Kerzner, 2001). Most project managers know the problems of using only partial information to track the status of a project: when only costs and time are used to monitor the progress of a project, the true status of a project cannot be determined. For example: half of the project budget may be used when the project is half-way in its time scheduled. This may indicate that the project is doing well, while much less than half of the work may be finished.
This is why an integrated cost/schedule/performance system is needed, that will provide the project manager with meaningful feedback *during* the project rather than *afterwards.* This will also ensure that corrective action can be taken in time, when corrections can still be made at the least costs (Turner, 1993; Oberlender, 2000). Kerzner (2001) confirms this: possible cost reductions are more readily available in the early project phases, but as the project progresses through its life cycle, the cost of corrective action becomes higher and higher.

So, in order to control costs, the actual expenditures should not be measured against the scheduled expenditures, but against some measure of performance: how much of the work is actually done. The WBS will help to do so (Turner, 1993). The cost estimates are prepared against the WBS, since it specifies the work elements and the resources needed to obtain its deliverables – the WBS identifies the project elements to which costs should/will be allocated (PMI, 2000). It is the framework on which costs, time and performance can be compared against the forecasts made for each level of the WBS (Kerzner, 2001).

Earned Value

In order to know the status of a project, different variances can be calculated. Variance analysis is reviewed more in-depth in Appendix IV. It is also the basis for Earned Value Management (EVM). Three basic types of costs are used in variance analysis, and are also used to apply EVM:

- **Budgeted Cost for Work Scheduled (BCWS):** the budgeted amount of cost for work scheduled to be accomplished in a given time period (Planned Value)
- **Budgeted Cost for Work Performed (BCWP):** The budgeted amount of cost for completed work in a given time period. This is sometimes referred to as *Earned Value.*
- **Actual Cost of Work Performed (ACWP):** the amount reported as actually expended in completing the work accomplished in a given time period (Actual Costs).

The 'earned value' (BCWP) concept is important to be able to estimate the variance in costs at the end of a project: a forecasting variable to predict whether the project will finish over or under budget. However, earned value is applied to completed work. To establish the *percentage complete* for a project, the *work-in-progress* also needs to be taken into account, for some allowance has to be made for activities started but not finished yet (Kerzner, 2001; Turner, 1993). The percentage complete is the budget used so far, as a percentage of the estimated total budget. There can be a large amount of work-in-progress, and this method is used to take that amount of work into consideration

as well. There are different methods to determine the percentage complete of an activity (Oberlender, 2000):

- *Units completed:* the measurement of work is determined as a percentage that is calculated by dividing the number of specifications completed by the total number of specifications to be produced. Each part of the specifications should therefore require an equal effort of work.
- *Incremental Milestone:* the incremental milestone method is appropriate for activities that consist of easily recognized milestones.
- *The Start/Finish Percentage:* this method is applicable to those activities that lack clear intermediate milestones. Those tasks are given 50% complete when the activity is started, and 100% when finished.
- *The Ratio method:* is applicable to tasks such as project management that have no particular end product, but are needed for the duration of the project. The percent complete is then estimated by dividing hours spent to date by the current estimate of hours at completion

Turner (1993) argues that some subjective estimate of percentage completed for activities can be made, but that it is likely to be an overestimate. He states that it has proven to be more accurate to assume that, on average, activities in progress are half finished. In other words, he is rooting for the start/finish percentage method, and this is backed up by Kerzner (2001). He calls it the *50/50 rule:* "half of the budget for each element is recorded at the time that the work is scheduled to begin, and the other half at the time that the work is scheduled to be completed. For a project with a large number of elements, the amount of distortion from such a procedure is minimal".

After the percentages for each individual element have been determined, the *Earned Value* can be calculated, using this percentage completed:

Earned Value (BCWP) = (Budgeted work-hours (for the particular task)) x (percentage complete)

After determining the progress for each task, using one of the methods above, the percentage complete for the overall project can be determined using earned value (Oberlender, 2000):

Percentage complete = (earned work-hours all accounts) / (Budgeted work-hours all accounts)

To complete analyzing the project's status, the Budget At Completion (BAC) and the Estimate At Completion (EAC) have to be determined. The BAC is the sum of all budgets (BCWS) allocated to the project, and often coincides with the 'project baseline'. It shows what the total effort *should* cost. The EAC identifies the hours/monetary value that represent a realistic estimate of the finished work. It is the sum of all costs to date plus the estimate of all work remaining (Kerzner, 2001).

Using these definitions of the BAC and EAC, the Variance At Completion (VAC) can be determined:

VAC = BAC – EAC

Overall, it is stated that, although Earned Value gives a crude estimate, it can identify trends concerning the status of specific WBS elements. Earned values can be used to check whether costs are being incurred slower or faster than planned, and whether these cost overruns are will lead to an overall

overrun, or if they are caused by activities finishing faster than planned (Kerzner, 2001). It can answer the essential questions “where are we today?” and “where will we end up?”

EVM for Enexis E&P

In the case of Enexis, EVM can be a great tool to assess how a project is doing. It will also help to make forecasts that are probably more reliable. In order to be able to use EVM, the information on planned and actual costs need to be derived from the control system in use. As stated before, a WBS is one precondition in using EVM. It is of importance for this research to review which other requisites there are to be able to use the method.

3.4. Three main theories

As explained before, CPM and PERT will for now be left out of consideration, for their main focus is planning, and it requires a clear project structure, or WBS: therefore, this thesis will focus on WBS. Life cycle theory is considered useful in reviewing what the difficulties and risks are for each stage of a project. However, most literature on life cycle theory focuses on commercial projects, which are not the type of projects E&P carries out. It is therefore also left out of consideration.

From the literature review, there are thus three theories that will be reviewed more in-depth:

- The Iron Triangle: because it is of importance to review whether all project personnel is as involved with *cost* control as management would want them to be. It is interesting to see if there are differences among different groups, with respect to how important they find the three constraints. Furthermore, if people are more focused on quality or time, this may have an effect on how involved they are willing to be in cost control.
- The WBS: from the preliminary interviews, it became apparent that a WBS is currently in use at E&P, but not used correctly. The structure of a project, including defining activities clearly as the WBS prescribes, is not only important for having a clear overview of the project, but also to be able to use other planning techniques like CPM and PERT, and to be able to use Earned Value Management. It is therefore considered an important basic method in project (cost) control
- The EVM: Defining the earned value of a project, as well as variances in budgets, is of great importance for cost control, and is the most mentioned method for applying cost control. It would thus be very useful if Enexis E&P is able to apply the technique to their projects. In order to do so, some preconditions need to be in place, and it is therefore important to review what they are.

4. Aspects of Control

In this chapter, aspects of control are defined that are derived from the three main concepts (theories) described in the Literature Review. These concepts are in order of appearance: the Iron Triangle, the WBS, and the EVM (variance analysis). The aspects of control described in this chapter define the preconditions that have to be in place to design and use a proper project (cost) control system. To review the aspects, and assess whether they are used at Enexis, they are discussed during interview sessions, which are further discussed in Chapter 5.

4.1 Iron Triangle trade-off aspects

"When implementing the Iron Triangle into practice it is crucial to ask the project team to rank the three constraints" (Ebbesen & Hope, 2013). This quote is in line with Kerzner (2001), who also describes these preferences for different industries. In order to act accordingly when changes occur, it is important for the project manager to assess the impact of the changes, and recreate the right balance between the three constraints. More importantly, discovering the priorities and motivation for different stakeholders can show how well the project is understood, and whether stakeholders are aligned or not (Ebbesen & Hope, 2013).

- How do stakeholders at Enexis E&P assess the importance of the three constraints (time – cost – quality)
- How do different stakeholders (management, AsM (customer), project team) review the importance of the triple constraint? Are there noticeable differences?
- How is the success of a project evaluated? Which constraint is most important?
- Is the perceived importance of aspects in line with the control on these aspects.

4.2 WBS aspects

WBS is already being used at Enexis as a way to subdivide the work that is needed for a project. From the literature, some important aspects that a WBS should have, or how a WBS should be designed, can be defined. In Appendix V, the aspects that are mentioned and explained in this paragraph can be found. The appendix shows the list of aspects, combined with a table that shows which authors mention which aspects in their literature.

Structuring the WBS

First of all, the WBS should be easy to understand (Kerzner, 2001). To make sure that it is, it should fit the way work on a project is done. Work performed, budgeted and scheduled is literally translated into the WBS.

By 'summarizing', it is meant that "the content and resource requirements of a work element are the sum of the activities and resources of related sub elements below it" (Sullivan et al., 2009). By making sure the WBS is designed like this, it can be provided that any level of the WBS also shows the costs of all elements below it. This ensures cost account traceability: each lowest subdivision will have a number of accounting codes, adding up to collect costs for each level (Heinze, 1996).

- **The WBS should be structured in the same way as the work will be performed, and thus should reflect the way in which project costs and data will be summarized and reported.**

The explanation of the structuring of work states that accounting codes help to summarize costs. Therefore, each element in the WBS should have its own activity code. This code also shows in which level the activity is subdivided: usually, the level is equal to the number of characters indicating the element of work (Sullivan et al., 2009). How this works, is shown in figure 4.1.: each lower level has an additional number added. According to Oberlender (2000), code numbers help to use the WBS as the basis of a Project Management System: coding does not only make it possible to relate the breakdown of work to the breakdown of costs, but also to the organizational breakdown, so it can be used for the management of people and time (schedule).

- **Each element in the WBS should have an activity code, these code numbers relate the WBS to costs**

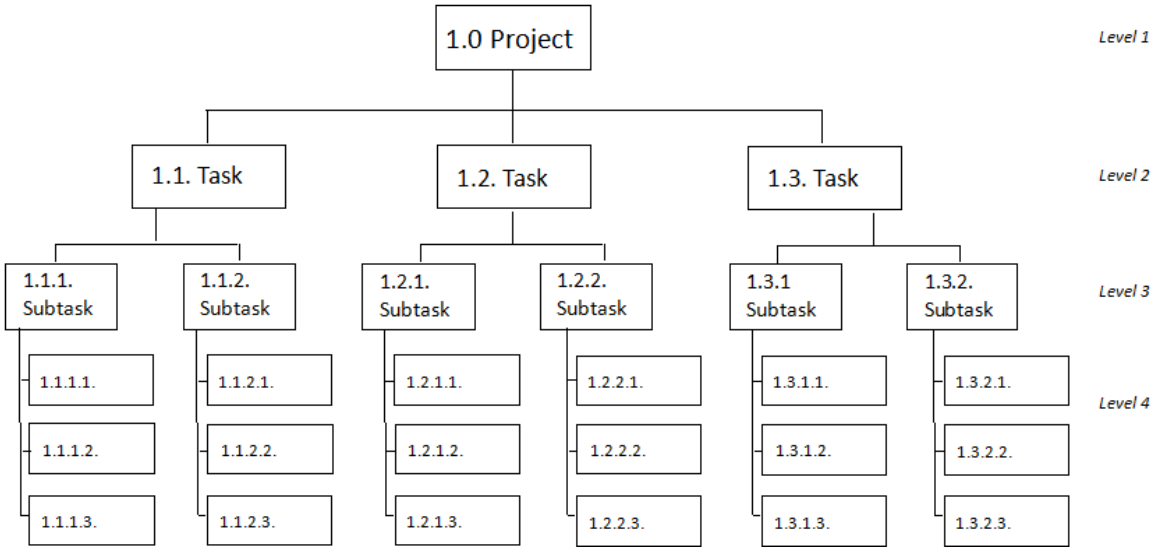


Figure 4.1.: *Coding of elements within different levels of the WBS*

Apart from the activity coding, figure 4.1. also shows how a WBS structure is build up: it goes further into detail for each lower level of elements. Kerzner (2001) and Turner (1993) emphasize that each element of work can only be assigned to one level of effort, and no more. Each of these work elements have to be defined well, in terms of work definition as well as accountability (Heinze 1996).

- **By providing an increasing level of detail, the WBS makes sure that each major and minor activity is accounted for; each item should be clearly and completely defined.**

Work Packages

Clearly defining the activities needed helps to distinguish each work package (WP) from another. As stated before, the work package level is the critical level for managing the work. Therefore, WPs should be a natural subdivision of cost accounts, making managing the work easier (Kerzner, 2001). More importantly, WPs should specify the work budgeted in measurable units, like monetary terms or man hours: they are defined by their output, or the specific product that completes the task. These are called deliverables, or milestones, as mentioned before. Milestone planning helps to show how the individual deliverables help to reach the ultimate project objectives, setting a stable framework for the project team (Kerzner, 2001; Heinze, 1996; Turner, 1993).

- **Work packages show a natural subdivision of cost accounts and effort planned. They must have a definable *deliverable* that must be generated for the task to be completed.**

While it is important that work packages show a natural subdivision, it is also advisable to make the WPs relatively short, for then little assessment of work-in-progress (which is difficult and time consuming to measure) is needed. Arbitrary cutoff points that subdivide the work to a level as low as possible, are however undesirable, for they will make the system unnatural and more difficult to use (Kerzner, 2001; Oberlender, 2000). As an ideal measure for WPs, Kerzner (2001) mentions 80 hours or less than 2-4 weeks, while also stating that WBS elements at the lowest control level (which may or may not be the WP level) should range from 0.5 to 2.5 percent of the total project budget.
In terms of time, every WP should have a definable beginning and end. At the same time, all work elements at a given level, and therefore all work packages, should be comparable in terms of both time and money (Kerzner, 2001; Heinze, 1996).

- **Work packages should be relatively short, so that little or no assessment of work-in-progress is needed. They are comparable in terms of size, with a defined duration.**

Levels of the WBS

So, we established what Work Packages should look like and at which levels they should be defined. There are, however, also guidelines for the number of levels a WBS should have in total. If the WBS does not have enough levels, the integration of activities becomes difficult, but when there are too many levels, unproductive time will be spent on controlling them (Kerzner, 2001). To make sure the WBS is designed properly, the lower level items should be reviewed: are they both necessary and sufficient for completion of the decomposed items (PMI, 2000)? Controlling at a high levels means costs can get out of hand before they are recognized.

- **The amount of levels should fit the project: too many levels means too much time is spent on control, while too few levels make it hard to act timely in case of cost overruns**

The higher (upper three) WBS levels are usually controlled by project managers. These managerial levels of a project are expected to be the same for all similar projects, and therefore, standardized methods may be used for these levels, making parts of the WBS reusable. Lower levels should be more project-specific, and responsibility over these levels should be clearly defined and communicated. As a matter of fact, it should be very clear for each item in the WBS who is responsible and accountable for them. “Doers” and “planners” must be in agreement about how the work is divided. For each work package, responsibility can be given to an individual party in the project team. Recognized experts on each item should be given this responsibility by project managers, preventing project managers having to tell people more technically skilled than themselves how to do the work.

- **Higher levels of the WBS are controlled by the project managers, and can be reused if they are standardized. Lower levels should be more project-specific, and responsibility over the work needed for those levels should be clearly assigned and communicated.**

4.3. Aspects for the Earned Value method.

In this section, aspects of control are derived from the literature, and the most important factors that are needed to be able to perform EVM are defined. In Appendix VI, an overview of the EVM aspects can be found, with an overview from which literature the aspects are derived.

An incorporating system

From the theoretical framework, it became clear that in order to be in control of costs, project leaders have to record and analyze data, making it possible to take corrective action before costs run out of hand. Kerzner (2001) uses the expression 'management cost and control system' to describe the system by which cost control is carried out. This concept may be a bit misleading, because an effective control system monitors schedule and performance as well as costs: measuring expenditures against the budgets that have been set and assuring that these expenditures are right requires also monitoring of performance and schedule (Kerzner, 2001). More importantly, the actual expenditure should not be compared to the scheduled expenditures, but to some measure of the value of work actually done (Turner, 1993). In order to do all this, integrating time, cost, and performance is essential. The control system should provide information that will give an image of the true work progress, by relating cost and schedule performance (Kerzner, 2001).

- **A control system incorporates schedule, performance and costs. To control costs the actual expenditure must be compared not to its schedule, but to some measure of the value of work actually done.**

WBS

For input of the cost control system, a proper WBS should be in place. It serves as the tool from which performance can be subdivided into (sub)objectives. It provides a way to compare costs, time and performance against a measure of the value of work done, provided by budgets for each level of the WBS (Kerzner, 2001; Turner, 1993). Estimates of costs are also prepared against the WBS. This links the WBS to cost accounts, by coding tasks and work elements. Work order releases can then be used by project management to authorize cost centers to begin charging their time to specific cost reporting elements (Oberlender, 2000; Kerzner, 2001). Finally, the WBS makes reporting easier: reporting criteria are naturally nested in the WBS, making the control tools simple and friendly (Turner, 1993).

Overall, the WBS helps to establish aspect 1: an incorporated system.

- **A proper WBS structure should be in place, providing the input data to the cost control system.**

Estimating

The very first step in cost control is, naturally, estimating the costs. Cost estimates are needed to provide a measure against which to control costs. These estimates may be quite detailed, prepared for a low level of the WBS (Turner, 1993). Estimates can be based on historical costs, best estimates, or industrial engineering standards (Kerzner, 2001). The estimates should be supported by a description of the scope of work, referencing to the WBS, an explanation for the basis for the estimate, and an indication of the range of possible results (PMI, 2000). One important risk related to estimating is

that there is a natural tendency for functional and project managers to estimate costs substantially higher, in order to protect the organization by leaving some margin (Kerzner, 2001).

- **Meaningful cost estimates are needed, to provide a measure against which to control costs. These estimates need to be quite detailed, and also explained in terms of work definition, the basis for the estimates and a range of possible outcomes.**

Responsibility within project teams

For large projects, the project manager may be supported by a project team in using the cost control system. Cost control has to be performed by all personnel who incur costs, and not just the project managers. In order to do so, each level of management needs accurate and appropriate data for decision making. Centralized authority and control are, however, the responsibility of the project management division. The level of detail in the control system is also specified by the project manager, and approved by top management (Kerzner, 2001). Heinze (1996) adds that there should be understanding among project staff of the total flow of financial and cost information: from the production of cost estimates to the collection of actual costs.

According to Kerzner (2001), a project team should have regular team meetings, with a formalized agenda and action items. At these meeting, reports about project performance may also be discussed. The focus should however be on identifying problems, and who has the responsibility for solving them, but a solution to the problem should not be looked for at meetings, for it will take too much time (Turner, 1993).

- **Centralized authority and control over projects are the responsibility of project management. All personnel in the project team that are responsible for incurring costs, also have to perform cost control, and project staff needs to understand the total financial structure.**

- **Project teams must have regular team meetings, with a formalized agenda.**

Forecasting

An important characteristic of the cost control system should be that it provides for end-value prediction, to answer the question: “where will we end up?”. After evaluating where the project is today, the estimate at completion (EAC) shows what the total job will cost *now.* In order to determine the Earned Value, it needs to be assessed what percentage of work is already finished, including work-in-progress (Turner, 1993). The cost variance (based on earned value) to date can then be used as a forecasting variable to predict whether the project will finish over or under budget.

The objectives of the project have to be translated into performance standards to be able to control the project. The actual performance to date can then be compared to the predetermined plans and standards. Comparing actual progress to the scheduled progress will show how well the project is coming along. The BCWS will show how much work *should* have been done, and the BCWP shows how much work *is* done in reality. The ACWP will show how much money that work has cost (Kerzner, 2001). This can be done for each work element: when it is finished, the actual costs can be compared against what it was estimated to cost (Turner, 1993).

- **The actual performance to date should constantly be compared to the estimated performance: is there a variance? A forecast of cost at completion can be made by assessing the percentage of work done, including work-in-progress.**

Variances and re-estimating

Variances will show major deviations from plan, and are the difference between the estimate and the actual performance. The question 'where are we today?' can be answered by calculating cost variances, schedule variances, percentage complete and percent money spent. If there is a large variance, the cause of this variance has to be found, as well as its impact on final cost, time and performance (Kerzner, 2001). Minor deviations from the original plan are normal, but the cause for major deviations that are reported should be determined by project management (Oberlender, 2000). The project manager should take action to correct the problem within the original budget, or a new estimate should be justified. However, not all variances require corrective action, so this should be assessed as well. According to Turner (1993) variance can be negligible, significant but recoverable, or large. When the variance is large, the estimates need to be revised.

- **Periodic re-estimation of time and costs is needed: if there is a variance, it should be assessed whether corrective action needs to be taken. There needs to be consensus on when (budget) changes are authorized.**

Effective Reporting

It is too late to record accrual and earned value only as invoices are paid. Although it provides a valid comparison, the comparison is made too late to overcome problems. Value should therefore be recorded at an earlier time, usually as the cost is committed, so effective action can still be taken. The cost can be committed either when the order is placed or when the work is done (Turner, 1993). This is especially true for material costs, since labor hours are booked when they are accomplished; values for materials can be recorded at various points in time. Materials should therefore be recorded *separately* from labor hours, for they do not reflect the cost of work completed (Kerzner, 2001).

According to Oberlender (2000) reports should be "written in a clear, concise, coherent and legible manner". Turner (1993) mentions the need for defined criteria: "if people are asked to make ad-hoc reports, they usually tend to report the good news and hide the bad news". Defined criteria will help to acquire honest reporting about the project, but it is also important that as little time as possible is needed to fill out reports, therefore single-page reporting using the WBS, and simple numeric or yes/no answers are mentioned as two simple and friendly tools to make reporting for project personnel more convenient. Finally, reports should be made at defined intervals, for if people know that both good news and bad news should be reported at defined intervals, they will report more freely than when they are only asked to report things when there is something to discuss. The frequency of reporting depends on the project's total length, current stage, the risk of the project and the level of reporting (Turner, 1993).

- **Value should be recorded as early as possible, all value has to be reported properly. Reports on project control are short, use defined criteria and are made at defined intervals.**

4.4. An overview of the Control Aspects

The control aspects defined in this chapter are used in the interviews to gather the results for this thesis. For the Iron Triangle, questions will be asked concerning the priorities different persons give to the constraints. The control aspects defined for WBS and EVM are presented in the interviews to discuss shortly, and are therefore presented once more as an overview:

Work Breakdown Structure:

- The WBS should be structured in the same way as the work will be performed, and thus should reflect the way in which project costs and data will be summarized and reported.
- Each element in the WBS should have an activity code, these code numbers relate the WBS to costs
- By providing an increasing level of detail, the WBS makes sure that each major and minor activity is accounted for; each item should be clearly and completely defined.
- WPs show a natural subdivision of cost accounts and effort planned. They must have a definable *deliverable* that must be generated for the task to be complete.
- Work packages should be relatively short, so that little or no assessment of work-in-progress is needed. They are comparable in terms of size, with a defined duration.
- The amount of levels should fit the project: too many levels means too much time is spent on control, while too few levels make it hard to act timely in case of cost overruns
- Higher levels of the WBS are controlled by the project managers, and can be reused if they are standardized. Lower levels should be more project-specific, and responsibility over the work needed for those levels should be clearly assigned and communicated.

Earned Value Management:

- A control system incorporates schedule, performance and costs. To control costs the actual expenditure must be compared not to its schedule, but to some measure of the value of work actually done.
- A proper WBS structure is needed, providing the input data to the cost control system.
- Meaningful cost estimates are needed, to provide a measure against which to control costs. These estimates need to be quite detailed, and also explained in terms of work definition, the basis for the estimates and a range of possible outcomes.
- Centralized authority and control over projects are the responsibility of project management. All personnel in the project team that are responsible for incurring costs, also have to perform cost control, and project staff needs to understand the total financial structure.
- Project teams must have regular team meetings, with a formalized agenda.
- The actual performance to date should constantly be compared to the estimated performance: is there a variance? A forecast of cost at completion can be made by assessing the percentage of work done, including work-in-progress.
- Periodic re-estimation of time and costs is needed: if there is a variance, it should be assessed whether corrective action needs to be taken. There needs to be consensus on when (budget) changes are authorized.
- Value should be recorded as early as possible, all value has to be reported properly. Reports on project control are short, use defined criteria and are made at defined intervals.

SECTION III - RESULTS

5. Results: The control aspects for Enexis E&P

This chapter shows the results that are derived from the interviews. First, the results for the Iron Triangle are described: which departments or groups of employees prioritize which constraints? Next, the results for the control aspects for both WBS and EVM are given. They have been summarized, and an in-depth explanation of the results can be found in Appendix VIII.

5.1. Iron Triangle

In the interviews with employees, they have been asked about the Iron Triangle, and on which of the three constraints they feel their department focuses on. The focus can vary per project: some projects have a strict finish date, while other projects may have a large focus on quality, and may therefore take more time or money to finish. However, these projects are usually an exception and in the following paragraphs a more overall image of the relationship between time, quality and costs is given that are true for most projects carried out.

The general manager at Transport North has mentioned: “in the past, costs did not matter: the work had to be done. Nowadays, we are more cost aware, also caused by the changing market (privatization; the split from Essent) and the current crisis. Money has become a more important factor, we even have shareholders these days; the provinces and municipalities. There is more focus on the results: significant cost overruns, as well as surpluses, are both undesirable”.

The focus on quality, time or costs, varies with the departments within E&P. This is somewhat logical, since each specialism is evaluated differently, and value the three constraints accordingly. Some employees have mentioned as well that the focus is shifting to more cost awareness over the last few years. However, it is clear that quality is embedded in the organization and valued highly by almost everybody.

The importance of the constraints for the Iron Triangle are now discussed more in-depth for each department.

5.1.1. Asset Management

Time:

Projects are not always finished on time. Usually there are good reasons to explain the delay, and when there are, AsM knows the reason. If projects need to shift in time, this is also done in agreement with AsM. For example, the year order book for 2013 was higher than 2012. But the capacity of Transport North, especially the security specialists, was too low to do all the work. AsM therefore reviewed which projects could be delayed to start in 2014. Other reasons for project delays can be the weather, acquiring land or licenses, or projects that require close cooperation with TenneT: an external party can cause insecurities in the planning.

Project management: “AsM will ask us from time to time: ‘why do you take so long every time? If you did it once, then the plans for a project are already there?’ But that is not how it is here, we do not

have standardized documents or anything; the situation is just completely different for each power station we work on". Asset Management feels that projects can be done faster and cheaper.

Cost:
Asset management feels that the costs of projects are too high by definition. "If the work is focused more on satisfying standards, without doing all the extras, our goal to be more efficient, cheaper, and faster, can be achieved". AsM acknowledges that this is a challenge because of the projects dealing with existing buildings, work that is hard to standardize, and other complexing factors. One employee with AsM feels that a reason for projects being 'too expensive' can be that project managers are budgeting the costs higher than the true expectations. "Which is very understandable, because that is what they are controlled on: they are evaluated on their project results, and will therefore prevent a negative project result".

Quality
The quality of the finished projects are tested by Netbeheer, and is also of importance for Asset Management. The Chamber of Energy checks whether Enexis carries out the work that is needed, and whether it is done up to standards. Asset management is therefore also interested in the quality of the work. When established standards are met, the work done is considered satisfactory.

5.1.2. Project Management

Time
Project managers are controlled mostly on costs, but also on time: the projects need to finish in time. Time is however somewhat flexible; if more time is needed to finish the project according to standards, AsM is usually quite flexible.

Cost
The interviews with (assistant) project managers for E&P have made clear that for them, the focus is mainly on costs. This is because they are evaluated on costs: their projects should stay within a set margin of 10% (or 5% for larger projects), which is why they are focused on assuring that the final project result will not deviate too much from the budgeted costs.
At the same time, evaluation on project costs is, even for project managers, not always that strict: "when you do exceed your margin, there is no reprimand, it is not like in a commercial market: one more exceeding and you're out". The market in which Enexis operates, is one explanation for low cost awareness. One of the project managers mentions that "when you are in a competing market, you are constantly challenged to do things cheaper. If you want to make a profit, you will have to". This is different for Enexis with a monopolist position as grid operator. It makes it also harder for a project manager to put an emphasis on cost awareness for their entire project team.

Quality
Quality is considered very important to project managers, but they do state that it is sometimes hard to measure: "Costs and time are measurable, which makes it easier to evaluate on them". Since time, but mainly costs, are what project managers are evaluated on, those are also the constraints that they focus on in doing their work. However, project managers state that quality is usually considered a reasonable explanation for cost overruns. When extra budget is needed, it is usually no problem receiving extra budget from AsM. As a project manager mentions: "You are talking about power installations with high technology, safety: I can deliver a power installation within time and costs, but if

the whole city is subsequently in the dark: I may have finished weeks or even months earlier, but than those months do not matter anymore".

5.1.3. Engineering

Time

Engineers are evaluated on time: do they finish their work according to their planning. The reason being that time is the only truly measurable factor for engineering, but also because the advance of the rest of the project is waiting on engineering to finish. "We are asked to shorten the lead time of a project to cut costs, so for engineering there is a lot of pressure on time. Execution of the work is waiting, so there is pressure to order materials and finish the drawings in time. This high priority on time lowers the quality of the work". A project manager explains why engineering sometimes takes as long as they do: "the drawings are always neat and of high quality, because in the situation of a power outage you do need those drawings. And if they are not correct, the outage will last longer while you could have prevented that. So engineering takes long for a reason".

Cost

One of the engineers mentions "Costs are always under pressure. 'It is expensive', is what we hear all the time. But what is expensive?". Engineering costs are currently controlled by keeping the lead time as short as possible. If engineering is not finished in time, other critical tasks (executing the work) are delayed, which leads to high costs. What is evident, is that it is very hard to evaluate on costs for engineering: there are no standard values for the work, or ways of comparing true costs (or, if there are, engineers do not have those tools).

Quality

Engineers mention that they are controlled mainly on time, for it is measurable. But, on quality, an engineer mentions: "We want to keep quality as high as possible ourselves: being engineers, quality is what is most important to us". Engineers add that they try to hold on to their high quality standards as long as possible. "Project managers consider time and costs more important, and for quality it is good enough when it meets standards: satisfactory is all they need. But we like to find the best solution, focusing on the long term". Sometimes they have to consult with the client (AsM) whether they want to sacrifice quality for less time or costs, and usually they do not want to.

5.1.4. O&S (Construction)

Time

O&S is focused mainly on quality, according to O&S employees, but second important is the factor time: "we are organized to carry out activities as fast as possible, that is also how we restrict costs. As a manager, I do not look at costs, only at the timeline of our work".

Cost

O&S is not focused on costs, the only way costs are controlled is by keeping the lead-time of their work as short as possible. No other comments on cost awareness are made by O&S personnel.

Quality

Quality is the one constraint that both O&S employees elaborate on, and is the factor that they agree is definitely most important to them: "We work with protocols that secure quality. I also control my employees on quality: I'd rather have that they take five minutes longer, making it ordered and de-

cent, so it is accessible and easy to work with in the future. That is a part of quality we like to focus on as a department". Both O&S managers mention that costs are therefore far less important to them: "when it comes to materials, we want to use the best, and are therefore far less aware of costs". Another factor they mention is the culture within their department: because O&S is also responsible for fixing outages, they are usually more focused on good and fast solutions. For outages, costs usually do not play a role: the outage has to be fixed as soon as possible.

5.1.5. Conclusion

From the description given per department, a ranking is made for each constraint in the Iron Triangle. The following figure shows this ranking:

Department	**Constraint**		
	Time	Cost	Quality
Asset Management	2/3	**1**	2/3
Project Management	2	**1**	3
Engineering	**1/2**	3	**1/2**
Construction (O&S)	2	3	**1**

Figure 5.1.: *Ranking of the constraints per department*

*Overall, it can be concluded that there is friction between the constraints **cost** and **quality**.* Costs of projects are high, for quality should always be up to standards. It can be stated that AsM and Project Management are focusing on keeping costs to a minimum, while Engineering and O&S are focusing on keeping quality as high as possible. While this causes friction, it also ensures that both components are present in each project.

While Project Management is held accountable for the complete costs of projects, they are dependent on the Engineering and Construction (O&S) departments to keep costs in line. The Engineering and O&S departments are, however, not evaluated on project costs. It is therefore hard to align project goals with functional goals. *The difference in rating constraints shows the friction between the functional organization and project organization.*

5.2. WBS

In order to find results for each control aspect of the WBS, the aspects are presented to E&P personnel in the interviews that are carried out. The results for these aspects are reviewed in-depth, and can be found in Appendix VIII. In order to prevent going too much in detail, and losing sight of the most important results found, the main results found per aspect are showed in the following table. The most important findings are derived from these results and reviewed in the following section.

5.2.1. WBS: Results per control aspect

	Aspect	Main findings
STUCTURING THE WBS	1) *The WBS should be structured in the same way as the work will be performed, and thus should reflect the way in which project costs and data will be summarized and reported.*	• Everybody recognizes the term WBS, it is currently used to book the costs of a project. • The current WBS structure only reflects the main phases of a project, activities are not further detailed • The WBS is used more as a way to describe the main components of a project, than its main activities. While not according to the true structure of a WBS, it *does* reflect the way the work is performed (a natural subdivision of costs)
	2) *Each element in the WBS should have an activity code, these code numbers relate the WBS to costs.*	• Each WBS element does have an activity code, on which costs are booked. There is, however, a limited amount of activity codes • It is not always clear which activities belong to which code • The activity codes are not used in a uniform way for each project.
	3) *By providing an increasing level of detail, the WBS makes sure that each major and minor activity is accounted for; each item should be clearly and completely defined.*	• The level of detail is not that high, not every major and minor activity is therefore included in the current WBS • The items are not clearly and completely defined: it is unclear which activities belong to which item of the WBS • If the work is broken down into more detail, personnel fears that it is no longer controllable. The activities therefore need to be described properly, and in a uniform way.
WORK PACKAGES	4) *WPs should show a natural subdivision of cost accounts and effort planned. They must have a definable* deliverable *(or milestone) that must be generated for the task to be complete.*	• The current work packages are large, but do show a natural subdivision of accounts and effort planned: construction has more activities, reflecting the main components of the project, while the engineering phase knows far less details and milestones. This is a natural way of subdividing, for the engineering phase has less 'true' deliverables. • The dependencies among different activities (what happens when a milestone is not reached in time) are important in deciding smaller milestones within phases of the project. • The most important milestones reflect the transition from one project phase to another, or the completion of important components during construction. These milestones are defined for each project, and are usually met.
	5) *Work packages should be relatively short, so that little or no assessment of work-in-progress is needed. They are comparable in terms of size, with a defined duration.*	• The duration of a task depends: most of them are relatively long. Engineering is one long task, and the construction phase focuses on completing components: relatively long work packages that finish all within a short period of time. • There are, however, a lot of project meetings (every two weeks) in the construction phase: in these meetings, agreements are made about the work that needs to be finished in the two weeks to come. These agreements can be considered 'informal' work packages: that are relatively short, and comparable in time. • Overall, work packages are not comparable in size: there are long activities (like engineering), that take up to months, but also shorter activities (ordering an installation), that may take only a few hours, but may cost a lot of money.
LEVELS	6) *The amount of levels should fit the project.*	• At this point, there are only 2 or 3 levels in the WBS: the levels that are controlled by the project manager. • Lower levels are calculated in the VoCa, but these levels are not detailed out in activities, or controlled in detail during the process of a project.

7)	*Higher levels of the WBS are controlled by the PMs, and can be reused. Lower levels are more project-specific, and responsibility over the work needed for those levels should be clearly assigned and communicated.*	• The higher levels are controlled by the project managers and they are described in the project plan. These levels are recurring for each project. • The responsibility over activities in the lower levels of the WBS is highly ambiguous: there are no clear or formal agreements on responsibility over specific work packages.

5.2.1.1. Structuring the WBS

Currently, a WBS is in use at Enexis E&P. However, this WBS only focuses on the top levels of a WBS that are controlled by project managers. Activities for departments and disciplines are detailed in the VoCa, but this structure is not used to book costs to. The WBS is focused more on main components, than on activities.

The WBS also has a limited amount of activity codes because of this. The SAP-system connects activity codes to the WBS elements it holds, but only on a very high level: activities are not subdivided per discipline, or in terms of hours/materials/third parties. The only subdivision that is currently made, is between the four phases in a project. Still, with the small amount of activity codes, it is not always clear to project personnel which tasks belong to which activity codes: there is no uniform way of using the WBS. Activities need to be better and more uniform defined, in order to make sure that costs are booked properly, and thus that the WBS is used properly.

So, while a WBS is in use, it is not used for controlling project costs in detail. Costs are not summed up, for there are no levels that go further into detail of the activities below them. The work elements are not defined well, both in terms of work definition and accountability.

Wishes of project personnel

From the interviews with employees for Enexis E&P, the following wishes on the structuring of a WBS can be derived:

- Personnel, especially project managers, would like to have the tools (within the current system) to build a more detailed WBS. Reviewing the project in subsequent levels of detail, will help project managers to focus more on the main phases and milestones of a project
- If activities in the WBS are more detailed and better defined, they can be used properly by all project personnel: a uniform structure for all projects can be set up, this structure should be customized for each separate project by the project manager. Each activity that may occur within projects should be described, and have their own activity code. If everyone uses this system in the same way (which should be communicated to all project personnel), a proper review of the status of a project is possible by *all* project personnel, for every level of detail.
- Practically all employees are skeptical about using a true WBS structure on the short term: it is unknown to everyone how this structure should be built in the current SAP-system. Engineering and construction usually do not even use the SAP-system, while it is the central ERP system for all Enexis. The system was, according to personnel, built to support more 'bulk' activities, like the ones carried out by regional offices and other departments of Enexis. It is, in its current form, not concentrated on supporting projects. Employees would like to build a more detailed WBS, but do not see this as an option with the tools they currently have.

- Project personnel (especially engineering and construction) would like to be informed better on the structure of a project. It is currently different per project manager, which is why employees do not always know what is expected from them. The overall process of project can be better described an uniformed, most employees feel that higher management should give more attention to this.

5.2.1.2. Work Packages

The current Work Packages that exist are relatively large, the engineering phase is one big package, for example. In the construction phase, work packages are also long. Most work packages take several weeks up to several months. Although this is not ideal to review the finished work so far, it is a natural subdivision of work: the WBS is focused on components, and deliverables. There may be multiple components in the construction phase that are tangible to review in terms of how far they are finished. There is only one tangible deliverable for engineering, which is the set of drawings they deliver at the end of the engineering phase. Work packages are therefore not comparable in terms of size: some encompass a lot more work than others.

There are defined milestones within projects that also focus on those components to finish. The milestones are usually met in time. They are not always defined in detail, and dependencies with other elements in the project can be better described.

There are very regular team meetings, at which the project status is reviewed. Especially in the construction phase, these meetings review the work done in the past two weeks and look forward to the work for the coming two weeks. In this way 'informal' work packages are defined and agreed upon. While these agreements and tasks are not formal, or controlled through the WBS, they do help to control the project: a project manager knows what activities are finished, and which may take longer.

Wishes of project personnel

- O&S is in favor of better defined work packages and milestones for their part of the work. They know what their work entails and what needs to be done, but it is not formalized.
- O&S would like to have better defined milestones, to be able to review the dependencies with other activities. They are highly dependent on engineering, and on other tasks in the construction phase to finish. If the risks for not reaching milestones are better defined, their impact on other parts of the work will become more clear.
- Milestones and their Work Packages need to be defined in more detail. The overall milestones that are used now, include too many disciplines and activities that are hard to split up. If milestones can be 'checked', it can be easier to review what the status of the project is, and it will also become easier to review phases of the project that are already finished.

5.2.1.3. Levels of the WBS

The WBS currently only has 2 or 3 levels. They are the main phases of the project that are overviewed by project managers. They are described in the project plan. The VoCa, that comes with the project plan does detail out the activities and working hours needed for lower levels of the WBS, but these budgets are not used further on in the project: costs are summed up only on higher levels.

The responsibility over lower levels of the WBS is very unclear. The activities and accompanying costs for these levels are calculated by the experts for Engineering and Construction that take part in the

SPT. When the project starts, other personnel may be working on the project, and accountability over those levels is delegated back to project managers.

It can be concluded that there are too few levels in the current WBS structure to be able to act timely in case of cost overruns, as was defined by the control aspects. The levels are too high over, making it almost impossible to review finished activities during a project: the large, undefined activities, cause the problem of only being able to review costs in hindsight.

Wishes of project personnel

- All project managers state that it is hard for them to know the specific details of the work that the departments carry out. In the current structure, project managers are however responsible for all project costs, so they feel obligated to 'dive into' those details. They would like to have a WBS that defines activities more clearly, but especially defines who is responsible for those work packages. It will help them to focus on the overall status of a project, without spending too much time controlling details.
- Engineering personnel would also like to have more ownership over their part of the work. If they are given the tools to monitor the work they do, it will be easier for them to review how they are doing. Projects become more comparable, and controllable.

5.2.2. WBS: Main Issues

Overall, 5 main issues can be defined from the results gathered for aspects of control of the WBS. These main issues are:

1. Not manageable: While the main goal of a WBS is to break down the work into manageable steps, this is not how the WBS is designed at E&P: steps are too large, and on too high levels to be properly manageable.
2. The activities in projects are not properly defined: it is unclear which activities belong to which WBS element, it is unclear who is responsible/has authority over the activities, and the dependencies with other activities are unclear.
3. The WBS does not help to share responsibilities, all responsibility over the entire project is now for the project manager. Specialists need to be held accountable for smaller Work Packages, for they know what the work for their discipline entails.
4. The deliverables, or milestones of a project, are not measurable at this point. There are too few levels, so project managers are unable to sum up costs and project information that define a deliverable.

5.3. EVM

In order to find results for each control aspect of the EVM, the aspects are presented to E&P personnel in the interviews that are carried out, just like the aspects for WBS. The main results found per aspect are also showed in the following table. The most important findings are derived from the more extensive results in Appendix VIII and reviewed in the following section.

5.3.1. Results per control aspect for Enexis E&P

Aspect	Main Findings
1. *A control system **incorporates** schedule, performance and costs. To control costs the actual expenditure must be compared not to its schedule, but to some measure of the value of work actually done.*	• Comparing costs to the work that is done is done relatively well: project managers have, through regular meetings and constant checking, a good idea of how the project is doing • The control system is *not* incorporated. The time planning is tracked separately from costs, and the VoCa, which establishes the budget, is separate from the booking of working hours. • Measuring the work actually done is hard, especially for the engineering phase of the project.
2. *A proper **WBS** should be in place, providing the input data to the cost control system.*	• The activities in the current WBS structure are not detailed enough to provide proper input to the cost control system. • The WBS structure is put in the SAP-system by the Finance department, instead of the project manager. Project managers should be in control of the structure, and thus be able to 'build' the suitable structure themselves • Communication: the way the project is structured, with the activities that personnel should book costs to, is not communicated properly with the project team. They should know what the activities entail.
3. *Meaningful **cost estimates** are needed, to provide a measure against which to control costs. These estimates need to be quite detailed, and also explained in terms of work definition, the basis for the estimates and a range of possible outcomes.*	• The Small Project Team is responsible for the VoCa: experts from the departments indicate the budget. • The engineering department does not feel that the VoCa is very specific: it is hard to assess up front what you will run into during the project. • Responsibility over the engineering part of the VoCa is not always clear. The senior engineer delegates it to the project engineers for each respective discipline. But the project engineer ultimately working on the project may be someone else than the person calculating the VoCa. • The engineering part of the VoCa is based on expertise, not on indexed (or standard) values. • The construction part of the VoCa is calculated by technical specialists in the SPT. They base the VoCa on standard values, derived from experience. • The O&S department have to base their estimates on a non-complete plan, they are dependent on engineering for knowing the exact activities. • A more standardized way of estimating may help to control projects better: VoCa's should be more uniform. • The VoCa cannot be made very detailed, so early on in the project, there are too many unknowns, which is why standardizing may be an option • Risks are not taken into account (enough). More standardized VoCa's may help to compare projects amongst each other, and estimate risks (from occurring in the past). If activities are more clear and uniform, lessons can be learned from previous projects.
4. *Centralized authority and control over projects are the **responsibility** of project management. All personnel in the project team that are responsible for incurring costs, also have to perform cost control. Project staff needs to understand the total flow of financial and cost information.*	• Tasks are clear, but the responsibilities linked to those tasks are unclear: responsibilities are not formalized. • The project manager is responsible for all costs, but does not have the tools or specific knowledge to look into all costs on a detailed level. • Project engineers calculate their discipline's part of the VoCa; the responsibility over controlling the costs is taken away by delegating it to the project manager. • Agreements on the responsibilities of all project personnel (and the project engineers specifically) should be more clear, and more uniform. • Giving project engineers more ownership on their part of the project will help to gain a better insight in planning and costs for work packages. • The O&S department can control their working hours, but not their complete costs: materials are ordered by the engineers, and there are too many dependencies to give the O&S department full accountability over their part of

		the process, for they cannot influence all costs. • Departments currently do not have the tools to properly control the costs of a project: E&P is currently unable to tie budgets to all activities in the WBS, or to subdivide them into materials/working hours/third parties. • There is a wish for functions in the SAP-system like attaching an owner to work packages, defining project teams, receive warnings when a certain percentage of the budget is spent. This would help to get a grip on costs. • Currently, a lot of costs are booked on the wrong activity codes. It may help to give project engineers more ownership of their part of the process, to give them insight where his budget is spent on. He will probably know earlier on whether costs are booked correctly or not. • There is friction between the functional organization and the project organization in booking costs: working hours are approved by the team manager of a department, not the project manager. The person approving working hours should know what the activities in projects entail. • Project personnel is not evaluated on their functioning in projects/project teams, while project managers are evaluated on projects every month. • The project team is not aware of the total flow of financial and cost information. More awareness and information on the financial structure and activities, helps to gather more reliable input for the control system.
5.	*Project teams must have regular team **meetings**, with a formalized agenda.*	• Project team meetings are held regularly. In the construction phase of a project, meetings are usually held every two weeks. • Meetings for the SPT are not held regularly: there is usually only one meeting for the SPT.
6.	*The actual performance to date should constantly be compared to the estimated performance: is there a (large) variance? The percentage of work done has to be assessed, and a forecast of costs at completion can be made by using the earned value and cost variance so far.*	• The activities in the engineering and construction phase have a time span that is too long to be able to assess the work in progress properly. • A prognosis is made by looking at the planning of work time-wise, and the planning of costs (the VoCa). They are compared to have an idea of the status of the project. • Working hours need to be filled out in time, to prevent a distorted image of the status of a project • Milestones are usually met, and planning is usually on track, and reliable. Project managers have a good idea about how far along the project is. • The work done is thus not calculated in percentages, but reviewed and assessed with the experience a project manager has. • The forecasting is most difficult for the engineering phase of the work.
7.	*Periodic re-estimation of time and costs is needed: if there is a **variance**, it should be assessed whether corrective action needs to be taken, and when such changes are authorized.*	• The prognosis that is made, shows whether there is a large deviation from planned budget or not. • If the deviation is a result of 'out of scope' work, an alteration form can be filed with AsM. If it is approved, extra budget is released for the project. • If (partly) standard VoCa's are used, risks need to be reviewed more in-depth, for there might be more out-of-scope work. • Deviations are not assessed for separate phases or activities, but ultimately for the total sum of the project. If one activity is 50.000 euros short, it is compensated by another activity having 50.000 euros left.
8.	*Value should be recorded as early as possible, all value has to be reported properly. **Reports** on project control are short, use defined criteria, and are made at defined intervals.*	• Value for materials is recorded as early as possible, when the obligation to pay them is made: they are put 'in obligo'. • Value for other materials, or working hours, are not always recorded as early as possible: costs are sometimes booked too late. • Costs are not always booked correctly. Hours or materials are booked on the wrong WBS elements, making it harder to review the status of projects • The distinction between working hours and materials is made in the VoCa (and in the prognoses VoCa-NaCa), but not in the SAP-system elements, where the costs are booked.

- Project managers report to their supervisor on a monthly basis. These reports are short, and use defined criteria.
- Project managers report to their project teams during project meetings. These reports are more 'ad hoc', and have no defined criteria.
- Tools for reporting are not optimized, but are improving. A concept budget reporting tool is being used now, helping project managers to review the status of their projects on a weekly basis.

5.3.2. EVM: Main Issues

From the results found for the aspects of control for EVM, some main issues can be defined:

1. **The control system is not incorporated**. Planning, costs, and work finished are assessed separately and compared to get an idea on the status of projects. It would be better if there is one overview of booked costs, working hours, planning and schedule. The tools to have such an overview are currently not in place, although the budget reporting tool that project management is starting to work with is a good start. There is a wish for more functions in SAP, to build projects: like building a proper WBS-structure, with owners for every work package, and the possibility to open and close activity codes.
2. **The structure of projects is not clearly communicated.** There is no uniform way of structuring projects. Activities are under-defined in terms of what they entail, and which budgets and activity codes are used. Detailing of the work is however hard to do up front, when a lot of information on the project is still unknown.
3. **Responsibility over the costs of activities need to be defined more properly**. It is now unclear who is responsible for the VoCa's that are made per discipline, and on the roles and responsibilities of project personnel. Especially the role of the project engineer is not properly formalized, as is the role of the SPT.
4. **Estimates need to be more uniform and formalized.** There is too much discussion on who estimates what, and on which activities are and are not included in the VoCa. It is not always clear where the estimates are based on, and better agreements have to be made to avoid conflict.
5. **Value needs to be recorded properly**. Currently, costs are booked on wrong activity codes, or booked too late, causing unreliable prognoses. Also, there is no appraisal of costs per category (either per discipline/department, or per materials/hours/third parties), but only the total sum of costs is of importance.
6. **There is friction between the functional organization and the project organization.** Evaluation of project personnel is only done by team managers for the departments working on projects, and working hours booked on projects are only approved by team managers, not project managers.

5.3.3. Wishes of Project Personnel

The results on the control aspects for EVM already incorporate some of the wishes project personnel has to achieve better cost control. In this section, some main issues raised by employees are described. Reviewing how project personnel feels about proper cost control, is helpful to establish the main issues on cost control. The wishes of employees are reviewed per department.

Asset Management

- The VoCa needs to be more exact: real costs need to be compared to budgeted costs for each element of work. Specific elements of work can then be better compared to each other.
- Final reports on projects need to be used to learn from finished projects for the future.

Project Management

- Project managers would like disciplines to be held accountable for their part of the budget. Or, if they stay responsible for all costs, they would like reporting from project engineers to them on what the status of their part of the work is; at this point they do not have a clear view of the lower levels in the WBS.
- Project managers would like to use a system that makes it easy to subtract the needed information from it, and would like this information to be uniform: everybody gets the same information. These reports from the system should be uniform enough, that project engineers also know how to use them.
- Project managers would like to have more knowledge about the SAP-system and how it can be used to see the information that they need than they currently have, or they would like to have someone in the project organization that does it for them.
- There is a need for more guidance and direction from higher management: management for E&P has changed several times in the past, project managers do not feel that there is a clear direction which they should follow.
- Project managers know that all the information they need for steering projects is available somewhere in the systems Enexis uses, but it is not clustered, and it takes too much time looking for all of it. There is a need for more user-friendly tools.

Engineering

- The structure of the project should be clearly communicated: engineers would like more insight on the budgets for activities, and be informed on what those activities entail.
- If engineers are held accountable for keeping the budget estimated for their discipline, they should be allowed to have a say about the estimate before the work starts. Furthermore, they need the tools to monitor that budget.
- Engineering would like to have a more clear and uniform process to follow: what forms are needed, how and when is communication on deviations needed.
- Engineering would also like the process of making a VoCa to be more formalized. Who is responsible for calculating which hours, to prevent counting work double.

Construction

- O&S would like more insight on the overall projects, instead of just budgets. They would like to see an overview of the hours planned compared to the hours spent, for example. They have a need for an integrated overview; this will also help them to guide their employees in projects: what is done well, and what not.
- The structure of the project should be clearly communicated.

5.4. Successes

Before the main issues are discussed, an overview of *successes* is given: which control aspects are in place, and what parts of the project process are currently going well already. The following control aspects are considered successful:

- **Project teams have regular meetings.** Project teams are meeting very regularly, on average every three weeks, but more or less regular based on the phase and progress of the project. According to Turner (1993) "meetings must have people invited because they have something to contribute, and holding review meetings at two or more levels of the planning hierarchy can aid this". Kerzner adds: "meetings are flexible and should be called only if positive benefits will result". The project team meetings at Enexis are currently flexible, and only involve those that need to be there for the stage the project is in, preventing unproductive work hours. All project personnel is currently satisfied with the amount and content of project meetings.
- **Project plan.** Although there are employees mentioning that the project plan is usually not detailed enough to calculate proper VoCa's for the plan, the lay-out of the current project plan is detailed enough according to literature. It is simply not possible to know the details of the work if engineering hasn't started yet. The main phases of the project are described in the project plan, which is correct according to the control aspects. Oberlender (2000): "The project plan must include a milestone schedule that shows major phases and areas of work, including critical due dates. An overall preliminary budget must be developed to guide the project". The current project plan meets all these conditions.
- **Milestones (and milestone planning).** There are not always a lot (or: enough) milestones in projects, but the most important milestones are always defined: the transition from one project phase to another, and the delivery dates of the main components of the station. These milestones are usually met: planning is going rather well. These main milestones are described in the initial project plan, and are the guidelines for the project team, who all know the important deadlines for a project .
- **Natural subdivision of work.** Although the WBS does not currently go into detailed levels about the activities of work, this does represent a somewhat natural subdivision of costs and activities. After all, the engineering phase is hard to describe in terms of activities and deliverables, and construction phase is dependent on the engineering phase. The WBS is therefore currently based on components: important material needed for the project. This shows a natural subdivision of the work.

5.5. Main Issues: overall

The overall issues, or main problems, are similar to the main issues concluded from the EVM aspects. The results for the Iron Triangle and WBS show overlap with the results for EVM, which is not surprising, since the control aspects defined for EVM touch many different areas, and since WBS is a precondition in being able to use EVM. The overall issues, derived from the results are therefore defined as follows:

- **There is no integrating control system in place, the WBS currently in use does not help to incorporate time, schedule and performance.**

- **The project structure is unclear, and no proper WBS is in place. Activities are not clearly defined.**
- **Responsibility and accountability over the costs of activities need to be defined more properly.**
- **Estimates need to be formalized and more uniform, persons responsible for estimating costs, need to be held accountable for those estimates.**
- **Value is not recorded properly. Costs are booked on wrong activity codes, or booked too late, and costs are not evaluated per category. Also, there is no appraisal of costs per category.**
- **There is friction between the project organization and the functional organization. This is also reflected in friction between the constraints cost and quality.**

6. Analyzing the Results

This chapter aims to put the results in perspective: how can the main issues be handled, and what are possible solutions. The reason for discussing the main issues before drawing the conclusion of this report, is that possible solutions to the current gaps are part of that conclusion. This chapter will start by discussing the situation at Transport South: this will help to reflect on the problems at E&P North, by comparing them to some similar issues at Transport South, and perhaps find some possible solutions. In section 6.2. the main issues are discussed somewhat more in-depth, and possible solutions or recommendations from literature are taken into account, as well as the solutions in place at E&P South.

6.1. E&P Transport South

Ultimately, Enexis wants to work towards more uniform processes within the organization. This research is carried out for the E&P department with Transport North (located in Zwolle), but there is another E&P department for Transport South (located in Weert, from now on will be referred to as 'South', or TP-Z), which carries out the same type of projects in the Southern part of the Netherlands. This department is mainly similar to TP-N, and deals with the same type of problems.

This section will give some details about the situation at TP-Z. In order to compare some of the results found for the E&P department in North, the departments will receive a short comparison, in order to see where they might learn from each other.

Brainstorm session

To tackle some of the problems E&P South was dealing with, they organized a brainstorm session. An important statement that was the starting point for the brainstorm session carried out at TP-Z is that "the common factor in the systems we have built over the years, is that they are built in order to show the data that is missing, or untraceable to us in the SAP system. It would be better to adapt the SAP system, but this is not possible at this point in time. It is something that needs to be addressed in the future, we will focus on the *quick wins* we can make for now" (Transport Zuid, 2013).

Important outcomes, or actions that resulted from the brainstorm session that connect to the findings in this report, are:

- The project engineers/budget holders will be made responsible for the prognoses for their part of the project
- Formalizing the project process, including roles and responsibilities.
- Make everyone in the organization aware of the importance of finances for projects (cost awareness)

Problems with the current systems in use, also show resemblance to the problems that E&P North runs into:

- Risks are not taken into account in the VoCa
- The SAP-system is complex, and not user-friendly
- The SAP-system does not incorporate the budget (VoCa). It would be helpful if the budget is part of the input for the project information in SAP.

From these problems and outcomes, it is already clear that Transport South is dealing with comparable problems: responsibilities are not clearly defined, and the systems are not user-friendly.

Differences

In this section, some differences in the way of working between North and South are discussed. It must be noted, that E&P South was only superficially reviewed, on main issues. No extensive interviews are carried out to dive into the problems for this department.

The project engineer

One important difference between North and South is the role of the project engineer. At transport South they are also called 'budget holders', a name implying more responsibility. There is a budget holder for Primary, Secondary and Construction. Although the name implies more responsibility, the same problems arise as in North: while the project engineer may be responsible, he is not held accountable, so the role should be formalized better over here as well (which is also an outcome of the brainstorm session). Another factor, which *is* different concerning the project engineers in North, is that the project engineers in South also incorporate the budget for activities in the construction phase of the project into the VoCa for their discipline. The overall budget is still the responsibility of the project manager, but project engineers calculate their part of the budget in consultation with the technical specialists. This makes sense, since one of the outcomes at E&P North was also that O&S is too much dependent on the engineering work to be solely held accountable for their calculations. This structure may therefore also be something to consider for the projects at E&P North.

The SPT

At TP-Z there is no Small Project Team for projects. There is no role like 'senior project engineer', but the way a VoCa is calculated is mainly the same: a specific engineer for each discipline (Primary/Secondary/Construction) is delegated to the project, and technical specialists for both disciplines of O&S are delegated to the project as well. The group of people making the VoCa and project plan is therefore very similar to the SPT, except for the fact that there is no senior project engineer specifically responsible for reviewing projects. The project engineers estimate the largest part: all materials for the project, and the hours needed for engineering. Technical specialists also estimate the hours they need based on the project plan, and the project engineers take them into account. The way of working is therefore relatively comparable.

Evaluating project personnel

As opposed to E&P North, in South engineers are also evaluated by the project manager for the work they do in projects. As the project manager in South explains: "we fill out an evaluation form, rather 'cold' in fact, but based on the form we plan an appointment with the engineer to discuss the evaluation shortly. I try to explain positive as well as negative points. If the engineer does not agree with me, I also make notes about his point of view. I send the filled out form to the engineer himself, as well as his team manager. I think it is an improvement of the way we did it before, because now I don't just complain to his team manager, but first discuss problems with the engineer himself". This difference may be of some importance, for it deals with the friction between the functional and the project organization.

VoCa

E&P South uses standard values for their estimates. Standard VoCa's are used for all projects, and are basically a checklist of activities that are/are not included in the project: if every activity is reviewed on being included in the project or not, the estimated costs for the project are somewhat 'automatically' derived from that checklist. This does mean that complete costs for a project may derive more from the initiate estimate. Overall, the sum of these deviations should stay around a mean of zero. This is different from the approach at E&P North, where estimates are usually rather custom-made, but therefore also generally a more exact estimate.

Prognoses and reporting

In forecasting complete costs, the same problems occur as with E&P North. The SAP system is also not structured with defined activities, and it is not possible to attribute owners to those activities, or determine who can or cannot book costs to those activities. Just like at E&P North, most project managers never had a course in how to use SAP. For reporting and forecasting, E&P South has recently started using a new budget reporting tool, that they are very happy with. It is more detailed, in terms of costs and working hours than it was before. The budget report should eventually also visualize the information in tables and S-curves, providing a direct overview of project status.

The problem of persons booking costs on the project that are not allowed to do so, or that book costs to the wrong activity codes is also encountered at E&P South. Problems concerning prognoses and reporting are therefore also assigned mainly to non-user-friendly tools, that do not support or fit the work done on projects well enough.

Use of this information

The process of projects is overall largely the same for E&P North and South (as far as this can be concluded on such a short analysis). The differences mentioned in this section, are those differences that may have implications for this report. They are used in the discussion of the results, and for the purpose of finding suitable solutions for the future.

6.2. Discussion

This section will show and discuss the main issues that are derived from the results. Each issue is shortly discussed, including possible solutions or advice taken from literature and from the interviews at Enexis. Each section is followed by a short conclusion, which summarizes the findings. These will ultimately lead to recommendations given in chapter 7.

6.2.1. Incorporating system

There is no integrating control system in place, the WBS currently in use does not help to incorporate time, schedule and performance. This was actually a given starting point for this research, so the results are not a surprise. However, it needs to be said that the control system (software) was mentioned in practically *every* interview as problematic. It is a point of frustration for many employees with E&P: "I know that the SAP system can be designed to allocate budgets to the disciplines. For one reason or the other, we do not make use of it", "the information is all there, but if we would have a system that combines all that information, then we can implement all kinds of project control much better". There is some disagreement among project managers about how possible it is to use the current SAP-system for this purpose. One of them mentions that other systems (which he has knowledge of) are just as worse, while another mentions that it may work much better if all functions are used to their full potential.

According to Oberlender (2000): "the automation of the concept of an integrated project control system has become widely discussed (…). Common among the approaches is development of a well-defined work breakdown structure (WBS) as a starting point in the system". The WBS is the current starting point of the planning and controlling in the SAP-system, although it may not be that well-defined. Kerzner (2001) mentions about the importance of incorporating time, cost, performance: "the WBS is the total project broken down into successively lower levels until the *desired* control levels are established". It is the thus starting point for an integrating control system. The current SAP-system is used to book costs to the WBS-elements (activity codes), but only on a very high level. Activities in the WBS are not defined in terms of budget, planning and activities. It is advisable to have the E&P department think about how they would want the WBS to appear and be used in the control system: what are their *desired* control levels?

The inappropriateness perceived by project personnel of the SAP system for project control, is not surprising according to Kerzner (2001). He mentions no less than 14 difficulties in implementing mainframe software packages for project management. In fact, according to Kerzner, they are even harder to implement than small software packages, since everyone is requested to use the same package. This is also true for Enexis, where SAP is the overall system used in the entire organization. Departments, and even individual employees use their own reporting tools to 'fill the gap' of a proper working incorporative system. Some of the difficulties that Kerzner (2001) mentions, may be of importance for E&P:

- "*Upper-level management may not demonstrate support and commitment to training":* According to Kerzner, ongoing training is a requirement for successful implementation of a software system. The project managers at E&P have mentioned to never having had any type of training for the SAP-system, let alone ongoing training. This may prove to be an unexploited opportunity by management.

- *"Clear, concise reports are lacking":* large mainframe packages can generate volumes of data. This is also one of the factors mentioned by project personnel: the SAP-system is great at dealing with large quantities of data (which is of importance for the other divisions of Enexis), but lacks specific features for specific projects. It is advisable to establish what kind of reports users would want the control system to show, as an outcome of the input data, so it can be established which input data is essential, and which reports are most useful.
- *"Sufficient/extensive resources (staff, equipment, etc.) are needed":* in the implementation phase, large mainframe packages consume a significant amount of resources. Although the SAP-system is already in use at Enexis, incorporating all functions and wishes needed for proper project control in the system, requires an intensive amount of time and energy: is it worth the costs?

At E&P South, the exact same problems are perceived with the SAP-system. The conclusion of the brainstorming session even was: "the common factor in the systems we have built over the years, is that they are built in order to show the data that is missing, or untraceable to us in the SAP system. It would be better to adapt the SAP system, but it has proved to be not possible for now. It is something that needs to be addressed in the long term, we will focus on the *quick wins* we can make for now". As a short-term solution, E&P South have decided to extend their budget reporting tool in Excel, including subdividing costs per discipline and per cost type (materials/hours/third parties). A similar solution is currently already in place at E&P North as well.

In the long term, it will be definitely advisable for E&P to improve the overall control system (SAP, for it is used throughout the entire organization, or perhaps a specific project control ERP system, if that is what they will opt for in the future), so that it includes the current wishes of project personnel. An integrating system should then make sure that less time and resources are spent on project monitoring and control, and that data can easily and efficiently be overviewed and compared.

Conclusion:

- What are the *desired* control levels: what information does the project team, and the project manager in particular, want reports to show. This information may be already available in the current budget reporting tool.
- In the long term, it is advisable to improve the overall control system SAP, for all information is available in the software, but it is currently unknown how to extract the right information from the system.
- Employees need training on how to use SAP, so that the opportunities of the system will be used to its fullest potential.

6.2.2. Project structure

From the results, it can be concluded that *the activities in projects are not properly defined, and the structure of projects is not clearly communicated.*

On the **project structure**, it can be concluded that the WBS should be the basis for the incorporated control system. Besides, it is also mentioned as the basis for being able to implement Earned Value Management, as well as other project control methods like CPM or PERT for planning. Currently, the activities in the WBS are too large, and on too high levels to be manageable. Activities are not

properly defined, and the ultimate project structure is not clearly communicated to the project team, who do not always know which activities belong to which elements.

Some employees wonder if the WBS should be defined into such detailed activities for lower levels. Kerzner (2001) mentions on this point: "Breaking the work down to small work packages can provide accurate cost control if, and only if, the line managers *can* determine the costs at this level of detail. Line managers must be given the right to tell project managers that costs cannot be determined at the requested level of detail" and: "at low levels of the WBS, the interdependencies between activities can become so complex that meaningful networks cannot be constructed". The project manager himself should not develop the WBS to lower than the upper three levels. The 'contractor' (in this case: the respective department) is required to extend this preliminary WBS (Kerzner, 2001). The top three levels are thus the same for all projects. The lower levels differ per project, and should, in this case, be filled out by the SPT or the persons responsible for those work packages.

The challenge for the E&P department is to design a WBS for projects that has the right amount of activities for project control. As Turner (1993) stated, some projects are planned at a detailed level only, encouraged by computer software, while others are planned only at a very high level and there is no coordination. The kick-off meeting is now used as an orientation for team members about the project. Oberlender (2000) explains that each team member is also responsible for the development of one or more work packages for the work he will perform, including a detailed description of the work including time, budget and scope. To be effective, all the aspects of the project need to be integrated; the work to be done, who is going to do it, when it is to be done, and what the cost will be (Oberlender, 2000). A WBS will thus help to create the integrative system discussed in the previous paragraph, in order to be able to perform forecasting of the final project results.

More sub objectives should thus be defined by the respective responsible persons delegated to lower levels of the WBS. "By defining sub objectives, we add greater understanding and, it is hoped, clarity of action for those individuals who will be required to complete the objectives. Whenever work is structured, understood, easily identifiable and within the capabilities of the individuals, there will almost always exist a high degree of confidence that the objective can be reached" (Oberlender, 2000).

A formalized process is needed, which describes which activities belong to which WBS elements and –codes. It needs to be clear who is responsible for the activities, and the project structure needs to be similar for each project/designed according to pre-arranged criteria, so there is less confusion on what activities the project entails, and so that everybody in the project team knows how the entire project is structured, and what role he has in this whole.

Conclusion

- The project manager should only be responsible for controlling the upper three levels of the WBS.
- Activities in the WBS need to be defined properly: uniform agreements on which activities belong to which WBS elements and codes, and who is held accountable for them.
- The process of building a project structure needs to be formalized further.

6.2.3. Responsibility and Accountability

From the results, it can be concluded that *responsibility over the activities and their costs need to be defined more properly.*

A much used proverb on project management states (author unknown): *too few people on a project can't solve the problems – too many create more problems than they can solve.* At Enexis E&P, there are enough people working on projects, but almost none of them are responsible or held accountable for the progress of that project, only the project manager. In the current situation, it may therefore be true that there are 'too few people on projects to solve the problems'.

It has become evident that people assigned to the project, need to take more ownership of the activities that they have responsibility over. Oberlender (2000) states that "serving on the owner's project management team are project managers who are responsible for leading lower levels of teams that are responsible for engineering design and construction of the project", and although each team performs a different function, they need to develop an attitude of shared ownership in the project. Kerzner (2001) adds that functional managers usually have more expertise, and can therefore identify high risk areas. "Both the project manager and team members must understand fully the responsibilities and functions of each other, so that total integration can be achieved as effectively as possible".

An important factor in this for Enexis E&P is the **role of the project engineer, that is currently not properly defined**. Kerzner (2001) mentions that "on high-technology programs, the chief project engineer assumes the role of deputy project manager". This is also the way Enexis E&P wants to approach their projects, only most personnel feels that there is a lack of direction in filling out the roles in the project team more strictly, especially concerning the project engineer. Project managers struggle to control the total costs of projects, for they do not always know exactly the specific progress for each engineering discipline.

At E&P South, project engineers are also 'budget holder' for their respective discipline, although their role is rather undefined as well. However, the name implies the direction most project personnel would want the role of project engineer to take: a specialist project leader for their discipline, who has more insight on the work needed for their respective field in the project, and is therefore responsible for that part of the budget (that they have also estimated). Project engineers are currently not held accountable for the part of the budget for their discipline, and making him responsible for it may also help to have the costs and progress reported properly, and costs booked under the correct activity codes, for they are closer involved in the work. However, project personnel states that project engineers should then also receive the tools and knowledge that will help them do so.
Also, it may be advisable to make the project engineer also responsible for the budget of construction work for his discipline. As was discussed in the results, this is already the way of working at Transport South, and it makes sense, since O&S is very dependent on the engineering phase of the project for their budget and planning. It is therefore advisable to look further into this possibility: how is this way of working currently functioning for Transport South, and what do project personnel at Transport North think about it.

Another area at Enexis E&P that needs more formalization, concerning responsibility and accountability, is the Small Project Team (SPT). The SPT was initiated to have experts with much knowledge

and experience assess projects and feedback the information within their departments. Currently, the SPT usually only has one project meeting, when a project is initiated. This is not enough to share proper feedback, or learn from experiences on projects in the past. An evaluative meeting when the project is finished would help to assess whether estimates were realistic, whether all risks had been taken into account, and to review how similar projects should be handled in the future.

Conclusion

- The role of the project engineer needs to be formalized and defined more clearly.
- The role of the SPT needs to be reconsidered.
- Project team members should have full knowledge on the project structure and activities, including the roles and responsibilities of themselves and others.
- Defining work packages (in terms of activities, budget, man hours, responsibility) are the responsibility of the respective department.

6.2.4. Estimating

Estimates need to be formalized and more uniform, persons responsible for estimating costs, need to be held accountable for those estimates.

From the interviews, it has become apparent that AsM wants a more exact VoCa, for they fear that projects are estimated higher on purpose, to prevent negative project results. But at the same time, they also have the wish for more standardized estimates, to be able to compare projects to each other, or the work on specific parts of a project. This would help to assess whether projects are carried out effectively and efficiently. This shows that their true wish may not be to have even more detailed estimates, but instead have more exact expenditures, that estimate where the money is spent on: how much did each phase and discipline cost? And what part of the budget was spent on hours/materials/third parties? This may also help to achieve more accurate (historical) data to estimate the costs for future, similar projects.

Currently, the estimate (VoCa) is made together with the project plan by the SPT, before all work has started. The margin of error for the estimates is 5 – 10 percent. Different persons within a project team each estimate the budget for their part of the work. Estimates are made by the project engineers, who report to the senior project engineer, and the technical specialists with O&S. It is not always clear who estimates what, so some work may be estimated twice in one project. Also, costs of engineering are hard to estimate when the work has not started yet: it is unknown what issues may arise during the project. The same is true for the construction phase of the work: the O&S department is very dependent on the engineering phase (in which materials are ordered, for example) for their part of the work.
While each discipline or department estimates their part of the work for specific activities, they are then put together on to one big pile, without being able to evaluate the accuracy of the estimates in hindsight: the budget may have been spot on, but it is still possible that costs for construction were a lot higher, but that this is cancelled out by the work on, for example, detailed engineering that turned out a lot lower.

A more standardized VoCa with budgets per phase and activities might be a solution, but some employees think it may cause problems: they state that the work is not standard, but specialized for each separate project carried out, and the situation per station differs. However, to make the process

of estimating more efficient, but also easier to evaluate in hindsight, more formal guidelines for the estimates are needed. Oberlender (2000) underlines this: “in the early phases of design development, there may not be sufficient information to define the scope accurately enough to know the work to be performed”.

However, since the scope of the work may not be completely defined at the time the estimates are made, it is hard to have very accurate estimates at that point in time. According to Kerzner (2001) and Oberlender (2000), there are three kinds of estimates for different phases of the work. The first are *order-of-magnitude estimates,* used in the planning and initial evaluation stage of projects, for level 1-2 of the WBS. These estimates have an accuracy of 30 – 50 %. The second type of estimates, *semi-detailed* or *budget estimates,* are used in the preliminary or conceptual design of projects, for level 2-3 of the WBS and their accuracy is in the range of 15 %. The third type, *detailed estimates* are the only one with accuracy of 5 – 10 %, used in the detailed engineering and construction phase of projects, based on specifications, drawings, site surveys, and in-house historical records (Oberlender, 2000; Kerzner, 2001).
This information shows that it is impossible to have such an accurate VoCa as is currently strived for (a margin of 5 to 10 percent for the total project costs), so early on in the project’s life. Only the final detailed estimates can be this accurate, but they cannot be made earlier than at the end of the engineering phase.

So, it can be concluded that the current estimates strived after by project management, exact VoCa’s with an accuracy of 5 – 10 percent, are unrealistic. Literature states that it is not possible to have all the information needed about the project at that stage. This is underlined in the interviews with E&P employees, who state that it is hard to know the exact activities up front.

Oberlender states that “during an early stage in project development, the design engineer must convert the sponsor’s project definition into an engineering scope of work. However, the design engineer may feel the sponsor’s definition is inadequate or there is missing information”. He adds that in those situations, the engineer must define the scope of his part of the work to the best of his ability and develop a budget and schedule based on that assumed scope of work, documenting and communicating the assumptions that were made about the work. When there are changes in the scope of work, the project manager or project engineer should communicate this as soon as possible with the project’s sponsor (AsM for E&P). Changes in scope can then be used to apply for extra resources (Oberlender, 2000). This way of working, with scope changes, is already in use at Enexis E&P. It is important to keep it in use when standard VoCa’s will be used. Instead of very exact prognoses, the VoCa’s should include *risks:* describing which changes in scope or changes in the project context, will cause which risks concerning the budget.

Conclusion

It can be concluded that more standardized estimates, based on clear guidelines, are needed. It should be added however, that these estimates will be less accurate: more room needs to be created in the current margin of error for a project manager, if standard VoCa’s are used. Risks of possible changes in the project situation should therefore be taken into account in the project plans and VoCa. Estimates may be somewhat more off in the future, but in return they will become more comparable and easier to evaluate.

6.2.5. Recording value

***Value needs to be recorded properly**. Currently, costs are booked on wrong activity codes, or booked too late, causing unreliable prognoses. Also, there is no appraisal of costs per category (either per discipline/department, or per materials/hours/third parties), but only the total sum of costs is of importance.*

As already mentioned in the previous paragraph, there are no budgets for costs per category in the current VoCa's. Kerzner (2001) explains why it is important to separate material and labor costs to be able to use the EVM correctly. The actual and budgeted costs of work performed are used to calculate the estimate at completion, and differences in labor and material costs may be essential. Since one of his examples clearly shows the risks of not separating labor and material costs, it is considered useful to show this example here, to show what the risks are of not separating those costs:

Labor:		For simplicity's sake, the following formula is used: **EAC = (ACWP/BCWP) x BAC** Therefore, EAC(labor) = $900.000 and EAC(material) = $675.000 If both EACs are added together, the estimated cost at completion will be $1.575.000, which is $25.000 *below* the planned budget ($1.600.000 total). But if the costs are combined before the EAC is calculated, then: EAC = [($450.000 + $90.000)/$500.000] x $1.600.000 = $1.728.000, which is a $128.000 *overrun.* Combining the costs may thus lead to a different estimate at completion, making it important to separate labor from material costs.
ACWP	$90.000	
BCWP	$100.000	
BAC	$1.000.000	
Material:		
ACWP	$ 450.000	
BCWP	$ 400.000	
BAC	$ 600.000	

***Example NO##:** Separating labor and material costs for calculating EAC (taken from Kerzner, 2001, p.848-849)*

For Enexis, this is of importance, for they do use the separation of costs in *monitoring* the costs: working hours, material costs and third parties are tracked separately and the prognoses are based on them. However, when there is an overrun for one of those type of costs, but it is expected that there will be budget left somewhere else, than these differences cancel each other out. So while the costs are monitored separately, they are combined into a total budget when comparing it to the original VoCa. This means that opportunities for cost reduction for specific types of costs, or phases in the project may be overlooked.

Another problem is that value is not recorded properly for projects. Costs are booked too late, or booked to the wrong activity codes, which leads to unreliable prognoses. Kerzner (2001) explains more on the cost account code breakdown, related to the WBS to solve these kinds of problems. The way it works is made clear by figure 6.1:

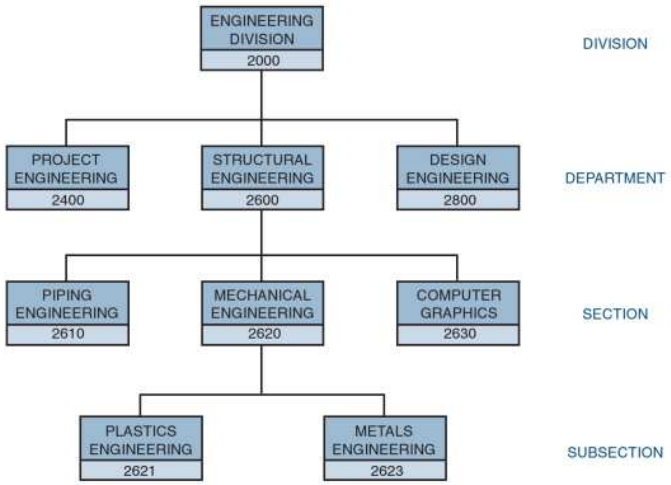


Figure 6.1.: *Cost account code breakdown (Taken from Kerzner, 2001, p.823)*

The cost account code breakdown shows the cost centers related to the WBS. In short, it works as follows: if the man-hours are assigned to cost center 2400 (in the estimates), then any 24xx cost center can use the charge number. If it specifies cost center 2610, then any 261x cost center can be used, and if 2623 is specified, then no lower cost accounts exist and this is the only cost center that can use this work order charge number (Kerzner, 2001). In other words: *if a charge number is opened up at the department level, then the department manager has the right to subdivide the assigned man-hours among the various sections and subsections."*

Using this structure will lead to an automatic output of working hours per category. Making it work efficiently is however still reliable on employees filling out their hours in time. Also, the greater the number of charge numbers that project personnel can book hours to, the less likely it becomes that it is filled out correctly. Most personnel will find it hard to remember how much time they have spent exactly on each task. It is therefore advisable to use no more than three to four charge numbers for each project member to use.

The next thing that needs to be derived from reporting, and recording value, is the *percentage complete,* which is needed to derive an estimate at completion (using EVM). Clear agreements have to be made on how this is done, especially on how work-in-progress is measured: the 50/50-rule mentioned before may be helpful (activities started, but not yet finished are all estimated as half complete). Still, it is hard to measure certain activities, especially engineering. Oberlender (2000) underlines the problems in progress measurement of engineering design: "measuring progress of design is difficult because design is a creative process. Considerable time may be expended in the design effort without seeing any physical results". As a solution, Oberlender (2000) recommends milestones in the design schedule, like a 60% design complete milestone for example. There must then be agreement between the project manager and the engineering team on how this 60% is defined.

Conclusion

It can be concluded from this information that formalization is advisable: how are costs and working hours booked to the project, who books them, and how is the percentage complete defined? Every-

one working on a project has to agree on these issues, and the way they are handled need to be clear to everybody and communicated properly.

- A cost account code breakdown is advisable: making it possible to open and close cost accounts, as well as determining who can book costs/hours to a project.
- Labor costs and material costs need to be recorded separately. Not only in monitoring the project costs, but also in estimating the total costs at completion.

6.2.6. Project organization vs. Functional organization

From the results, it is concluded that there is *friction between the project organization and the functional organization.* It was already stated in the definition of project management that this is very common.

Turner (1993) mentions on the friction between the project and functional organization, that project personnel is sometimes placed in a difficult position, for they have reporting lines to two people, a short-term (project) boss, and a long-term (functional) boss: “Although the project manager tries to motivate the individuals towards the project goals, they often give their primary loyalty to their functional manager. It is that manager who writes their annual appraisal, and has greatest influence over long-term career development” (Turner, 1993). It is also mentioned by project managers, that feel that they have little control over employees in project teams, for they are not the ones evaluating them.
Kerzner (2001) mentions that “the willingness and ability of project team members to give feedback to each other regarding performance” is an important part of project control. The evaluation method used at Transport South may be a solution: the project engineer is also evaluated by a project manager. But, in order to obtain constructive feedback, it may also be advisable for Enexis E&P to make more use of the knowledge of the SPT, and to have some guidelines and agreements on how the project as a whole is evaluated, but also how project personnel and SPT members can be evaluated separately in the process. The senior project engineer might function as the ‘bridge’ between the project manager and project engineers, evaluating their teamwork.

Globerson and Zwikael (2002) mention that “the project manager is directly accountable for the scope definition process, the major output of which is the WBS. However, he will not be able to carry this process out effectively without the cooperation and the knowhow of functional managers”. According to Kerzner (2001), the solution to friction in the organization is for the project manager to provide the technical direction *through* the line managers: “After all, the line managers are supposedly the true technical experts”. Good communication between project managers and functional managers is therefore highly recommended. Project managers need to ‘outsource’ any work packages below the upper three levels of the WBS to functional managers, or the ones defining the work packages for those levels.

Conclusion

- Some formalization is needed on how project teams are evaluated: more communication between project managers and functional managers is needed to make agreements on how this is done.
    - The SPT may play a role in evaluating project personnel, or the way E&P South currently evaluates project engineers may be used as an example.

- Project managers should only concern themselves with the higher WBS levels of a project, that define the main project phases. Smaller work packages are the expertise of technical specialists, that have the knowledge to review those elements.

SECTION IV - CONCLUSION

7. Conclusion & Recommendations

The objective for this research was to analyze the current project control system for the department E&P, focusing on budgeting. This was done by measuring the control aspects defined from literature, and review which aspects are not (fully) in place yet, but are essential for monitoring and controlling project costs.

Section one of this thesis has described the organization and its departments, in order to understand the environment in which projects are carried out. Then, the goal and objectives of the research were presented.

The first objective of the research was to *describe the current process for carrying out a project at Enexis E&P.* Chapter 2 has described the process of a project in terms of the four project stages (preparing, engineering, construction and completion) and the persons and departments involved in those stages. Enexis has a process model in use, which describes the steps taken during projects.

The following objectives were to *find out how project costs should be monitored and controlled, according to literature on project management*, and *defining control aspects deducted from the most important concept found in literature: what preconditions should a proper project cost control system meet?* In chapter 3, important literature on project (cost) control is reviewed, from which the Iron Triangle, WBS, and EVM are used to review more in-depth. These theories were considered useful in assessing the current situation at Enexis E&P, and in Chapter 4 control aspects are deducted from literature on those theories.

The aspects of control are discussed during interviews with the main persons involved in projects, in order to reach the objective *describing if and how these aspects are currently in place at Enexis E&P.* In Chapter 5, the results derived from these interviews show a summary of the aspects and which are, and are not in place (they are discussed more in-depth in Appendix VIII). This chapter has therefore also reached the objective of *analyzing the aspects that are missing*.

The second to last objective, *analyzing the opportunities that are still un- or under exploited in the current situation*, was done by analyzing the results in chapter 6. The situation at Transport North was compared to Transport South, and possible solutions from literature on the missing aspects are reviewed and discussed. This has led to the final conclusion of this thesis, and the answer to the main research question.

7.1. Research Question

Analyzing the current project control system for the department Engineering & Projects at Enexis, focusing on budgeting: what opportunities are there to improve the monitoring and control of project costs?

The results for this research were derived from interviews with project personnel. Some overall questions on projects and their progress were asked, followed by presenting and discussing the de-

fined aspects of control for WBS and EVM. The aspects of control that are currently not in (proper) use, are defined as the opportunities for improvement.

Overall

First of all, the overall conclusion for all project personnel is that they are pleased with the cooperation between departments and that they are all open to suggestions for improving project control in the future. Frustrations that may arise, and that were discussed during the interviews, are mainly due to the different views of different departments regarding projects, the unclear responsibilities of persons in project teams, and the under-defined process of a project

The first gap to close is therefore: *higher management should give more attention to supporting the project organization in place*. All personnel working on projects would like to know more exactly what is expected of them, but most of them feel that it is not a priority of management, and therefore do not prioritize it themselves. Change initiatives from personnel themselves are therefore usually snowed under by the daily routine. It is therefore recommended that higher management, perhaps supported by the new organizational form, gives priority to structuring and defining the process for projects more clearly.

Control aspects

The main conclusion drawn from the Iron Triangle, and accompanying trade-off theory, is that there is a friction between the constraint **costs** and **quality.** Overall, quality is valued important by all project personnel, but since project managers are evaluated mainly on project costs, and the engineering and construction (O&S) department are not, this causes friction: the project manager is held accountable for the complete costs of projects, but is dependent on the other departments to keep those costs in line. This is also one of the causes for the friction between the functional organization and project organization: project goals are not aligned with functional goals.

From the control aspects measured for the WBS, it is concluded that the current WBS is not properly used. The 'work packages' in the current WBS are considered to be too large to be properly manageable, and the activities of projects are not completely defined. They should not only be further defined into tasks and measurable deliverables, but also in terms of responsibility: the project manager is now held accountable for the entire project, but specialists should have responsibility over the work packages, for they require technical expertise, and also so that the project manager can monitor the upper three (main) levels of the project to be able to take corrective action when it is needed. It is hard to detail the activities up front, when some information on the project is still unknown, but using a standard WBS for projects (on the highest levels) will help to standardize and uniform the way of working, and preventing costs booked to the wrong WBS elements.

The WBS is very important as a project structuring method: it is also the basis for the integrative control system that is needed to apply EVM. The WBS summarizes planning, costs and performance per task and activity, integrating all the information needed for applying EVM into one structure. The lack of a proper incorporating system is mentioned by most employees as a problem. However, project managers feel that they have a rather good grip on the progress of projects through controlling methods they have developed over the years. Currently, a budget reporting tool is in place at E&P North and South that fills the gaps that the current SAP system leaves. It is recommended that this budget reporting tool is developed further (and that E&P North and South meet up to design an ide-

al, combined tool together), as long as the SAP system is not optimized for project control. However, it is definitely recommended that these optimizations in the SAP system for building a complete project control tool are developed in the near future, for all costs and working hours are also booked through SAP – it is the system that should ultimately provide project personnel with the incorporating project control system EVM prescribes.

Incorporating planning, costs and performance is of importance in applying EVM for costs should not only be compared to their estimates, but to some value of the amount of work actually done. Therefore, EVM requires an assessment of the percentage of work finished, and the work-in-progress. To be able to do this, input information from the WBS is also needed – the activities and tasks finished (in the WBS) will help to derive a percentage complete.

To be able to derive the percentage complete, it is also important that value is recorded properly. This is not always the case in the current situation: working hours are booked to the wrong activity codes (or even the wrong project), or are booked too late. This causes unreliable prognoses; well-defined activities, in terms of planning, scope, costs, but also corresponding activity codes, will help to have value recorded under the right cost accounts. The system used is also of importance here: it would be desirable for project managers to be able to open and close cost accounts in the WBS, or prescribe which persons are allowed to book costs to certain codes.

Also, the current VoCa, or estimates, that are made need to be more uniform and formalized. It is not always clear who estimates what, and which activities are or are not included in the estimates. Clear agreements have to be made on who is accountable for different parts of the VoCa. It is advised to implement a more standard VoCa, for project teams are currently spending too much time on trying to include each little detail. Literature prescribes that the current margins of error (5-10%) for estimates in relation to the final project costs, are unrealistic. This level of accuracy cannot be estimated earlier than when design engineering is almost finished. Standard VoCa's will help to be able to compare projects, and derive lessons learned, but also possible risks form previous projects. Standard VoCa's are a wish of AsM and higher management, and can prove to be a good solution, if formalized agreements are made about how they are used, and if the room for error for the estimates made by project management is expanded.

Another important issue that needs formalization, is the role of the project engineer. This role was introduced to have budget holders for lower levels of the WBS: the disciplines (Primary, Secondary, Construction) included in the project that require specific technical expertise. Project engineers draw up a VoCa for their part of the project, and these are summed up with the other sub-estimates to the total estimate. However, the project engineer is usually not held accountable for his part of the budget, the project manager is, but he does not have the knowledge of that part of the process. The role of the project engineer should therefore be formalized in clear agreements.

7.2. Recommendations

In this section, recommendations are done that may help to fill the 'gaps', for control aspects currently not (fully) used at Enexis E&P. The recommendations are based on the discussed results and solutions, as well as the wishes of project personnel. Many of the recommendations made supplement each other; they will be elaborated on in the following sections, and summarized to describe clear, concluding recommendations.

This section aims to answer the research question w*hat improvements can be recommended to the current processes for projects, in order to improve the monitoring and control of project costs?*

Formalization

The process of projects need to be formalized further. This was one of the outcomes of the brainstorm session at E&P South, showing that there is already an identifiable need for a more formalized way of working. The interviews with E&P personnel at Enexis Transport North have also shown that there is a clear wish for more uniform and structured information. The project process should show what steps are needed for every project, and who is responsible for those actions. One of the most important elements to define more clearly for all projects is the WBS.

WBS

A WBS is mentioned by all authors on project management as highly recommended. This is underlined by the fact that the WBS provides the input to other control techniques for scheduling, but also EVM. The current WBS at Enexis only describes the three upper levels. This is correct in the sense that the project manager is responsible for those levels (and is currently the only one responsible for project cost control). From here on, agreements have to be made on how project teams would like a WBS to be structured.

A recommendation that can be made, is for E&P to **start using a standard WBS structure for all projects.** This WBS may look as follows:

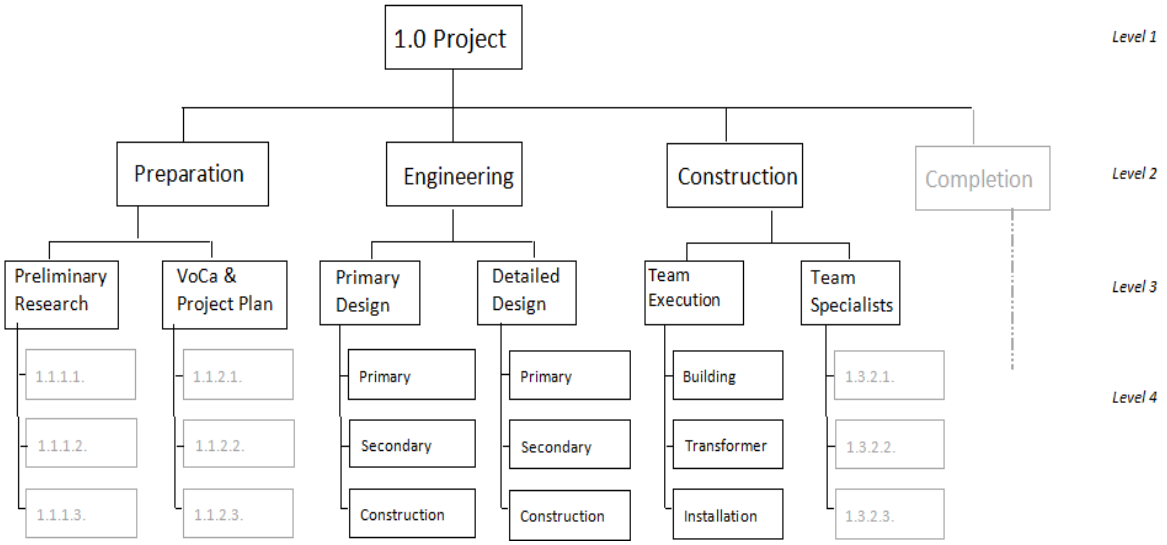


Figure 7.1.: *An example of a WBS for E&P*

First of all, it is import to consider this as an *example.* How tasks should be subdivided and into which elements or activities, should be decided on by the project team and project managers. However, the example shows a rather *natural* subdivision of costs: each project phase becomes a WBS element at level 2, and the sub-stages of those phases, or the responsible teams, become a WBS element at level 3. From here on, the persons responsible for those teams or stages in the project, can define their own sub-project WBS for the respective work packages: an example is given by subdividing the engineering designs into the engineering disciplines, and the construction part of the work into the main components of the power stations. However, work packages can be defined for each element at level 4 and below.

Those work packages should then be filled out by the person delegated to that work element, for that stage in the project (which is preferably a project engineer). Activities can be further subdivided in subtasks that follow each other (probably especially useful in the construction phase), or in working hours/materials/third parties. The respective departments also have the right to say that costs *cannot* be determined for these lower work packages (which may be true for engineering, for example), but than they are still responsible for that one work package in terms of budget, costs, an resources.

Most important is to **define a formalized basic WBS for projects**. The upper three levels should be controlled by the project manager, and can be made standard to fit *all* projects. **The project manager is responsible for designing the WBS**, and may make use of a 'checklist': checking boxes for elements that are, or are not included in the project, fitting them into the standard WBS automatically. The basic WBS is needed to be able to always use the same numbers for WBS-elements (designing the project plan, for example, is always the same number). This will prevent confusion among project personnel, who will know after a while on which exact number they can book their working hours. More importantly, since departments will design their own work packages, they will automatically have more ownership over those work packages. Making one person accountable for each sub-activity also makes sure that that person feels responsible for its budget and schedule. **Activities should have defined cost account numbers**, that are used for each project in which the activity takes place. For each project, the project WBS should be designed together with the project plan and VoCa.

An integrating system

As concluded and discussed, the current project control system in use (SAP) does not integrate time, schedule and performance. The budget reporting tool is currently used to combine project data derived from different software programs. The following recommendations can be done:

- **Perfecting the current budget reporting tool**. Both E&P North and South are currently using a (rather new and improved) budget reporting tool in Excel, that incorporates planning, costs (derived from SAP), and forecasting. It would be very useful if **both departments have a meeting to discuss what information they need,** and what the reports resulting from this tool should show. Both budget reporting tools can be combined into one integral overview, including the best of both current tools. This recommendation, should however be considered a 'quick win' (as it is at Transport South), for in the future, Enexis E&P definitely needs one integrated control system, holding all the data needed.

- Project personnel (especially project managers) need to be **trained in how to use the SAP system**. SAP is the overall system used for all Enexis, and the E&P department may be able to derive more useful data from the system, if they are learned how. Currently, almost nobody at Enexis E&P ever had SAP training. It is recommended to look into possibilities for having a SAP professional, specialized in project cost management training E&P personnel.

Future:

- In the long term, there should definitely be some more research done for an **integrated system.** The SAP system should be able to include the wishes that project managers and personnel currently have (who is able to book costs, closing activity codes, hanging booking codes to activity codes, etc.), and assessing the information they need from such a system; implementation of these integrating activities should definitely become a priority in the future, for it is *the* precondition for proper cost control. Moreover, the WBS that is highly recommended can then be designed in SAP and filled automatically.

Estimating

VoCa's (estimates) need to be more standardized and uniform. Currently, project managers (and –teams) aim to make a tailored VoCa for each specific project, which is understandable for the estimate needs to be very reliable so early on. However, literature has shown that it is impossible to know the exact project structure and activities when the project has not started yet. Because of this, and also in order to estimate risks properly (from occurring in the past), the VoCa needs to be more standardized. This also means that at such an early point in time, a margin of 5-10 % for the final project result is not reasonable. According to literature, the level of accuracy cannot be more exact than +/- 35%, at such an early stage of the project (when no design work is done yet). It is only after detailed engineering is finished, that it is possible to decide on an estimate (at completion) that has a margin of error of +/- 10 %. More standardized VoCa's can therefore only be implemented, if higher management also adjusts there expectations of the reliability of the first estimate (VoCa).

Responsibility:

One of the main issues derived from the results, is the lack of formalized responsibility and authority over project activities. The project manager is currently held accountable for the entire project. There are two recommendations that can be made to improve the situation:

- **The role of the project engineer needs to be clearly defined**: what are their responsibilities? The project engineer should become the 'budget holder' for his respective discipline. It may be a good idea to also include the activities in the construction phase for that discipline under the responsibility of the project engineer: O&S is too dependent on engineering to be held responsible for the costs they make: engineering orders the materials, and has a great influence on planning. The project engineer for, for example Primary, should therefore be responsible for the budget of *all* primary activities (in close cooperation with the technical specialists).
- Personnel responsible for the budgets, should also be held **accountable** for them: currently, project engineers are not evaluated on their project results. If they are truly held accountable for their part of the budget, they should also be evaluated on the outcome. This means

that more user-friendly reporting tools are required, that also give project engineers, their managers, but in fact all project personnel in general insight to the total finances of a project.

- **The role of the Small Project Team needs to be reviewed**: they are now responsible for the project plan and estimates, but usually only have one single meeting together. Persons in the SPT are regarded experts for their departments, and their knowledge and experience is an important asset to the E&P department. The SPT should be used more intensive than it currently is, to be able to evaluate projects more intensively and draw lessons from them. The SPT may also be used in evaluating project teams and personnel. This is needed, for there is friction between the functional managers and project managers: project managers cannot evaluate the people working on their projects, and at the same time, functional managers do not know how to evaluate their personnel, for they are not part of project teams. The SPT can be a link between these two groups.

Recording Value

Clear agreements have to be made on recording value: (1) who is allowed to book costs to a project, (2) on which activity codes should hours and costs be booked, and (3) working hours need to be filled out in time. Also, (4) material costs and working hours have to be recorded and monitored separately. Point 1 and 2 can be solved by using the project building tools in SAP correctly. However, the SAP system is not designed at this moment to do so. It is recommended that the WBS of a project can be filled out in SAP *including project team members and budgets per activity* as soon as possible. Point 3 can be solved by monitoring filled out working hours more closely, this is the responsibility of the respective team manager.

Forecasting

In order to have proper forecasts, and to be able to use EVM, the *percentage complete* and *work-in-progress* have to be defined. Clear agreements have to be made on how this is done: when is a task 50% complete? To use EVM properly, this information is essential. However, project managers already have a good idea on how projects are progressing already, for they monitor hours spend an materials ordered very closely already. This is therefore a recommendation for the *future,* when all the more important preconditions are already in place.

7.3. Recommendations concluded

This section summarizes the recommendations derived from the previous paragraph, and prioritizes them: which implementations should (preferably) be done first, and which solutions might be implemented later, considering the difficulties in implementing them.

SHORT TERM	
Recommendation:	Solves:
The process of projects needs to be formalized more in-depth	*Activities in projects are not properly defined, and the structure of projects is not clearly communicated.*
Start using a formalized, standard Work Breakdown Structure for all projects (The project manager is responsible for designing the WBS) - Each item in the WBS should be clearly and completely described.	*Activities in projects are not properly defined, and the structure of projects is not clearly communicated.*

The upper three levels of the WBS are controlled by the project manager, work packages should be filled out by the person delegated to the respective lower level work element. - The project manager should provide technical direction *through* the line managers	*Responsibility and accountability over the project activities and their costs are not properly defined.* *Friction between the project organization and the functional organization.*
Activities should have defined cost account numbers	*Activities in projects are not properly defined*
Perfecting the current budget reporting tool - Meeting with Transport South to look at which information the tool should provide.	*There is no integrating control system in place, the WBS currently in use does not help to incorporate time, schedule and performance. (short term solution, in the future an incorporated control system is highly recommended)*
VoCa's (estimates) need to be more standardized and uniform. - The current error margin of 5-10% for estimates needs to be adjusted, for it is not realistic.	*Estimates need to be formalized and more uniform, persons responsible for estimating costs, need to be held accountable for those estimates.*
The role of the project engineer needs to be clearly defined - Project engineers need to have the tools to be able to monitor and control their budget.	*Responsibility and accountability over the project activities and their costs are not properly defined.*
The role of the Small Project Team needs to be reviewed - The SPT may play a larger role in evaluating a project, and project personnel	*Friction between the project organization and the functional organization.*
Value needs to be recorded properly: 1. Who is allowed to book costs (should be prescribed in the WBS elements) 2. To which activity codes should costs be booked 3. Working hours need to be filled out in time. **4.** Materials and hours spent should be recorded and monitored separately.	*There are no clear agreements on how value is recorded*

FUTURE RECOMMENDATIONS	
Recommendation:	Solves:
Clear agreements have to be made on how to value work-in-progress and the percentage complete.	*To be able to use EVM properly, an assessment of percentage complete and work-in-progress is needed.*
An integrated system is highly recommended. - E&P personnel need to be offered training on how SAP works.	*There is no integrating control system in place, the WBS currently in use does not help to incorporate time, schedule and performance.*

7.4. Strengths and limitations

The control aspects defined in this report are used in the interviews to gather the results for this thesis. It should be stated that the aspects are rather general, for they cover multiple aspects of project design and control. This being said, they do cover all main characteristics of the theories explained in the literature review. They are therefore considered to give an overall and complete view on the current project control system at Enexis E&P. The nature of the theories used (in particular EVM), is that they mention integration of all project activities as a very important part of control. This has led to some overlap and repetition throughout the thesis.

Another limitation of this research is the changed situation. Due to the reorganization that has taken place at Enexis Infra Services in December 2013, the departments on which the results are based do not longer exist. However, the process concerning projects remains unchanged for now. One of the causes for this research was the wish of management to have more uniform processes and information, and this report can help to implement such processes, based on recommended methods from literature on project monitoring and control.

One of the strengths of this thesis is that it is based on a very elaborated literature review. Main theories are derived from many different articles on project (cost) control. Next, the literature review has focused on authors that have described these theories in detail. The control aspects on which the results are based, are mentioned by multiple authors. The theories on which this research is based, can therefore be considered a firm basis on which to draw conclusions.

The diverse group of employees interviewed for this research are another strength: all departments and disciplines involved in the projects that are carried out, are taken into consideration. This gives a complete overview, assessing the problems found from different angles. The downfall of this approach may by my personal limitation of wanting to be too elaborate about all viewpoints mentioned in the interviews. The interviews were all very elaborate, which led to an overload of information. It was impossible to include every opinion of every employee in this thesis, and therefore I have aimed to focus on the main points as much as possible.

7.5. Future Research

It may be useful for Enexis E&P (now E&R) to perhaps visit some other companies that are involved in large (construction) projects. There is currently hesitation from employees concerning more standardization and formalization of work processes. Some employees feel that the projects carried out by Enexis E&P are too specific and specialized to be standardized. However, there are other companies (a manager mentioned a company building ships as an example) that are involved in projects that are different each time. It may be helpful for Enexis to learn from these companies, and see how they have designed their project control system.

Also, it is highly recommended to review the opportunities the SAP-system offers, with regard to projects. Many project organizations use the SAP project building tool, and SAP offers some good solutions for project management: it is one of the most used ERP systems for project organizations. Enexis may benefit a lot from such an incorporating system, which may lift the project organization to a higher level. It is recommended to do some further research on the possibilities, and perhaps also visit some other company in order to see what ERP system they use and how it works.

Last but not least, there are some opportunities to make use of in-house knowledge in implementing the recommendations done in this research. As of December 2013, Enexis also has some new departments like Processes (Processen) and RAK (Reporting Analyzing and Quality), that may support the project organization in defining their processes more clearly, or in supporting project managers by providing clear reports on project progress. It is recommended for these departments to review the project organization at Enexis E&P somewhat more in-depth, to be able to take the wishes of personnel into consideration in designing an even better and more all-round control system.

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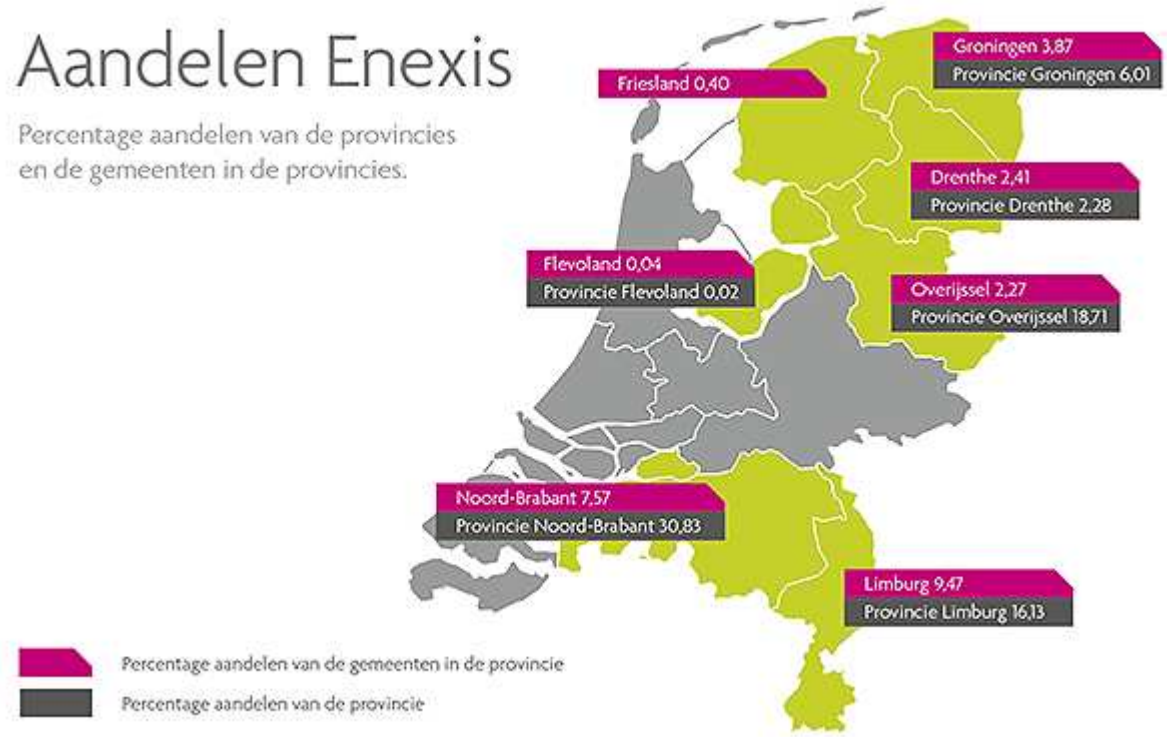
APPENDICES

APPENDIX I: Glossary

- **ACWP:** Actual Costs of Work Performed
- **AsM**: Asset Management, the department responsible for realizing and maintaining the company's cable and piping infrastructure
- **BCWS**: Budgeted Costs of Work Scheduled
- **BVC**: Business Controlling Centre (Bedrijfsvoeringscentrum) The command control from where switching within the grid is possible. The current situation of the power grid is constantly monitored from within the BVC.
- **Chamber of Energy:** (Energiekamer) is part of the Dutch competitor authority, and responsible for supervision the electricity law, and acts by order of the Ministry of Economics.
- **CPI:** Cost Performance Index: BCWP/ACWP
- **E&C:** Engineering & Consultants, the team of engineers within the department E&P
- **E&P:** Engineering & Projects, the department Engineering & Projecten, with Transport.
- **E&R:** Engineering & Realizaton, the new department for realizing projects as of December 2013 (projects are carried out by its sub-department Projects & Programs)
- **EAC:** Estimate At Completion - a realistic estimate of the finished work. It is the sum of all costs to date plus the estimate of all work remaining.
- **EBS:** (Expertise, Bedrijfsvoering & Stations) – Expertise, Business Conduct and Stations. A new department, replacing the Transport departments.
- **Engineering:** engineering is divided into three disciplines: Primary, Secondary, and Construction. The engineering department consists of Consultants, Project Engineers, and Detail Engineers for each discipline.
- **EVM:** Earned Value Management
- **High Voltage Power Station:** junction in the high voltage power grid, with a switch installation in which transformation from High Voltage to Medium Voltage is taking place.
- **IS:** Infra Services, the executive division of Enexis B.V., responsible for realizing the work
- **KCD:** (Kwaliteits- en Capaciteitsdocument) – Quality and Capacity Document.
- **KR:** (Klantrelaties) – Customer Relations
- **Netbeheer:** Grid Control. The department with Enexis responsible for maintaining the company's infrastructure
- **O&S:** (Onderhoud & Storingen) – Maintenance & Outages. The current department within Transport that executes the physical work on location for projects. Besides projects, they solve technical problems (outages).
- **PERT:** Program Evaluation and Review Technique. A method for scheduling project duration.
- **RAK:** (Rapportage, Analyse, Kwaliteit) – Reporting, Analysis, Quality: a new supporting division, in the new organizational structure, supporting departments with information they need.
- **SAP:** the enterprise resource planning system in use at Enexis
- **SCADA:** Supervisory Control and Data Acquisition: department responsible for collecting, processing, and visualizing signals from distribution stations. The Scada-system facilitates the exchange of measurement data.
- **SPI:** Schedule Performance Index: BCWP/BCWS
- **SPT:** Small Project Team
- **TenneT:** the company responsible for the high voltage electricity grid in the whole country

- **TP:** Transport. A department with Enexis Infra Services. The department responsible for realizing and controlling the infrastructure in the main power stations, and the operational installation for the complete infrastructure
- **TP-N:** (Transport Noord) – Transport North. It is the department where this research has taken place, located in Zwolle
- **TP-Z:** (Transport Zuid) – Transport South. It is the department similar to the one in Zwolle, but focused on the Enexis regions in the South of the Netherlands. TP-Z is located in Weert.
- **VoCa:** (Voorcalculatie) – 'pre-calculation', or estimate. It is the estimate of total project costs.
- **WBS:** Work Breakdown Structure
- **WP:** Work Package

APPENDIX II: Shareholders of Enexis NV



APPENDIX III: High Voltage power stations for Transport Noord.

Figure III: *Geographical overview of the High Voltage stations in the district of Transport Noord. (Source: KCD 2010-2016, Enexis, 2009)*

APPENDIX IV: Variance Analysis for the EVM

A variance is defined by Kerzner (2001) as "any schedule, technical performance, or cost deviation from a specific plan". They are used by management to verify the budgeting and scheduling system, which must be compared together because cost variance does not provide a measure of comparison between work scheduled and accomplished, and schedule variance does not improve costs (Kerzner, 2001). In order to calculate the variances, three basic type of costs are defined[1]:

- **Budgeted Cost for Work Scheduled (BCWS):** the budgeted amount of cost for work scheduled to be accomplished in a given time period (Planned Value)
- **Budgeted Cost for Work Performed (BCWP):** The budgeted amount of cost for completed work in a given time period. This is sometimes referred to as *Earned Value.*
- **Actual Cost of Work Performed (ACWP):** the amount reported as actually expended in completing the work accomplished in a given time period (Actual Costs).

These costs can be applied to any level of the WBS (project, task, work package) for work that is completed, in-program, or anticipated. The following variances can be measured using the different type of costs:

- **Cost Variance (CV):** CV = BCWP – ACWP
  - A negative variance indicates cost overruns.
- **Schedule Variance (SV):** SV = BCWP – BCWS
  - A negative variance indicates that work is behind schedule.

In this analysis of both cost and schedule, costs are used: schedule variance is also given as a function of cost. The variances are usually shown in percentages to diminish this issue:

- **Cost Variance (%) =** CV/BCWP
- **Schedule Variance (%)** = SV/BCWS

By using both the cost and schedule variance, an integrated cost and schedule reporting system can be developed, providing the basis for variance analysis by measuring cost performance in relation to work accomplished. This sequence makes sure that both cost budgeting and performance scheduling are composed on the same database (Kerzner, 2001).

Another measure is needed to review how efficiently the work has been accomplished, and for trend analysis. The Cost Performance Index (CPI) and Schedule Performance Index (SPI) provide a quantity measurement of the progress of a project, and can provide a basis for forecasting models. Fleming & Koppelman (1999) argue that these indices provide an accurate assessment of the true status of a project. Also, they state that the CPI can be used to statistically predict the final range of costs for a project, and therefore provide an early warning signal to avoid negative final results. These CPI final value forecasts have proven to be very accurate, even in very early stages of the project (as early as 15 – 20 % project duration) (Fleming & Koppelman, 1999; Zwikael et al., 2000).

[1] While all main authors on Earned Value Management describe the same values, the terms they use are sometimes different (PMI (2000) and Turner (1993) use *accrual, earned* ,and *planned value,* but their explanation is identical). I have chosen to use the values as described by Kerzner (2001), since his book on project management is the most recent compared to the others, his explanations are most elaborate, and the way he names the values corresponds with Zwikael et al. (2000), Slack, Chambers & Johnston (2007), and Oberlender (2000).

- **CPI =** BCWP/ACWP
- **SPI =** BCWP/BCWS

In both of these equations, an index of 1.0 or greater are favorable: if CPI is exactly 1, there is perfect performance, if the CPI exceeds 1, performance is exceptional. Poor performance is shown by a CPI lower than 1. The same is true for the SPI (Kerzner, 2001; Oberlender, 2000). Their respective values can be plotted in a graph, in order to monitor project performance during routine reporting periods. It should be noted, however, that due to the dynamic nature of projects, the values of both indices will deviate over time, starting with an SPI and CPI of 1.0 at the very start of the project. Minor changes in the CPI and SPI are thus expected. Only when there are major deviations from one period to the next, the project manager should investigate the cause of the significant change (Oberlender, 2000).

Especially for CPI it is important that it includes only tasks with a set budget. If people are working on a task that does not have an established budget, the project manager has to make a change order for out of scope work. This is needed to make sure that all actual work-hours are properly reported, so that accurate historical records can be established, which can be used for future similar projects (Oberlender, 2000).

APPENDIX V: Aspects of the WBS

The following aspects describe how a Work Breakdown Structure should be designed, and what elements it should have. The aspects are found in some of the main project management literature consulted. Which authors mentioned the aspects can be seen in the table at the end of this appendix. Some aspects are grouped together to form one main aspect, used in chapter 4.

1. The WBS should be structured in the same way as the work will be performed, and thus should reflect the way in which project costs and data will be summarized and reported.
2. Each element in the WBS should have an activity code, these code numbers relate the WBS to costs.
3. By providing an increasing level of detail, the WBS makes sure that each major and minor activity is accounted for; each item should be clearly and completely defined.
    a. By providing an increasing level of detail, the WBS makes sure that each major and minor activity is accounted for, but each element of work can only be assigned to one and only one level of effort.
    b. Each item should be clearly and completely defined (using a Work Scope Definition).
4. WPs should show a natural subdivision of cost accounts and effort planned. They must have a definable *deliverable* that must be generated for the task to be complete.
    a. WPs must have a definable *output* and *specific product* (deliverable) that must be generated for the task to be complete.
    b. The Work Package level is the level where the work is managed. Work packages should be a natural subdivision of cost accounts and effort planned.
5. Work packages should relatively short, so that little or no assessment of work-in-progress is needed. They are comparable in terms of size, with a defined duration.
    a. The ideal duration of a WP is about 80 hours, over less than 2-4 weeks. WPs should be relatively short, so that little or no assessment of work-in-progress is required. Most Work Packages should range from 0.5 to 2.5 percent of total project budget.
    b. All WPs should be comparable (same size).
    c. Every WP must have a definable beginning and end.
6. The amount of levels should fit the project: too many levels means too much time is spent on control, while too few levels make it hard to act timely in case of cost overruns.
7. Higher levels of the WBS are controlled by the project managers, and can be reused if they are standardized. Lower levels should be more project-specific, and responsibility over the work needed for those levels (in particular Work Packages) should be clearly assigned and communicated.
    a. Higher levels of the WBS are usually controlled by project managers, and can consist of standardized methods, making the WBS reusable for those levels. Lower levels should be more project-specific, and responsibility over those levels can be the task of line managers.
    b. It should be clear who is responsible and/or accountable for each item in the WBS: 'doers' and 'planners' must be in agreement about how the work is divided, especially on a Work Package level.

The following table will show which aspects were mentioned by which authors. The letters in the table represent literature by the following authors:

- **K** = Kerzner (2001): *Project management: a systems approach to planning, scheduling, and controlling*

- **O** = Oberlender (2000): *Project management for engineering and construction*
- **SWK** = Sullivan, Wicks and Koelling (2009): *Engineering Economy*
- **H** = Heinze (1996): *Cost management of capital projects*
- **T =** Turner (1993): *The handbook of project-based management*
- **P** = Project Management Institute (PMI) (2000): *A guide to the Project Management Body of Knowledge, (PMBOK© guide)*

	K	O	SWK	H	T	P
1-a	X		X			
1-b	X	X		X		X
2		X	X	X		
3-a	X	X	X		X	
3-b	X			X		
4-a	X			X	X	X
4-b	X	X				
5-a	X					
5-b	X			X		
5-c	X	X		X		
6	X		X		X	X
7-a	X			X		X
7-b	X			X	X	X

Table V.1.: *Literature defining the WBS aspects as mentioned before*

As can be found in this table, most elements are defined by Kerzner (2001). He is very elaborate in his description of the Work Breakdown Structure, and summarizes many of the aspects already himself (rather than most of the other authors, where the elements have been derived from the text). Therefore, the aspects are mostly based on the work of Kerzner, using mainly those aspects that are also mentioned by the other authors.

APPENDIX VI: Aspects of control for EVM

This appendix shows the control aspects found for EVM. The aspects are found in some of the main project management literature consulted. Which authors mentioned the aspects can be seen in the table at the end of this appendix. Some aspects are grouped together to form one main aspect, used in chapter 4.

1. A control system incorporates schedule, performance and costs. To control costs the actual expenditure must be compared not to its schedule, but to some measure of the value of work actually done.
2. A proper WBS structure should be in place, providing the input data to the cost control system.
3. Meaningful cost estimates are needed, to provide a measure against which to control costs. These estimates need to be quite detailed, and also explained in terms of work definition, the basis for the estimates and a range of possible outcomes.
4. Centralized authority and control over projects are the responsibility of project management. All personnel in the project team that are responsible for incurring costs, also have to perform cost control.
    a. centralized authority and control over projects are the responsibility of project management, who also specify the level of detail.
    b. Commitment and accountability for controlling the cost of work at various levels in the organization hierarchy: all personnel in the project team that are responsible for incurring costs, also have to perform cost control. There has to be understanding among project staff of the total flow of financial and cost information (from the production of estimates to the collection of actual costs).
5. Project teams must have regular team meetings, with a formalized agenda.
6. The actual performance to date should constantly be compared to the estimated performance: is there a (large) variance?
    a. The actual performance to date should constantly be compared to the estimated performance: is there a (large) variance?
    b. In order to make proper forecasts, the *percentage of work done* has to be assessed, which includes assessing the *work in progress*.
    c. A forecast of cost at completion can be made by using the earned value and cost variance so far.
7. Periodic re-estimation of time and costs is needed: if there is a variance, it should be assessed whether corrective action needs to be taken, and when such changes are authorized.
        a. If there is a variance, or deviation from the original plan, the project manager should assess whether corrective action needs to be taken.
        b. There have to be clear consensus on when changes are authorized: the baseline budget schedule is not inflexible, periodic re-estimation of time and costs is needed, to be able to take corrected action without loss of recourses. (foreseen vs. unforeseeable events)
8. Value should be recorded as early as possible, all value has to be reported properly. Reports on project control are short, use defined criteria and are made at defined intervals.

a. Value should be recorded as early as possible, usually when cost is committed. All value has to be reported properly. Material costs are separate from working hours.
b. Reports on project control are short, use defined criteria, and are made at defined intervals. S-curves can be used to provide a visual presentation of the project being over- or underspent as it progresses.

The table shows which aspects were mentioned by which authors. The letters in the table represent literature by the following authors:

- **K** = Kerzner (2001): *Project management: a systems approach to planning, scheduling, and controlling*
- **O** = Oberlender (2000): *Project management for engineering and construction*
- **SWK** = Sullivan, Wicks and Koelling (2009): *Engineering Economy*
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- **P** = Project Management Institute (PMI) (2000): *A guide to the Project Management Body of Knowledge, (PMBOK© guide)*

Aspect		K	O	SWK	H	T	P
1.		X	X			X	X
2.		X	X	X		X	X
3.		X		X	X	X	X
4.	a.	X			X		
	b.	X		X			
5.		X				X	
6.	a.	X	X		X	X	X
	b.	X	X			X	
	c.	X	X			X	X
7.	a.	X	X		X		X
	b.	X			X	X	X
8.	a.		X		X	X	
	b.		X			X	

Table VI.1.: *Literature defining the EVM aspects as mentioned before*

APPENDIX VII: Interview Slides

Wat is de reden van dit interview:

Onderzoeksdoel: Het analyseren van het beheersen en monitoren van projecten uitgevoerd door de afdeling E&P, door te kijken naar de literatuur en de situatie in de praktijk. Aan de hand hiervan 'best practices' opstellen, en te kijken of er verbeteringen mogelijk zijn in het monitoren/rapporteren. De focus ligt hierbij op kostenbeheersing.

- Concepten uit de literatuur: hoe ervaar je deze concepten in de praktijk? Pas je ze toe?
- A.d.h.v. deze concepten zijn beheers*aspecten* geformuleerd: hoe kijk je tegen deze aspecten aan?
- De concepten zullen in de basis worden neergezet in dit gesprek. Doel is het gesprek zo open mogelijk te houden, om de focus te leggen op jouw zienswijze.

Als je kijkt naar de beheersing van jouw projecten:

- Waar lig je 's nachts wakker van?
- De manier waarop je werkt, heb je het idee dat je daarmee het project geheel beheerst?
- Weet je op ieder moment waar je staat binnen het project, wat betreft planning en kosten?

Project

- Wat voor soort projecten leid je voornamelijk?
  - Duur van een project, kosten van een project, wat komt er bij kijken
- Kan je me kort vertellen over een project waar je op dit moment mee bezig bent of wat je onlangs hebt afgesloten?

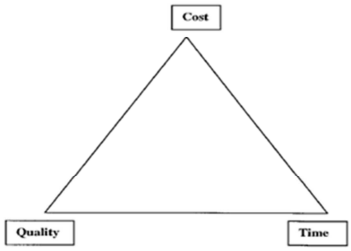
Projectfasen

- Hoeveel en welke fasen zijn er
- Wie doet wat (m.b.t. VoCa, projectplan, uitvoering, etc.)

Projectteams

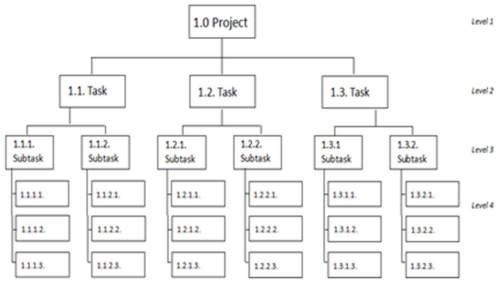
- Rollen binnen een projectteam
- Taken en verantwoordelijkheden
- Hoe verloopt de samenwerking?

Iron Triangle (triple constraint)



Er zijn drie componenten bij projecten: kosten, tijd, en kwaliteit (of scope). Deze moeten in balans zijn, daarom is het belangrijk om te weten welke aspecten prioriteit hebben.

WBS



WBS

- De WBS sluit aan bij de manier waarop het werk wordt uitgevoerd, en bij de wijze waarop project informatie (kosten) wordt opgeteld en gerapporteerd.
- De WBS maakt gebruik van een nummering of codering systeem (die de WBS relateert aan kosten (gekoppeld aan kostenplaats/kostencode)
- Door verschillende niveaus van detaillering zorgt de WBS ervoor dat iedere grote en kleinere activiteit wordt meegenomen. Iedere activiteit moet duidelijk gedefinieerd zijn. (verantwoordelijkheden, planning, schatting)

Werkpakketten resulteren in duidelijk meetbare doelen (of mijlpalen) → deelproducten

Activiteiten (in werkpakketten) hebben een relatief korte tijdsplanning, zodat er niet teveel schattingen nodig zijn w.b. onderhanden werk (work in progress). Ze zijn vergelijkbaar in grootte.

De bovenste niveaus (levels) van de WBS bevatten taken die de hoofdfasen van het project vormen, deze hoofdfasen staan beschreven in het projectplan.

Subfasen , die zijn opgedeeld in deelproducten, zijn meer project-specifiek.

De WBS helpt om de verantwoordelijkheden te verdelen

Cost Control: EVM (Earned Value Method)

Als alleen tijd of kosten worden gebruikt voor het monitoren van een project, geeft dit geen volledig beeld van de status van het project: er moet gemeten worden hoeveel werk er daadwerkelijk is uitgevoerd: waar sta je?

Gebudgetteerde kosten van gepland werk, gebudgetteerde kosten van uitgevoerd werk, werkelijke kosten van uitgevoerd werk.

Variaties worden hiermee berekend en kunnen gebruikt worden om het uiteindelijke projectresultaat te voorspellen.

Percentage complete: hoeveel van het benodigde werk is klaar?

Budget at Completion vs. Estimate at Completion

Realisatie en prognose

EVM

Om kosten te beheersen, moeten de werkelijke uitgaven niet worden vergeleken met de planning, maar met de waarde van het reeds uitgevoerde werk.

De input voor cost control komt vanuit de WBS.

Er moet een goede kostenschatting worden gemaakt, waartegen de gemaakte kosten kunnen worden vergeleken. Deze schattingen zijn gedetailleerd en het is duidelijk waar ze vandaan komen

EVM

Iedereen binnen het projectteam die kosten maakt, is ook verantwoordelijk voor het toepassen van kostenbeheersing (cost control).

Projectteams hebben daarom regelmatig overleg over de voortgang van het project.

Het werkelijk uitgevoerde werk tot nu toe moet constant vergeleken worden met de planning: is er variantie?

Als er een noemenswaardige afwijking van het originele plan wordt waargenomen, moet er gekeken worden (door de project manager) of corrigeren nodig en mogelijk is.

EVM

Om goede voorspellingen te doen over het uiteindelijke projectresultaat, moet het *percentage van uitgevoerd werk* worden bepaald, waarbij ook het onderhanden werk (work in progress) moet worden meegenomen.

Een voorspelling van de uiteindelijke kosten wordt gemaakt aan de hand van de varianties (overschrijdingen of onderbesteding) van kosten tot nu toe.

Rapportages zijn relatief kort, bevatten vaststaande criteria, en worden gemaakt op vaststaande momenten.

Periodieke herijking van tijd en kosten is nodig: wijzigingen in planning of budget moeten tijdig worden doorgegeven.

Afsluitend

Heb je de stuurinformatie die je nodig hebt?

Heb je controle over de resultaten waar je verantwoordelijk voor wordt gehouden, of waar je op geëvalueerd wordt?

APPENDIX VIII: Results: control aspects at Enexis E&P

In this appendix, the results for each aspect of control are described more in-depth. Different views of different employees in the departments are discussed, as well as some more detailed information for each aspect.

VI.I. WBS

This section will describe the results that are based on the control aspects for a Work Breakdown Structure. The results are described per aspect.

Aspect 1

The WBS should be structured in the same way as the work will be performed, and thus should reflect the way in which project costs and data will be summarized and reported.

All (assistant) project managers I have spoken to, recognize the term WBS. In the current system, used to book costs of the projects, these costs are booked on WBS elements. However, WBS is not being used for detailing activities or summing up and reporting costs: “I do recognize it, but using it also to provide budgets, planning, responsibilities for each part of the WBS: no”. Another project manager backs this up: “we do use some of its structure, in making a planning in steps, and subdividing some larger parts in smaller tasks. But that is very limited and depends on the project manager as well”.

Project Management sees some important reasons why the work is not truly structured like a WBS right now, there are some practical objections. One of them is the way project budgets and planning are entered into the current SAP-system, and the way this system is being used. “We use WBS elements in our VoCa, but the person preparing those WBS elements in our SAP system, usually activates all codes, and not just the ones included in our project. It is possible that activities are ‘open’ to book working hours on, while those activities are not being carried out in the project”. Another project manager is also concerned that detailing activities more than they are now will create a problem in the booking of costs. “If you create a budget for each activity, and then the work is carried out, the costs should also be booked on that activity. And that is the risk: that the costs are not booked correctly. At that point, your WBS structure loses its added value”.

The way the WBS is used now, is not to subdivide activities, but is focused more on products or materials: a distinction between the building, and the primary and secondary elements of the power station. For example a distinction between work needed per discipline on the transformer, the MS installation, the building, securities, or connections. Instead of distinguishing between phases in the work, the distinction is made more naturally on technical aspects of the work. In this way, the WBS does fit the way of work done in projects: based on technical aspects.

An engineer says that the WBS is not being used as it should right now. “The VoCa is not put in detail into the SAP system. I would say: we should, but at the same time you have to make the consideration: up to what level do you want to set this up. The deeper you go, the more you have to dress up and put in SAP. It may take too much energy to win back. I think that we can go more into detail then we are doing now, but it has to be balanced”. Most project managers do see an added value to a more detailed WBS: “If you look at how many projects each project manager has to lead, it is clearly impossible to have knowledge about the project at those detailed low levels. But that is what is ex-

pected of us at the moment: we should be able to tell how the project performed at those levels". Overall, project management would like to use the WBS as a tool to be able to review which activities within the project cause problems, and that is not possible now.

Aspect 2

Each element in the WBS should have an activity code, these code numbers relate the WBS to costs

There are activity codes in the SAP-system. These codes are connected to a WBS element and to a project number. The system is however not used to its full potential. There are only a few activity codes, and little specification. Where there is specification, project managers are not checking whether the project team books their hours and costs on the right activity codes. Most project managers feel that the activity coding system is not used correctly, and not used to its full potential.

There is no uniformity in using the activity coding system. It also depends on how the project structure is represented in SAP. The person at the Finance department responsible for designing the project in SAP, decides which activity codes are turned on and off for the project. Sometimes, all codes are open, while there may be only three with a budget attached to them. One of the engineers: "when, at a certain point, I want to book my hours, and take a look at the project structure, there is much left to be desired. (…) Somebody from Finance ultimately decides the structure, I don't think that's right. The project manager should decide the structure. He is the one accepting the job from the bidder, and should be responsible for a proper project structure, and that everybody works with that structure. That should really be improved".

Engineering adds that it is not always clear which activity belongs to which code, and that the more codes there are, the more confusing it gets. Engineering is not subdivided in activities, so it is possible to book materials to specific codes, but not activities. The coding of activities is not clear to the persons booking the costs to those activities. O&S, responsible for executing the work, confirms this: "project management should state clearly which code stands for which activity, and when to book costs to which code. Our technicians know one code, and book the whole project to that code, while activities are changing when the project is progressing. If the information is not transmitted to the people filling it out, distinguishing activities will never work. They might even hang a poster in the site hut, so the technicians know how to book when they are doing multiple activities. Otherwise, a project manager has to do a lot of work to split those costs again afterwards". One of the project managers confirms that they could do more about it: "we are not transmitting this in the direction of the project teams at this point".

Project managers all agree that they would like to have systems in use that are more supporting in their work, with more uniform information. They share the wish for subdividing activities better, since it would also help them in controlling projects. However, they do not know how to translate this wish into reality using the current SAP system. "It should be possible in SAP to create all those things, very elaborately, but here with Transport North there is nobody who knows how", "our budget is the input on the front-end, but in reverse you want to be able to see if the budget is fully utilized. I would like a signal when we are at 80-90 percent of the budget for example", "It should be possible to open and close activity codes, or allocate names to them who is allowed to book on those codes". None of the project managers have had a course about the SAP-system while working at

Enexis, and there is also little knowledge about how it could be used best within the rest of the E&P department.

Aspect 3

By providing an increasing level of detail, the WBS makes sure that each major and minor activity is accounted for; each item should be clearly and completely defined.

The level of detail is, as mentioned before, not that high. Project management is also not steering on a higher level of detail. Project managers mention that there is a *will* to do so, but that the current climate in the organization does not help to implement changes.

Activities are named, in the form of WBS elements, but what the definition of those elements truly is, is not always clear. There is no definition of what work exactly belongs to an activity, and there is no uniform way in which the project managers expect the activities to be filled in. “An example is a TF-installation. This is an activity for secondary engineering. But what is its definition? Does it include mounting the installation? The bidding process? There is another activity number called securities and testing, on which of both numbers should you book the costs for testing the installation? I think that when calculations become more standardized, such a VoCa should be very clear in the definition of the activities”.

In the VoCa that is used, the project engineer, or detail engineer, gives all the entries and its expenses. They are combined into the VoCa, but the project manager does not check all details that the engineer gives. They control at a higher level. “The Voca is made and used to apply for the project budget, but as for the rest it is hardly looked at again. Also, I don’t know everything, when it comes to engineering. And to be honest, I don’t want to know, but I do want to know that a project engineer knows exactly what he is doing, and what it costs”. So while the VoCa is very detailed, with all small components mentioned, this (extremely) detailed overview of the project is not used later on in the project for subdividing the activities or process of the project as well.

Ultimately, the project manager makes the planning. In this planning, engineering is considered one long bar, without subdividing into smaller activities. Project management would like to get a better grip on the engineering phase, but they do not know the engineering activities in enough detail to subdivide them (it would be an unnatural subdivision), so they steer the project on milestones and main activities. Engineers I have spoken to, do see the benefits of more detailing and defining their activities as well: it will help them monitor their own work better and be more efficient. The engineers agree with project management however, that it may be very hard to do so: engineering is hard to divide into separate activities, it is usually viewed as a whole and if it needs to be rushed, many different engineers may work on one project. So, for the three disciplines of engineering, there is only an end date they should meet.

Execution is easier to subdivide. The assembling department O&S explains that the project has an overall action plan, which describe the building process in important milestones: when the building should be finished, and when main components should be in place. On crucial moments in the execution process, O&S may write a more detailed action plan, that is used mainly to inform the assemblage crew how things are planned and carried out.
Another reason for the construction phase being more detailed, is that the project team wants to

know more in detail when activities are planned: it needs to be taken into account when the needed materials are ordered. “When you need transformer cables, you do not want them to lay around a station for days or weeks: you can be sure that they will be stolen (copper theft). That is why we are planning more and more detailed: when are we finished, when do we need the cables, and when are they put in place, you also need to know all that for hiring security in those periods”.

As a concluding remark, one of the employees mentions “you could ask whether it is advisable for us to start using such a system: can you control such a large amount of details? But when we do, we definitely need to have proper descriptions for those activities: what do they entail, and what belongs to which element. Also: what costs are thus booked on those activity codes”.

An overall view is that while the VoCa’s that are made for project may be *too* detailed, the activities or WBS are *not enough* subdivided or detailed.

Aspect 4

WPs should show a natural subdivision of cost accounts and effort planned. They must have a definable deliverable that must be generated for the task to be complete.

The current ‘Work Packages’ are definitely a natural subdivision of cost accounts and effort planned. Phasing of the project is rather strict, with important milestones distinguishing the transition from one phase to the other. The construction phase is subdivided naturally according to the important components at the station that should be placed or completed. At the same time, the engineering phase is not subdivided into smaller activities or cost accounts, simply because E&P does not feel that there *is* a ‘natural’ way to do so: that particular stage of the process (designing) may simply be too hard to subdivide in a good way. One of the engineers: “yes, that is very hard, especially for the secondary components. I can see how it works for construction or primary engineering. In that case: you could say, the foundation is finished: first milestone reached”. So, one reason for the lack of milestones in the engineering phase is that there are no ‘tangible’ products to deliver: “Our product are a bunch of folders with paper, it is not tangible like an installation. That is what makes it harder for a project manager to assess the work we do”.

There are more milestones for the construction phase of the project. When building a new station for example, the building has to be finished before the installation is put in. Such an installation has a long time of delivery; at the delivery date, the building needs to be finished. Those large components have milestone dates. Most milestones are ‘product’- related: when are the drawings finished for a large component, or the component itself.
The O&S group does have the wish for these milestones to be defined and described better. “At this point, it is in fact just a date, nothing more. If you describe smaller milestones in the process, and their interdependencies, there is more grip on them. What are the consequences when something goes wrong? If an engineer forgets to order a component, we cannot reach the milestone date in time. We are now sometimes acting based on incidents, there is no good overview”.
It also depends on the project manager for each project how a planning is set up, and if there are clear milestones in that planning or not. But, according to engineering: “the most important date, or milestone: when the engineering of the project needs to be finished, is always known”.

It can be said that, for the milestones that are currently set, there are always two important milestones in every project: the inspection (schouwing) of the drawings from engineering (transition from engineering to construction phase), and the in-operation date (IB-stelling) when the construction of the work is finished (from the construction phase, to the completion phase). Other milestones that are used in projects, are mostly operation dates for the components that are needed in the station; they are focused on materials. The milestones are now especially important for and guided by the project manager. A project manager: "I do believe that the disciplines should also have their own milestones, or should know, with input from their departments, what their milestones are". Another project manager adds: "in fact we do use milestones at this point, but they include all disciplines, we have to finish something together in order to move on. So there are many dependencies on each other, that are hard to split up. I only focus on those main milestones, and am dependent on the respective discipline to translate that milestone within their department. It is only on a high level that milestones are set, not further in detail".

Some employees think that a more defined WBS may help to ultimately define more defined milestones. "It would be possible to connect a milestone to a smaller activity: is the installation ordered? Check. Is it installed? Check.", they see how it may help to divide the work into steps, with specific people that are responsible for those steps. Even one of the engineers thinks that the engineering phase can be subdivided into milestones a bit more than it is now: "we can define smaller steps in the activities that we do now. If we have to do detail engineering for an (electricity) cupboard, we can split it up in how it should be constructed, and how we incorporate the instrumentation".

Aspect 5

Work packages should be relatively short, so that little or no assessment of work-in-progress is needed. They are comparable in terms of size, with a defined duration.

For some activities, work packages are relatively short. But as said before, engineering for example, is one entire package. Secondary engineering has a run-through time of three to six months. The project engineer is supposed to keep an overview of these work packages. Also, since detail engineering is usually outsourced, tracking their work becomes easier: since the external company will give specifications of the work they have done so far and how much more time they need.

In the execution of the work, there is also a longer period of preparing the work and the work packages are relatively long. The work packages are finished, when the components on which they focus go into operation. There are usually several of these operation-dates (IB-stelling), and they can follow each other with little time in between. So seeing things in proportion, there are relatively long periods of preparation, and then a period of smaller steps following each other relatively quick. On the other hand, when the project is in its construction phase, there are usually project team meetings every other week. In those meetings, the amount work done is reviewed, and the work for the next two weeks is discussed and planned. So looking at it from that point of view, there are shorter work packages, that are defined and agreed upon, lasting two weeks, but those are more 'ad hoc', and may have multiple deliverables. This is currently not formalized, but progress is being made: the work that needs to be done and the mutual dependencies between tasks are more and more put into clarifying steps.

The work-in-progress is sometimes hard to measure, because of the long timespan of work packages. This being said: because of the high amount of project team meetings, and involvement in the projects that are going on, project management does feel that they are usually on top of things. They know where they are in the project as good as possible with the tools they have.

It can be concluded that work packages are not comparable in size. An example is ordering an installation: this 'work package' is very large, considering costs, but very small, considering time.

Aspect 6

The amount of levels should fit the project: too many levels means too much time is spent on control, while too few levels make it hard to act timely in case of cost overruns

Project management feels overall that the main idea of a WBS is being used, but only up to the second or third level. The amount of levels is currently not more than that: only the levels that, according to literature, should be controlled by the project managers, exist.

The current project plans that are written are also not very detailed, the work is only described in broad lines. One of the project manager says that they might consider two project plans: one that stays within those broad lines: how is the project tackled, for only that information is of interest for the principal (AsM). And another more detailed plan for the project team, for they need more information on the components that go in, the exact planning, and more of such details.

The project manager currently only looks at the overall budget, on the highest levels. Smaller activities are not so detailed that cost exceedings are analyzed at such low levels. The activities are too large (time-wise) to do so. One of the engineers says "I think that we should (have more details), but on the other hand you have to make considerations: this level, and not further, because than you would have to establish such a detailed system, which may take a lot of energy, and those costs may be out of proportion. I do believe that we can be more detailed than we are at this time". Another engineer adds that it also depends on the VoCa that is made, and the margin of error coming with it. "If there is a margin of five percent, you will have to look more in detail. But if VoCa's are more standardized, it will not be possible to always be so specific, and then a larger margin is needed. The question remains: how deep do you *want* to detail it out? Are we not in-depth enough or too much detailed?"

Project management wants to control the project on its main outlines: milestones, important delivery dates. For the intermediary activities, they are only interested in whether there are important deviations from plan. "When the primary components get out of step, compared to their planning, it is important to signal it, but how it is resolved should be the decision of the primary engineers". Another project manager adds: "when you look at the amount of projects we are controlling per manager, it is clear that it is not manageable for us to know the projects into such detail".

Overall, it can be concluded that project managers already control the higher levels, but that there are no lower levels. There is definitely a need to also have the smaller activities mapped, but the project managers do not have the capacity, or wish to do that themselves. "It is now expected of us to do it, as project managers, but we cannot decide for them about the work that they do". The low-

er levels are detailed in the VoCa, in terms of materials and hours that are needed, but they are not controlled in later stages of the project, there is no tool to review them. On the other hand, the engineering department for example does want to detail their levels out further, but "then something needs to be done with that information. I don't see project managers doing something with that detailed information at this point, or monitoring it. I really would like to have our activities better mapped out, also to be able to compare and evaluate projects better, but I do not have the idea that someone wants us to at this point".

Aspect 7

Higher levels of the WBS are controlled by the PMs, and can be reused if they are standardized. Lower levels should be more project-specific, and responsibility over the work needed for those levels (in particular Work Packages) should be clearly assigned and communicated

As was established for the former aspect, the higher levels are controlled by the project managers. The first level in the WBS (under the 'project' level), can be considered the four stages preparation-engineering-construction-revision. These stages are the same for each recurring project, and are reused. The level under that, is somewhat the same each time, with engineering and construction subdivided into Primary, Secondary, and Construction disciplines, and engineering also subdivided into primary engineering and detail engineering. Those higher levels are described in the project plan: what is done in the engineering phase, what is done in construction phase. The engineering phase is usually described a bit more in detail, for engineering decides what the construction phase will entail. The lower levels do indeed entail more specific tasks, and differ for each project.

The biggest issue for those lower levels, is that responsibility over them, is *not* clearly assigned and communicated. The senior project engineer is responsible in the SPT for making his part of the VoCa. He delegates this to the project engineers for each discipline within his department. These VoCa's are made, but subsequently, the project manager is responsible for the result. It is not the reason why the role of 'project engineer' was introduced, and so responsibilities over the work have to be better formalized. One of the project managers mentions "we divided the work per discipline and activity in the VoCa, but in fact we might have just as well made one big pile of summed budgets, because we do not use that subdivision". Someone else adds "in former projects, the WBS is usually filled out by the project managers. I think that the SPT, the experts for those specialists, have to provide the WBS elements: what activities are there, and where should we as project managers focus on. There is now too much input from the project manager, which lead to incomprehension of others in the organization: why did you design it that way? They are the specialists, they know much more about it". Another project manager agrees: "We would like to not have to dive into the departments' work so much: those specific issues take up a lot of your time, and you lose track of the overall project problems. There is less focus on the whole, and on our 'helicopter-role', which is our job".

The planning for projects, time-wise, are usually on track. But someone in the O&S department says "to really control a project, we need detailed activities. We need a tool that is unambiguous for everyone. Everybody wants to do it better, the project managers as well as us, there is just not enough time to focus on it. We should not work with complex systems and all of that. But an integrated system: something connecting activities, planning, and costs, to see in one overview: we did this, this is the sum of the costs, this is what we have left".

A recurring problem is also the friction between the project organization and line organization. The personnel involved in projects, are not evaluated by project managers, or on their work in projects, but are evaluated by their team managers.

Overall, project managers as well as project engineers like the idea how a WBS may help to divide responsibilities. There are currently no agreements over the responsibilities of activities. One of the project managers says "I think that the WBS can make clear what the Work Packages are and who is responsible for them. But that responsibility should also be formalized within the organization, so there is no ambiguity on who is responsible", and another one adds "everyone is very committed to the work we do together, no doubt. But at this point we have only delegated the tasks, and not the responsibilities that go with those tasks. I think that if they are more clear, people will also be inclined to wanting to improve more". Engineering is also enthusiastic about transferring some of the responsibilities to lower levels in the project structure: "we want to do everything 'together', but when you do things together, it is easy to push those responsibilities off to another".

VI.II. Earned Value – Cost Control

Aspect 1

A control system incorporates schedule, performance and costs. To control costs the actual expenditure must be compared not to its schedule, but to some measure of the value of work actually done.

This aspect is in fact a combination of two factors: the control system should incorporate all three components, so that the costs can not only be compared to its schedule, but to the work that is already carried out. When talking to the employees that work on projects, it is clear that the second part, comparing costs to the work that is done, is done relatively well. Because there are regular meetings, and project teams work closely together, project managers always have an overall idea about how the project is doing. But this is done without the incorporating system: the first part of this aspect, those tools are not in place at this moment. The planning (schedule) of when the work is carried out is a separate system from the costs, and booking of working hours.

Project managers

The project managers agree that the planning of the work is separate from the financial planning. However, unconsciously they have a pretty good idea of where they are in a project. "Looking at a large MS-installation: placing it does not take a lot of work, but the component itself is very expensive. So you may still be in the beginning of your construction phase, while already more than half of the project budget is spent". The costs are split between material and working hours, and the sum of those is never linear: one million euros can be spent in one day, but later on in the project it may take several months to spend a million euros. At this point, project management makes a forecasting beforehand about when materials are ordered and paid, and how much working hours are spent in which months.

In their prognosing tool, Prisma, the actual expenses are compared to the initial forecast. If there are differences in the comparison, a project manager examines why: are materials paid that were expected later or earlier, or are there significantly more or less hours booked on the project. From this

information, the forecast for the overall project can be adjusted. An example is: less money is spent on installing one of the components. Does that truly mean that there will be budget left, or are some of the activities booked on other components. By looking at the booked costs and hours in such a way, project managers can assess whether the project will be over- or underspent when it is finished.

The problem is, that this assessment of the project can only be done in hindsight: when the materials are already paid for, and the working hours already booked. There is no good measure of the work done, which would make it easier to look at cost deviations for smaller activities. “What is 30 percent of the work? How do you define it? What is 30 percent of a building? It is hard to do”. Assistant project managers add that it is a part experience and expertise, which is needed to properly control a project.
Overall, the assessment about where the project is standing in its process is made by project management. The more they are on top of things, the better idea they have about how the project is doing.

Engineering
As already discussed for the WBS aspects, the engineering phase is hard to subdivide or describe in smaller tasks. A project manager tries to control the engineering phase by asking regularly about the progress made. The amount of work carried out is hard to compare to the planning, not only for project managers, but also for the engineers themselves: “It is hard to say: we are halfway in time, but did we do half of the work? We don’t know”. Usually, engineers can only make a good assessment about the work that still needs to be done, when they are at the end of their planning. If there is still 10 percent of time left according to planning, they can assess whether they will be done in that time.

Construction
O&S, responsible for the execution of the work, explain that the people that are part of the project team usually have an idea of where they approximately are in a project. But they feel as well that costs and planning can be joined together better. “Now the technicians only get to see an overview of the budget, and of the part of the budget they have spent. But that has no meaning to them, they do not know the value. Instead of those values, they would rather see how much work can still be carried out, before the budget is exceeded”. The team managers for O&S therefore stress that the complete oversight can be done better. How many hours are spent on activities, and is this according to the hours planned. The value of the hours spent compared to their planning will give a better idea about the efficiency of the work they do.

Aspect 2
A proper WBS structure should be in place, providing the input data to the cost control system.

Overall, there is consensus on the fact that a proper WBS structure is needed to describe the activities measured for cost control, almost all employees mention that it is a logical result. This may also be a consequence of the sequencing of subjects in the interviews: controlling costs and deciding the earned value of activities, is only possible if those activities are defined.

Project management
All project managers agree that, if you want to do a proper Earned Value assessment, the WBS struc-

ture should be used better. And that if and when that WBS structure is built into the SAP-system more clearly, it may become easier to assess the costs per phase or activity. “When the preparing phase is finished, it would be great if we are able to close that cost account, so nobody can book hours or costs anymore. Then we can assess whether it was done within time and budget, while the project is still running”. At this point, the WBS elements are not used in that way. All of them are open to book costs on when the project starts, and all personnel can book on all codes.

Part of the problem is that the structure is not set up properly. As discussed for the WBS aspects, the activities are not defined in such detail that they are also put in the system in such a way. Also, the WBS structure is at this time put into the SAP-system by personnel in the Finance department, who do not know the specific activities of the project. One of the project managers: “the person that prepares the WBS elements in SAP, usually puts all codes in the system, and not just the ones that have a budget according to the VoCa. So where we only use codes A-B-C, it is possible that codes D-E-F are also open in the SAP-system to book costs on”.
This lack of defining activities, also causes problems in booking hours and materials. An employee of the Finance department confirms this: “costs are often booked on the wrong WBS element. One budget may be two thousand euros short, while another one is two thousand over budget”. Project managers also see this happening. At the moment, they are only steering on the large main budgets, for primary, secondary and construction components of the project: is everything booked for the right discipline.

Engineering
The employees in the engineering department, which I have spoken to, also see problems concerning booking hours in the current project structure: “I book my engineering activities on one activity code, but subsequently I get e message from project management to also book on the other activity codes. Apparently they distributed the budget over several activities, but when you are not clearly notified on that structure of activities, it is hard to assess the costs afterwards”.
Another employee for E&P agrees that responsibilities within the WBS should be communicated more clearly, but also that employees should ask more questions: “When a project engineer orders materials, he should know on which elements the costs need to be booked. At this point, a lot of material is booked in the ‘preparing phase’ of the work for example: but that is not supposed to happen. Awareness is part of it: if they don’t know how to book it, they should ask project management for more guidance”.

Overall, it can be said that there is currently no proper WBS structure in place, to be able to apply a proper Earned Value appraisal. Also, the way the project is structured is not communicated clearly with the complete project team. To be able to review activities separately, everyone should know what the activities entail.

Aspect 3

Meaningful cost estimates are needed, to provide a measure against which to control costs. These estimates need to be quite detailed, and also explained in terms of work definition, the basis for the estimates and a range of possible outcomes.

When a project starts, the small project team comes together to discuss the work and planning. The experts in the SPT discuss the work that is needed within their departments, with the people that will

be working on the project, and in this way, the expected costs per discipline are put together. The project manager (or assistant) puts the separate calculations together into one VoCa for the entire project. In the past, there was some room for 'unforeseen' costs in the estimates, but since the SPT this is not taken into account anymore. "If you do, that budget will always be used up".

The VoCa is based on the experience of the specialists in the SPT. The only thing the project manager does, is ask critical questions. "What they have calculated goes, they know their work better than I do". The project manager calculates in some extra hours for meetings, but also some 'general' hours, like the hours the planner and program coordinator make.

Engineers

The engineers I have spoken to, do not see the VoCa as being 'quite detailed': the assignment, or project plan, is usually still quite rough. "When the project starts, we run into things that were not taken into account, because we did not assess in detail what needed to be done". There is a reason that VoCa's are not always so detailed: you would need to look on location (the station) whether the real situation is exactly the same as the drawings, if there are some old components or materials that need to be replaced, and if everything can be installed as planned. Working this out in detail beforehand costs a lot of time.

The engineers feel that this should only be done in detail, when the wish is to have a very realistic VoCa (a margin of five percent for example). "It is a choice you must make. The customer is usually not that interested in all those details, the engineering department may benefit more from it: that when the project starts, we already know up front what we can expect. At this moment, we run into things during engineering. We plan the work based on standard run-through-times, but when unexpected things occur, we have to deal with delays".

Another problem mentioned by the engineers, is that the responsibility over their part of the VoCa is not always clear. The engineering parts of the VoCa are drawn up by the project engineers appointed for their discipline, and then checked by the senior project engineer, that is also part of the SPT. However, when the VoCa is established, it is usually still unknown when the project will start. So, the engineers actually working on the project later on, may be other persons than the ones drawing up the VoCa, resulting in a situation in which the engineer working on the project does not know the exact budget, or at least does not know why the budget is what it is, and thus feels not responsible for it.

"I think that when a project engineer is assigned to a project, when the work on the project truly starts, should check the VoCa again: can he live with it, can he do the work for the budget that is set". At this point, there is no true detailing for the project engineer, explaining what the budget is based on. "The project engineer should have a say in it: if it is clear where the calculations are based on, and if he agrees with it, then you can keep him to that budget. If he accepts the work, than that is the price for which he should do it. That is not how it goes now". This also works the other way around: the person that has made the VoCa for a project, does not know how precise his budget was, when he is not part of the project team. If there is a large deviation from budget, the person who established that budget does not know.

There are no index numbers, or standardized values on which the VoCa for engineering is based. “We are constantly ‘reinventing the wheel’, while we should be able to know the value of the work from projects we did before”. More reconciliation is needed, between different engineering disciplines, so that the same work is not taken into account twice, or not at all, but also more reconciliation with the SPT: after the VoCa is made, it should be reconsidered and looked at again when the project starts. Also, there should be an evaluation with the SPT when the complete project has finished.

Construction

The view on the VoCa is for some points quite similar within the O&S department, responsible for the execution of the work. The technical specialists that are part of the SPT, are responsible for drawing up the VoCa for the construction phase of the project. “But we base the VoCa on the existing project plan at that point. The plan is usually not complete, and if the plan is not detailed, we cannot determine the exact hours we will spent on it”, another colleague confirms this: “sometimes we review the VoCa afterwards, and the project plan that was known at the time, and it still lacks a lot. If there is a clear project plan, which details the activities that need to be done, we can make detailed VoCa’s as well. At this moment, that’s impossible”.

The O&S department is currently not that involved in drawing up the project plan. The technical specialists are involved in the SPT, but they are dependent on the drawings made by engineers, that will describe the work they need to do. “If we are more included in that process, we can make better estimations. It is also dependent on our own technical specialists, will he look up the engineer for consultation. The closer they work together, the better we can make an inventory about what we need to do. That interaction is not optimal at this point, but that is also the nature of the organization: we are a functional department doing projects, and there are differences in approach”.

There are, in contradiction to the engineering department, standard amounts on which the VoCa for O&S is based. From experience, they know how many hours they will spent on certain tasks. When the project plan is not detailed enough to make an estimation of the activities, they will use another VoCa from a previous, similar project.

Exact or standardized?

The question is: do you want the VoCa to be exact, or is there a wish for a standardized VoCa, that is applicable to more projects, but less precise? The employees I have spoken to, do not agree on this matter. The manager (at that time) for Transport North mentioned the need for VoCa’s to be “much more exact”, while some project managers would like a more standardized way of working, but also not all of them. At this point, there are some VoCa’s that are standard, because the tasks are the same for those projects, but most of them are drawn up from scratch.

One of the employees mentioned: “I understand why they might want a standard VoCa, in which you would only have to tick the boxes of those components included, so to speak, and the costs will automatically sum up. We could do that, but not all our stations are equipped the same. A transformer change can be standard, but building a new 10kv-block to an existing station, or when you place new cables to raise capacity, the situation is new every time”. One of the project managers says: “the work we do is not standard, and projects are usually too unique to just copy stuff like that. There are always ‘ifs and buts’, but also: we *think* that because it is somewhat different, we have to tackle it in a complete new way every time”.

The problem is, that the VoCa cannot be made that exact, so early on in the project. The plan is, as said before, not detailed enough by then. So there is something to say for standard budgets. “And when you use such standards, you could estimate in consultation with Asset Management which tolerances fall around them. If it is standard, deviations can be bigger, but we should not quarrel about that then. The average should stay the same: around the zero line”.

A more standard VoCa may also help to set standards that everyone follows. There are at this point, not guidelines for the amount of hours calculated for project meetings, for example. Or agreements on who takes them into account. One of the project managers mentions that he takes into account all meeting hours, since he is the one initiating the meetings: “but if the disciplines also do that for themselves, they are counted double”. Hours are in any case the most problematic, another example: “a technical specialist for securities may look at the activities, and say: ‘from my experience, it will cost 800 hours’. But if those activities are assigned to an employee still in training, together with an experienced colleague, it will cost a lot more hours”. By using standards, there will be greater deviations from the mean: but that mean does provide a measure of efficiency.

Lessons learned

A final point, which is worth mentioning for many employees name it, is learning from the past. The VoCa’s are currently made based on experience, or for executing the work even on some index values, but projects from the past are hardly ever looked at again. A project manager says “we make a final report for a project partially so that it can be reviewed for a comparable project in the future, but I don’t believe that it ever occurs. There is no progress. It is possible that the current evaluation and end report is not something the project team can work with, but we never had such feedback from them. I would expect that when we make a VoCa, that the project engineers have a pile of papers, to review what went well in similar projects before, or what we forgot in our calculations. That way we can gradually improve our estimates”. Risks are also not taken into account in the estimates made. What happens when some activity takes longer, or when something unexpected occurs. “The costs related to those risks is definitely something we want to look into further with the project managers. But that should also include the project team, for otherwise those risks will only be my point of view”.

Overall, it can be said that there is a need for more uniform estimates. A standard way of estimating may help to be more clear on where the estimates are based on. If it is more explicit in the project plan which activities are needed, and what the definition of those activities is, the estimates will be more reliable. It will also help to compare projects, and to learn from previous projects.

Aspect 4

Centralized authority and control over projects are the responsibility of project management. All personnel in the project team that are responsible for incurring costs, also have to perform cost control; and project staff needs to understand the total flow of financial and cost information.

There is a lot to be told on this specific aspect of control, as it seems to be one of the central problems. Part of that can be derived back to the VoCa that is made: the persons calculating the costs are not always the persons ultimately responsible for the costs. In fact, the project manager is. Part of it

can also be derived back to the WBS: activities for lower levels are not defined, and there is a lack of clarity on the responsibilities connected to them. This section will review the problems more in-depth.

Responsibility of Cost Control

The responsibilities over a project are not always clear. One of the project managers sums it pretty clearly: “In working on a project, everyone knows what they need to do. The roles are understood, but what comes with those roles, concerning tasks and responsibilities: definitely not”. One of the problems may be that those responsibilities are not formalized, creating a culture in which, when problems occur, ownership and responsibilities are pushed away to others.

The small project team is responsible for delegating the tasks, and know the work that needs to be done best from their experience. However, as mentioned by a project manager “I would like to see that there is also more transmission of that information from the SPT back to the departments. That the persons ultimately working on that project know what to do. In that way information fans out: on the one hand, the SPT gathers the information from the department, but afterwards that information should be spread out in that department. I don’t think it is working like that right now, there are no established agreements on how we do it”.

However, project managers that work for E&P for some years now, do definitely see improvement with the way it was before. The SPT has helped to bring departments closer together, in an earlier phase of the project. The role of the project engineer is becoming more clear, now that they have worked with this set-up some time longer. But there are still many things in the process that remain vague or that cause disagreement.

Responsibilities of the Project Manager

The project manager is ultimately responsible for controlling the costs of the project. He is also evaluated on those costs, and thus wants to keep the project result within margins. “The project manager is held responsible for all costs, but the only thing he can do is ask questions to the project engineers. It would be much better if the project engineer has to make reports on the progress of his project to the project manager”. So while the project manager is responsible for all costs, he does not have the tools or specific knowledge to look into all costs of the projects in detail.

The E&P department is starting to change to a structure in which the disciplines are also held responsible for the hours they have estimated. “Ultimately, the project manager is and stays responsible for the whole, also towards AsM as the principal. But it would help to make a better estimate of costs”.

The engineering department agree that responsibilities can be shared better than they are now. They are also critical about the project management however. One of them thinks that project managers should be more critical and ask more questions, “they are the ones that are ultimately financially responsible. Even if they have less knowledge about the work, from their experience they should ask questions: where did this budget come from, what is it based on?”. Another engineer adds that project managers should also structure the projects better: “we make a VoCa, and when I want to book my hours, and look at the structure in which activities are divided, it leaves much to be desired. The project manager should steer more, using the structure, and not have someone from Finance decide how the structure of his project should be designed”.

Responsibilities of the Project Engineer

The role of 'project engineer' should be defined more clearly. They were called into existence with the idea to have a project leader for the respective disciplines. According to project managers, this is not working smoothly yet: "the emphasis is on project *engineers.* They do not feel responsible yet for their planning or budget, and they do not always know where they are standing in a project financially". All project managers agree that project engineers should be held more accountable for their part of the VoCa. "And not only be, but also *feel* responsible. A project engineer may not always agree with the VoCa given to him by a senior project engineer, but it is also not my responsibility anymore at that point", "My experience is that in the current situation, a project engineer is asked to calculate a certain part of the project. He returns this to the SPT, where the experts review the accuracy. If the estimate is accepted, the project engineer should vouch for it. But that responsibility is taken away from him, by delegating it to the project manager. But ultimately it is the project engineer ordering the materials and delegating work within his department; when his estimate turns out wrong, the project manager suffers for it".

The role of project engineer an improvement according to almost everybody, but the splitting of responsibilities in the project, between project engineers and project managers, should be clear to all project personnel. Now it usually depends on the project, and on the team members working on the project how responsibilities are delegated: different projects have different agreements on how to tackle the projects. So, apart from more clear agreements, the agreements should also be more uniform.

Overall, project managers and project engineers are not at all dissatisfied with the collaboration in project teams. They are only frustrated about not having the tools and ability to control the costs in the way they would want to. One of the project managers says "it is not that they don't feel responsible for the project, they do: they want to do their work as good as possible. There are just many persons involved in the process, making it easier to say: I did not make those calculation, I am not going to be responsible for them". One of the engineers also mentions it: "what we see now is that a project manager wants to know *everything,* when we order even the smallest materials… If those responsibilities are more with the project engineer, and there are clear agreements on when and how he should inform the project manager on the status of the work, that would work much easier".

The employees for the engineering department that I have spoken to also agree completely with giving the project engineers more responsibility, and defining their role better. "The role of the project engineer should be more considered a project leader role. With the difference that they are specialized on a certain discipline for engineering, which is why it is called a project *engineer*". One of the senior engineers mentions "if we give them more ownership of his 'part', he will have a better insight in the planning and costs, which will also make it easier to review the status of the work. We have to lift the function to a higher level, actually, instead of pushing off problems to others. Pointing at others will not help us".

The engineers also mention that the tasks do not *have* to be for the project engineer, a function like a calculator, or someone else tracking costs and work all day could do it as well, as long as *somebody* is made responsible. But, if they are held responsible for their part of the VoCa, they will also need the tools to monitor their work properly.

Responsibilities O&S

Some also mention the hours for executing the work. As mentioned before, it is hard for the O&S department to review what their activities will be and cost, because they are very dependent on the engineering department. “Ownership of your part of the process is a good thing, as well as having and taking responsibilities, but full responsibility is not possible. If an engineer is delayed in ordering materials, that will affect our work and planning. We cannot take responsibility for what we cannot control”. Also, when there are outages, people from the O&S department are needed to make sure it is fixed as soon as possible. This may mean that work on a project is somewhat delayed.

Overall, O&S can control their hours, but not the complete costs: materials are ordered by the engineers. The O&S department therefore does not agree that they should be responsible for cost control, there are too many dependencies with other departments. Also, they mention “we do not have the tools at this moment to get an insight on costs or budget”. Closer contact with the engineering is what helps them to control their work, and the working hours are usually estimated quite correctly. One of the project managers has mentioned that the O&S part of the work is also subdivided into the three disciplines (primary, secondary, construction), and that their part of the work could also be in control of the project engineer: “the three disciplines should have ownership over their part of the work, and that may include execution of the work for those disciplines, to get a better grip on the overall project”. One of the engineers also mentioned that there should be something like a ‘sub-project manager’ for the execution of the work, that can also assess whether costs and hours are booked correctly.

Having the tools for control

One factor that is mentioned repeatedly, is that the departments currently do not have the tools to properly control the costs of a project.

The program coordinator explains the current system (SAP) somewhat further: “to be able to hold everyone responsible, the reporting tools should be structured in a way that everyone who makes a part of the VoCa can also be held accountable for it. Then you should be able to tie budgets to all sub elements (activities) in the system, and at this point we can’t. Budgets can only be put in for main WBS elements, and they are not even subdivided into hours/materials/third parties. That is a shame”.

The wish to have project engineers report to project management on the status of projects is also more difficult because of this. “If that is what we want, we should support a project engineer much more: SAP is too complex. The best thing would be, a report that results *from* the information in SAP, in which he can see: how far are we, what materials are paid for, what should still be ordered”.

The systems should support employees in their work. There are some distinct wishes mentioned by different persons: “We should be able to put a name in SAP: who is in your project team, who is allowed to book on your project”, “when a project engineer used op 80 % of his budget, he and/or the project manager should get a signal, a warning from the system”, these are functions that should be possible in SAP, but nobody knows how to build them in.

Booking costs on the wrong numbers is a problem currently, making it also harder to work with the information that is put into the system. When a project engineer is more responsible for his budget,

this may also go more smoothly, is the hope of some project managers. “If he is made responsible for his part, he is forced sort or less to put the costs under the right heading”. A project engineer should be able to attach personnel to his part of the project: “he knows who are working on the project, who the contractors are, and which material there is”. Project management and the project engineers agree that project engineers can only be responsible for their part of the project, if they have the tools to monitor and guide their work.

The team manager for the engineer adds: “I would like to evaluate my project engineers on how they function in projects: these are the hours you calculated, this is how you did. But we do not have the tools”.

The linear organization vs. the project organization

As was explained in the definition of project management, project management deals with the interaction between the functional (line) and project organization. This is also one of the problems concerning cost responsibility. As an employee of the Finance department explained: “booking hours is a problem, because project personnel books hours directly to the project. Their team manager approves it, and not the project managers. That is troublesome, since a project manager may find hours on his project that he would not have approved himself. That is why they should constantly check who is booking costs/hours on their project”. A project manager agrees that this is problematic: “the only thing a team manager can see is: he worked 38 hours, fine. But that approval has no real added value, for he does not know the work that was done on the project in those hours”. Project management would like to see that an assistant project manager, or a project engineer, becomes responsible for approving the hours booked on projects: “someone who knows *what* you are approving”.

Another factor is, that when people are held responsible for the costs of a project, they should also be evaluated on the projects themselves. A project manager can only tell someone that they used up too many hours, they are not evaluated on it by their team manager. One of the project managers is cynical: “evaluation? I have worked some years for this organization, and not once did someone come to me to ask: he is working on your project, how is he functioning? But at the same time, I am evaluated on it every month: what projects are within budget, and will you finish in time. I think it is a bit crooked, there are so many people working on the project, but only one is judged on the final result, or on controlling the costs”.

Communication

The project plan should already divide the responsibilities. “Each paragraph describing activities per discipline, with also a financial part attached to it. So that when a project engineer sees the project plan, he knows which responsibilities are his. It would create more awareness”. It can be said, that at this point, the project team is definitely not always aware the total flow of financial and cost information, as the control aspect dictates. A person with the Finance department adds “they should indeed be informed about the financial structure: this is what we calculated, so these numbers are the ones you can book costs to, you should not use the other numbers”. This shows that a better defined structure, about which everyone is informed, will also help to structure the information in the control system better.

A better defined structure with defined responsibilities may also help to prevent communication issues. The status of projects is now reviewed by project managers asking a lot of questions, and by

project meetings in which the status of the work is discussed. But, if project engineers report to project managers, and are also held responsible for how their discipline is doing, the information will become more reliable. At this moment, a project engineer can only explain afterwards why more hours were needed. Project management would like to know earlier on what their project result will be: “extra work done by contractors is sometimes booked on your project, while you don’t even know. It is a surprise sometimes, and would be so much better to get a call or e-mail: ‘extra work is needed, is that all right’”.

Aspect 5

Project teams must have regular team meetings, with a formalized agenda.

The project team meetings are very regularly held at the moment. Project managers mention some different time periods, but overall the average amount of weeks between project team meetings is three weeks. More specifically, the amount of meetings depends on the kind of project and the phase the project is in. Project teams have meetings at least once per month when the project is still in its preparation or engineering phase. When the work is executed on location, project meetings are every other week. At important moments, or when problems occur, meetings may even be closer together, in consolidation with the project team members.

The project meetings are held to communicate about the progress of the project, and input is given by all project team members. What is completed in the past weeks, did we reach our goals so far, and the coming weeks are discussed: are the needed materials, drawings, needed personnel there. The persons attending the meeting can also be adapted to the phase the project is in.

SPT

For the SPT, there are no regular meetings, and in fact in can be said that it is not truly a ‘team’ in that way. For the SPT, there is only one meeting at the beginning of a project in which the project is discussed and delegated to the respective experts. There may be a meeting more, in which the project plan and VoCa are further discussed and reviewed, but usually there is only one formal meeting.

Overall, it can be said that the project meetings are done on a very regular basis already. This is not true for the SPT, which makes it hard for the SPT to review the process and progress of the project, or to evaluate the project.

Aspect 6

The actual performance to date should constantly be compared to the estimated performance: is there a (large) variance? The percentage of work done, including work in progress, has to be assessed, and a forecast of cost at completion can be made by using the earned value and cost variance so far.

At the beginning of this research, the manager for Transport North mentioned that one of the most important wishes for Enexis E&P is to have a continuous image of the project result. Both project managers and engineers stress that it is not a case of not *wanting* to do it better: the sort of work done by engineering is what makes it hard. There is a mutual understanding of the complexity concerning ‘percentage complete’ for the engineering department.

To determine a percentage complete is also hard for the construction phase of the work. This is partly due to the long work packages and activities. Milestones are focused on when components go into operation, or are technically ready. There is no way to estimate a percentage complete for activities with such a long time span.

Prognosis

In making a prognosis, the project managers are somewhat reliant on others giving them the right information. There is a time planning and a planning for costs: when are what costs expected? The project managers use this planning to steer the project. “If engineering costs 5000 hours, you calculate the value of those hours, and fill in your prognosis. If all is well, at the end of that period the money is spent, and engineering is finished. If less money is spent in one month, you raise the value for next month”. If there are large deviations, a project manager will zoom further in, to find where the deviation is coming from. The prognosis is made in Prisma, a system that tracks the cost made each month and presents it against the budget that was set for that period. “I compare the planning with the prognosis: is the work finished, and did we actually spent the money; the amounts in the prognosis are adjusted to show the costs that are still expected”.

WIE MOET HET DOEN / BOEKEN VAN DE KOSTEN

Materials are rather easy to control. The expected expenses (prognosis) for materials are put in Excel, and the true expenses are then compared: are they paid earlier or later, or did they end up cheaper or more expensive. One factor making estimating the final result harder, is that it is unclear whether all costs are booked already at a certain point in time. This is a bigger problem with hours than materials. “It is possible that someone did not fill out their working hours for some weeks, if there are more employees that did not do it, you miss a couple of hundred hours that are spent, but not booked”. Another project manager agrees, and mentions that you sometimes *think* that the project is going according to plan, but the next month it is possible that more costs are booked that you did not expect anymore. “You really have to dive in. And those costs do not come up automatically from reports from the system: you really have to ‘fetch’ yourself, within the departments”.

An assistant project manager explains how they help to forecast costs: “we as assistants make a lot of the print-outs for project statuses: the hours that are booked et cetera. But it is still responding in retrospect: the costs are already booked. We would like to be informed ahead of time on costs that are coming”.

Overall, project managers do feel that their prognosis’s are fairly on track, because they are usually on top of the process of projects. They usually just don’t have the time to look into all hours booked so detailed. According to other disciplines in the organization it is, however, the task of the project manager to check those bookings more closely. Someone from O&S mentions that it is “the task of a project manager to control the structure, and to have an overview of the hours that are booked at any point in time”. Someone from the finance department adds that “there can be more attention paid to the hours booked on projects, especially the hours that do not belong there, and the project manager should tackle those issues, speak to those persons as soon as possible, and not save those problems up to the end. And not take too much time to try to find all those bookings in SAP for themselves. That would be my advice”.

HOE WEET JE WAAR JE STAAT / WERK UITGEVOERD

Comparing the time and money spent to the work that is carried out is sometimes hard. At this point, project managers look over the run-through-time of a project: what are important milestones, and overall per month: we are here now, what will be the expected final result? Costs and time planning are now separate, but are compared to each other, to see where they are in planning, and if it adds up to where the project is concerning costs.

Although the booking of costs sometimes gives a distorted view, the time planning is usually quite reliable. One project manager mentions “most projects have (a) milestone(s) stating when things need to be finished, and we always meet those deadlines”, and another project manager adds “our planning is more and more detailed: when do we start digging, when are cables placed, we know which phases there are in the work”. There is a need to know all this so tight as well: expensive materials cannot lie around the building site for days, for they will be stolen.

So, because the project managers are tightly guarding the planning of projects, they always have a good idea of the amount of work that is finished, especially in the construction phase: “it is not measured in percentages, but especially in the construction phase, we can say almost per day but certainly per week: this is week 42, are we ahead of schedule or behind?” The engineering phase is still hard to measure, also for the engineers themselves. For how do you determine if the work estimated is truly carried out?

It is one of the reasons why some do not see the added value of a ‘percentage complete’ method for the projects that are carried out. As someone mentioned: “Putting a percentage on it: is it true, is it not true, it is hard to determine. Those are great tools in the construction industry, but I question how useful it would be for us, here”.

Aspect 7

Periodic re-estimation of time and costs is needed: if there is a variance, it should be assessed whether corrective action needs to be taken, and when such changes are authorized.

At this point, project managers do re-estimate time and costs. The prognosis that is made, helps to assess whether there are large deviations from plan. When there are deviations that were unforeseen, for work is carried out that is out of scope, an alteration form can be filed with Asset Management. The rules for an authorized alteration are clear: is it truly a deviation in the project (out of scope work), or should it have been anticipated? If it could have been anticipated, than it is considered a project risk, and there will be no extra budget for the change. If the change is unforeseen, extra budget can be released by Asset Management. If the extra (or less) work should have been anticipated, than the project manager has to justify the deviation in his end report: why was there a negative or positive project result.

It should be mentioned that project risks are, at this time, not taken into account in the project plan that is made: “we do mention some risks in our project plans, but hardly anyone reads those. And we do not connect conclusions to them: what happens when it takes more time?”. If the VoCa’s become more standard, which is a wish of management, then risks do need to be taken into account, and

then changes in scope have to be redefined: is something taken into account as a risk, or is it out of scope work in case it is needed?

One other factor that needs to be mentioned is that, at this point, only the *total results* are usually looked at: variances are not measured per discipline or activity, but summed up over the total project. One of the project managers says: "in one of my projects, I have money left: Primary and Construction finish under budget. But for Secondary, I need more money, for which I cannot request extra budget. If done correctly, I'd have to file an alteration form for 'less work' (minderwerk) for Primary and Construction, and more work for Secondary. But the deviations compensate each other, which makes it okay". The same thing is true for the distinction hours/materials/third parties. One of the project managers explains this as well: "If you are lucky, and the materials that you need turn out to be cheaper, I may 'earn' for example 50.000 euros in a project. But it compensates when I am 50.000 euros short for working hours. In other companies, that is not okay: materials are materials, and hours are hours, you can't throw them on one big pile. But here at Enexis, it is all the same".

So, if done correctly, it would be better to take risks in account for projects. What can be expected? And what happens when unexpected events occur? Also: is it okay to only review the overall budget, or would it be better to split costs, to also make projects, and their smaller activities, comparable to each other.

Aspect 8

Value should be recorded as early as possible, and all value has to be reported properly (materials and labor hours separately). Reports on project control are short, use defined criteria, and are made at defined intervals.

Project managers report to the manager for E&P on a monthly basis. Reports to their supervisor is done in Prisma, the program which shows the prognosis for a project, with the expected costs per month. Prisma works as a sort of dashboard for project control: for a project, the true costs are compared with the budget (prognosis) that was made. When there are deviations, the expected budget for the coming months can be adapted. Prisma also tracks time, colors show which phases are finished. Bottlenecks can be described in the system, and Asset Management puts the deadlines (dates) in the system: when should the work be finished.
When the project is finished, the project manager makes an end report for Asset Management, which explains the final budget. For project management, it can thus be stated that reporting is done at defined intervals. The defined criteria are guided by Prisma: the financial information per month is needed. For the end report of a project, there is also a standard document, focusing on how the project went, explaining budgets and bottlenecks that occurred during the project.

Reports about the project are hard to derive from the current system. The reports in the system are not properly maintained over the years, and the standard reports that can be derived from SAP are not up to date anymore. There has been some improvement in the last year: the program coordinator has worked on a standard report that can be derived from the input information in SAP at any time: "I have looked at what information we wanted such an output to show. Then I reviewed standard reports that already exist for the regional offices, or for Finance, that can be used in other departments as well. We dragged some formulas from one document to another, and then we had a concept that shows most of the information that a project manager needs. These reports are made

in Excel, for the VoCa (budgets) are not that easy to put in SAP at this time. Now we have a standard model, which meant we also needed an input form. If that input form remains the same, and everybody fills it out correctly, we have a much better idea of where we are. It means less work for me, and project managers have better tools to fill it out for themselves". The new budget report has already proved to be of great help: project managers that wish to receive more detailed reports on their projects, receive an updated report from the program coordinator every week.

Another problem complexing the reports that can be made, has already been mentioned before: the structures are not designed to be able to evaluate smaller parts of the process: if a discipline estimates their part of the budget, it cannot be monitored (and therefore evaluated) separately. There is a wish with all of the project personnel to be able to do this better. "It would be great if a project engineer could already fill out a smaller standard report. You can put those reports together, and then when you review them, the overall image you get of the status of the projects will be much more reliable". To be able to make this happen, a project engineer should also be more supported with standard reports that they can fill out and that give them information on costs and planning, which is automatically derived from the system, without too much manual actions needed. One thing that is mentioned multiple times as well, connected with this, is that the SAP system has much more options for managing projects than are used at this point. "There are so many possibilities in SAP, but we only use a very small amount. The knowledge needed for using it optimally is missing, which is a shame". One uniform system, that keeps track of projects and reports on them, is one of the most important missing factors at this point, according to project managers and engineers.

Reporting within project teams is less formalized. As an engineer explains: "within project meetings we are given an indication of the status of the project, the costs and working hours are presented. If there is a shortage for your discipline, or if you will not meet targets (in time), you have to point that out. It is more providing insight both ways, than true reporting". Also for these reports, it is mentioned that there is no uniform way of working: every project manager reports to his project team in the way he finds best: "there is no standard. I use report A, another project manager uses B. They are ultimately derived from the same input data, but it can be presented very differently. Even as project managers we have not found a standard amongst ourselves yet".

For O&S project members get an overview of the hours that are booked. "Then they ask if those hours are correct? Yes, of course, we booked them ourselves. But the question if we are also that far in executing the work as we should be, is not always easy to answer with the information we have from our systems".

Value

Value is recorded when materials are in 'obligo': a future obligation to pay the money reserved. In the financial reports that are made, costs are split between planned (budgeted costs), costs in obligo, and real costs. Costs in obligo are not yet real costs: but it is the value that is already reserved for ordering materials. It can be concluded that value is therefore reported as early as possible, for materials that are put in obligo. The costs for other materials are sometimes booked too late. That is also true for working hours: project personnel should fill out their working hours each week, and they are checked by their team managers. Working hours are, however, not always filled out in time. There is now more inspection on whether working hours are filled out in time, which should help to

have value recorded as early as possible for projects. One of the project managers: “the costs that are booked in SAP are summed up for making prognoses. Those are not always reliable, because hours and materials are sometimes booked too late; they are not taken into account in those prognoses”.

Working hours are sometimes booked on the wrong activity codes, as was discussed before. Project personnel does not always know the budget per activity code, or do not know which activities belong to which code. It is therefore common that working hours are booked on the wrong project phase, or that the budget for activity codes are ‘filled up’, and when the budget is reached, a new activity code is used to book working hours to. To have value recorded properly, the project activities and structure should be more clear for all project personnel, so they know what part of the budget covers the tasks that they carry out. Another example is materials that are now booked on the WBS element for the preparation phase, which is not correct. There is more awareness needed for the engineers ordering materials, to know to which codes and activities those materials belong.

The WBS-elements in the current SAP-structure are a total sum of the budget. There is no distinction made in materials/third parties/working hours, which is not according to what this aspect prescribes. The distinction between those three *is* made in the VoCa, and therefore also used in assessing the status of the project: VoCa/NaCa, which is good. It would be easier if the distinction is already made in the SAP-system, where the costs are booked: separate budgets for hours and materials.