Identification of Factors Causing Time and Cost Overruns in Offshore Petroleum Modification Projects

Dina Kayrbekova[1], Tore Markeset[1], and Sukhvir Singh Panesar[2]

[1] University of Stavanger, N-4036 Stavanger, Norway
{dina.kayrbekova,tore.markeset}@uis.no
[2] ApplySørco, P.O. Box 8040, N-4068 Stavanger, Norway
sukhvir.singh.panesar@applysorco.no

Abstract. Many of the production facilities and technologies operated on the Norwegian Continental Shelf are getting older and need to be modified to maintain the production performance at the desirable level. Each modification project is unique, and therefore needs to be evaluated and verified with consideration to all specifications. However, the oil and gas industry experience shows that the execution of modification projects within predefined time and cost are rather an exception, than a rule. In this paper we identify and discuss some of the factors that cause time and cost overruns in offshore facility modification projects. Furthermore, we discuss alternative cost methods to improve the quality and the accuracy of costs and time assessments.

Keywords: Modification project, Time and cost overruns factors, Cost evaluation, Activity-based life-cycle cost method.

1 Introduction

The development of offshore oil and gas is technologically complex and capital-intensive and utilizing increasingly advanced and complex products. In Norway many offshore production facilities have been developed in the North Sea in the south of Norway and in the Norwegian Sea. However, many of the oil and gas production facilities operated on the Norwegian Continental Shelf are getting older and require more investment, upgrades, modifications and more maintenance to achieve the maximum economic potential from the petroleum production operations. A large percentage of the projected cost can be allocated to maintenance and support activities associated with keeping the production facility at a desirable operational state. The cost of system maintenance and support can often be substantial, depending on industry and type of systems. Moreover, more reliable, cost-effective and environmentally friendly technical solutions are required to keep production performance and Health, Safety and Environment (HSE) issues at an acceptable and desirable level. Each modification project is unique and can vary in size, character and complexity. Modification project design assumptions are subject to creative solutions, as the fast speed of technology development and equipment degradation makes equipment/systems which are already in use, obsolete.

J. Frick and B. Laugen (Eds.): APMS 2011, IFIP AICT 384, pp. 268–275, 2012.

Furthermore, modification work (e.g. material cost and installation methods), depends on the modifications' purposes related to a specific function, or facility or location. The purpose of the modification project is to utilize the existing infrastructure for a new bulk of modified functions. New duties and functions can lead to disruption of the orderly progress of work on ongoing production and a growth trend in more material needs. Also, an increase in the complexity of work will strain project resources and time frames. Poor quality concept development in the modification projects can increase the risk of overrun from the pre-defined time and cost and of exposure to a change in the nature and quantity of work to be performed (e.g. resources and man-hours). A change in the quantity of resources and man-hours can result in cost growth and time overruns. Thus, modification project development phases need to be evaluated and verified with special consideration [see e.g. 1, 2] as it is still a challenge to execute modification projects effectively and within pre-defined, expected and predicted costs and time frames.

In the European standard prEN 13306, modification is defined as: "*a combination of all technical, administrative and managerial actions intended to change an item*" [3]. A modification project is a temporary multi-discipline alliance of work with defined tasks, goals, framework and budget. Furthermore, different installations' locations, work and installation technologies, climate conditions, authorities' recommendations and regulations need to be considered during the concept development of a modification project. It is important to identify all related cost elements. The direct and overhead costs are often not visible at the beginning of the modification project development. The oil & gas industry experience shows that modification projects always tend to rise above pre-defined and predicted costs and time, "*and large cost and time overruns has been the rule rather than the exception"* [4].

In this paper, we identify and discuss some of the factors that result in time and cost overruns in the development and execution of a modification project. Furthermore, we propose and discuss alternative cost assessment methods to be used in modification project development to reduce time and cost overruns.

2 Identification of Factors Causing Time and Cost Overruns in Modification Projects

Based on discussions with industrial experts from the Norwegian oil and gas industry as well as a literature review, the following factors are identified as causing time and cost overruns in the development and execution of an offshore production facility modification project:

1. Project control and integrated project team competence (management quality, human factors, work environment)
2. Data availability and uncertainty (information sources, knowledge, quality assurance, experience)
3. Reports and documentation (quality control, document formats and standards)
4. Indeterminate interface between the existing facility and the new installation – integration (depth of the technical understanding, micro/macro thinking, strategy and tactics)
5. Evaluation methods of technical solution alternatives (credible decision making, suitable decision-making support tool, suitable cost-assessment method)

2.1 Project Control and Integrated Project Team Competence

A multi-discipline organization such as that used in modification projects needs high quality supervision, coordination and control. The key responsibilities of modification project management are to keep an accurate overview and precise control during all phases of the project's concept development and execution to ensure that all required and reasonable decisions are taken, and all associated work and support activities are planned and will be followed up circumspectly. It is important to have an environment of good cooperation between involved project divisions, and to ensure that all goals and requirements for the project's development and its execution are met and clearly understood in the early stages of the modification project development. Later changes in the project can be costly and/or result in delays.

During the review process, the following issues need to be assessed: resources, available technical solution alternatives, HSE issues, vendor market and cost. Moreover, in order to develop a selected concept, relevant uncertainties need to be assessed and a plan for uncertainty reduction needs to be established. It is essential to have control processes in place; these aim to approve the selected concept for further detailed development, to verify that the concept is likely to be profitable and technically feasible in accordance with the pre-defined time plan and costs, and to provide the best management prospects possible, this will ensure the opportunity to take corrective actions in time to avoid growth in the volume of resources and significant deviations from the original assumptions regarding costs and time. It is critical to perform a systematic review and control of the modification project's baselines, such as scope verifications and updating costs' estimates; this should take place as an interactive process between the project controllers and estimators [5], [1].

The management work processes may be optimized for more efficiency and better quality by employing a highly qualified integrated project team; by application of suitable project decision-making support tools, resourceful databases and first-class organized execution procedures; and by skilled usage of existing experience. For example, individual understanding of the equipment and the long experience of the specialist can affect and increase the quality and reliability of the engineering decision making during the project's concept development. The more skilled specialists are involved in the modification project team, the better track records and more accurate time and costs' assessment can be expected during the project's development and execution phases. It is important to emphasize that it is advantageous for the team members responsible for economic evaluation to have a competence in the technical environment as well [6], [7].

2.2 Data Availability and Uncertainty

Each modification project is unique. Thus it is difficult to use a previous project's budget estimates without adjustments to evaluate the project costs at hand. The uniqueness of some modification projects can make for restricted availability of data. The quality of the available data may be hard to assess and the uncertainties need to be taken into account and analyzed separately. Nevertheless, the data and costs' estimates from similar modification projects can be accessible and obtainable if the information is open to use and not sensitive. Existing experience, knowledge and data from similar modification projects can be used as the basis for costs' and time assessments, as well as being helpful for gaining better knowledge of how to increase the quality of control and the total overview of the modification project at hand. Data and information which may be used for the evaluation of alternative technical solutions may be obtained from multiple sources and need to be meaningful and comparable. Reliable and meaningful data is one of the key factors in the early stages of the modification project's development, as poorly conducted early phases and poor quality data used in the development of the modification project can in turn lead to costs' and time overruns.

This can be exemplified in obviously different data packages which can be provided by different suppliers or vendors. In addition, the vendor/supplier can lack relevant equipment reliability and maintenance data and have a low capability to optimize a product or fail to provide the right technical solution. The consequence of this misinterpretation of data collected during concept evaluation may also result in costs' and time overruns from the pre-defined budget of the modification project during the execution phases. As poor quality data will be used in the development phases of the modification project, so the actual cost will overtake the budgeted cost. Moreover, the high uncertainty and incorrectness in costs and time assessments can be revealed due to the lack of suitable decision-making support tools and cost assessment methods. Uncertainty analysis must be performed in order to identify uncertainty elements that may affect cost and time; analysis of the uncertainties can be performed using variable statistical methods such as stochastic variable or probability distribution, etc. [8].

2.3 Reports and Documentation

The outcome from the early phases of the modification project's development is typically reports and documentation which the basis for approving the project according to economic and technical criteria. These reports and documentations normally need to be sent to the management, partners and authorities. The level of detail given in the various documentations needs to be sufficient to satisfy the requirements. The requirements for the level of detail will vary among management, partners and authorities. The consequence of an unsatisfactory level of provided details can result in delays; for example, one of the parties will require more information and data reports which will take time to produce.

However, reports which are too detailed can result in delays as well, as it can take time to decipher relevant information and data which are of importance. Thus, it is critical for involved parties to agree about the level of detailed information, data and specifications that they may require during the development and execution phases of the modification project. Many modification projects have been delayed or terminated in the early development phases due to disagreement between parties concerning the execution plans and the lack of required information in time [5].

2.4 Indeterminate Interface between Existing Facility and the Modification

The integration of the modification solution with the existing industrial facility is one of the core activities of the modification project. Lack of details on systems surrounding structure, bulk of the existing infrastructure, specifics and parameters of installations, as well as lack of detailed identification of modification activities and their detailed descriptions (e.g. type and volume of work, duration, scheduling of activities' performance, man-hours and competence of workers needed) may significantly impact on the modification project's development, costs and execution time. An indeterminate interface between the existing facility and the modification can challenge the execution of the project within the expected time and budget. It is a challenge to perform an accurate and adequate assessment of the time, costs and resources (e.g. material, man-hours) needed for the integration of the modification solutions and existing installations. Due to this uncertainty, it is hard to execute it within predefined costs and time frames. The industrial facility's function can be affected by integration activities, but these effects are hard to assess in the early phase of project development; often it can be evaluated more precisely only when project development proceeds to its detailed engineering phase.

The integration and installation processes require an extensive quantity of temporary work, demolitions, and relocations, etc. All concerns which are specific to a modification project need to be considered with respect to HSE requirements, reliability issues and from an economic perspective. Moreover, it is important to identify general complexities and specific conditions related to modification work as early as possible. The tendency of the work's complexity and need for extra resources to expand can interrupt ongoing work processes and can result in cost and time overruns [1]. For example, the modification changes (e.g. new equipment) to be implemented in one system can affect the function of other systems and produce the need for extra activities, which can be costly and time-consuming processes as well as creating contractual, administrative or organizational challenges for the project team. Furthermore, mitigating actions to reduce the possible cost and time overruns need to be considered.

2.5 Evaluation Methods of Technical Solution Alternatives

The evaluation of the technical solution alternatives' profitability and their business opportunities' feasibility needs to be performed in accordance with corporate requirements and business plans. Examining, comparing and selecting reliable and cost-effective technical, managerial and organizational solutions still constitute one of the bottlenecks when designing or modifying oil and gas production facilities. The economic evaluation of the comparable alternative technical solutions usually starts in the feasibility phase of the modification project development. The goal of this economic assessment is to select the most technologically acceptable and cost-effective alternative and eliminate uneconomic solutions. The cost assessment and estimation performance can continue through all the project's development phases, normally to the end point of concept development. However, it is still a challenge to make credible engineering decisions from an economic perspective and to provide reliable and well predicted end results. Moreover, it is still a challenge to predict from all related and possible perspectives, the consequences and changes of the selected technical solution alternative (modification) on the function of the modifying facility.

A suitable decision-support tool in a modification project cost assessment can be one of the key elements that can increase the cost and time assessment quality and provide support for the engineering decisions which need to be made during the selection and assessment processes. However, there are no standard decision-support tools which are suitable for cost and time assessments and capable of taking into account all the different modification project specifications. A tool that would help to inform a decision maker about future expenditure, and how to manage the existing budget and how to make decisions which lead to the lowest costs. A tool is needed that will assist a decision maker in obtaining more reliable and accurate cost and time assessments, in harnessing detailed information of the project control activities (typically estimates, collected data with metrics), and in eliminating data duplication processes in project administration [9], [1].

3 Discussion: Activity-Based Life-Cycle Costing as an Alternative Decision-Making Tool

In spite of long experience with offshore modification projects, we often find that they result in time and cost overruns. We identified some of the factors that cause time and cost overruns and found they are multifaceted, intertwined and complex. In the European standard definition it is noted that a modification is not a "replacement by an equivalent item" and that it has to do with "changing the required function to a new required function" [3]. This means that new or at least newer technology needs to be integrated with old or existing technology. Not only does the project team need to understand the existing technology used on the offshore production facility, but it needs to select the best option from the alternative technical solutions and integrate it with the existing installed technology.

Often one finds that information and data are missing about the existing installation, the new technology, and how the existing and new technology should be integrated. This may result in the team not being able to estimate what kind of activities are needed, how long they will take, what kind of material and tools are needed, how they should be tested, and so on. In addition, the project team lacks a tool that is better suited for the difficult task of planning the time and estimating the costs in modification projects. The goal of such a tool should be to define, evaluate and select the most cost-effective, reliable and suitable solution and to accurately predict the time the project will take [see e.g. 10-16].

Different engineering and economic techniques exist with the main goal of identifying and choosing the technical alternative that generates the highest revenue over the expected lifetime (e.g. life-cycle cost (LCC) analysis, cost-benefit analysis, activity-based life-cycle costing (AB-LCC), capacity-driven or time-driven activity-based life-cycle cost analysis) (see [10-19]). The goal is to justify alternative technical solutions with financial perspectives using net present value concepts and providing net present value calculations for discrete or probabilistic decisions [10], [15]. Moreover, the tools should help the decision maker to screen and eliminate costs before they can be incurred by taking mitigating actions and managing some economic risks related to cost and cash flows.

However, experience shows that often the standard LCC and cost benefit methods cannot handle uncertainty credibly enough, and this leads to wrong cost estimates. Thus, an alternative costs' evaluation method is needed [12]. Turney [17], in discussing activity-based costing, suggests that knowledge of activity costs may help a decision maker to focus attention on activities' performance processes, structure and flow, and be helpful in identifying activity drivers with the greatest potential for costs' reduction, as well as to model the impact of cost-reduction actions. We know that a traditional cost method such as LCC will fail to provide information about activities that are needed to ensure modification project execution is continuously within the predicted and expected time and budgeted cost limits. A modification project is a complex blend of multi-discipline work and activities.

Emblemsvåg [14] suggests that the identification of the underlying drivers of business performance and critical success factors' processes can be performed and managed more efficiently using activity-based life-cycle costing (AB-LCC). Kaplan & Anderson [18] also suggest a simplified activity-based costing technique, named time-driven activity-based costing method, in which one identifies activities and then uses estimates of activity times to predict costs. We believe that by using a time-driven AB-LCC analysis method, a decision maker should be able to establish cause-and-effect relationships between the activities, time duration and the costs [see also 19]. Thus, one should be able to increase the long-term profitability by identifying improvement opportunities and by making appropriate and proactive adjustments during the project phases. In addition, it will be easier to keep track of what efforts are needed to achieve the desired performance and to avoid non-value-adding activities with respect to quality, time and efficiency.

4 Concluding Remarks

In this paper we have identified some of the main factors that cause time and cost overruns in offshore petroleum production facility modification projects. The use of better and more suitable cost and time evaluation methods are needed to improve the accuracy and quality of costs' evaluation and time predictions as well as support engineering decision-making during the design phases. It may be easier to avoid non-value-adding activities with respect to quality, time and efficiency, as well as to establish cause-and-effect relationships between the modification activities and the cost and to show what activities take place and to keep track of what efforts are needed to achieve the desired performance during modification project development and execution. Due to the need of identifying detail activities and equipment and technology in interfacing the modification with the existing production facility structure and equipment, we found that the activity based costing, time-driven activity-based costing, as well as time-driven activity-based life-cycle costing may be alternative assessment and decision-making tools in modification projects to reduce time and cost overruns. These methods are based on the identification and pricing of detail project activities, resources, material and overhead costs.

References

1. Fouche, D.P.: Performance Measurement, Estimating and Control of Offshore Modification Projects. Doctoral thesis. NTNU, Trondheim, Norway (2006) ISBN 82-471-7853-4, ISSN 1503-8181
2. Løkling, Ø.: Cost and Schedule Overruns in Modification Projects: Reasons and Measures to Avoid. Master thesis, University of Stavanger, Stavanger, Norway (2010)

3. PrEN, 13306: Draft European Standard, Maintenance Terminology. European Committee for Standardization (1998)
4. Lunde, H., Tjaland, K.: Cost Effective Strategy for Modification Projects. In: The Proceeding of International Conference of Offshore Europe, Aberdeen, United Kingdom, September 5-8 (1995)
5. Coker, J., Gudmestad, O.: Introduction to Development of a Petroleum Installation (2003), http://www.norad.no/en/Thematic+areas/Energy/Oil+for+Development/OfD+Information+Package/Resource+Management/_attachment/132962?_download=true&_ts=12375ce725a
6. NORSOK O-CR-002: Life Cycle Cost for Production Facility (1996), http://www.standard.no/en/Sectors/Petroleum/NORSOK-Standard-Categories/O-Operation/O-CR-002/
7. ISO: Petroleum and Natural Gas Industries-Life Cycle Costing - Part 3: Implementation guidelines. International standard (2001)
8. Aven, T.: Foundation of Risk Analysis: A Knowledge and Decision-Oriented Perspective. Wiley, Chichester (2003)
9. Kueng, P.: Process Performance Measurement System (PPMS): a Tool to Support Process Based Organizations. Journal of Total Quality Management 11(1), 67–85 (2000)
10. Fabrycky, W., Blanchard, B.S.: Life Cycle Cost and Economic Analysis. Prentice Hall, Englewood (1991)
11. Barringer, P., Weber, D.: Life-Cycle-Cost Tutorial. In: The Proceedings of the Fifth International Conference on Process Plant Reliability, Texas, Houston, USA, October 2-4 (1996)
12. Kaplan, R., Cooper, R.: Cost and Effect: Using Integrated Cost Systems to Drive Profitability and Performance. Harvard Business School Press, Boston (1998)
13. Kawauchi, Y., Rausand, M.: Life Cycle Cost (LCC) Analysis on Oil and Chemical Process Industries, Report, Norwegian University of Science and Technology, Trondheim, Norway (June 1999)
14. Emblemsvåg, J.: Life Cycle Costing Using Activity Based Costing and Monte Carlo Methods to Manage Future Costs and Risks. Wiley, New Jersey (2003)
15. Barringer, P.: Life-Cycle-Cost Summary. In: ICOMS 2003, Perth, Australia (2003)
16. Kayrbekova, D., Markeset, T.: Activity-based Life-cycle Costing Analysis for Design of Arctic Petroleum Facilities. In: The Proceedings of the 20th International Conference on Port and Ocean Engineering Under Arctic Conditions, Luleå, Sweden, June 9-12 (2009)
17. Turney, P.B.B.: Common Cents: How to Succeed with Activity-Based Costing and Activity-Based Management. McGraw-Hill, New York (2005)
18. Kaplan, R.S., Anderson, S.R.: Time-driven Activity-based Costing: A Simpler and More Powerful Path to Higher Profits. Harvard Business School Press, Boston (2007)
19. Markeset, T., Kayrbekova, D.: Capacity-driven, Activity-based Life-cycle Costing in Strategic Maintenance Decision Making: Modeling the Cost of Performance. Accepted for publication in Journal of Quality in Maintenance Engineering (2012)