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Cost Estimation Challenges and Uncertainties Confronting Oil and Gas Companies

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ABSTRACT— Usually, when a company has a history of successfully planning and executing project developments, they make sure that detailed cost data for these projects are obtained. These costs are generally broken down into a common cost coding structure, thus giving the cost estimator a unique database for use in cost estimate modeling and enabling the company to develop accurate cost estimates. However, because of several factors during the last decade, including escalation in prices related to offshore developments, cost estimating has become more challenging. Companies have therefore initiated several studies, both internally and externally and implemented the results from these studies into the cost estimation models, resulting in more accurate and cost aggressive methods. This paper describes cost estimation challenges and uncertainties that most oil and gas companies are confronted with; it explains how a cost estimator can achieve an accurate cost estimate and finally presents the methods a cost estimator can use to contribute to more aggressive target cost estimates.

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Introduction

Cost estimation is an integrated activity in all development projects; in fact it's an important factor in all project phases up to sanction. In early phase concept selection for example, it contributes to deciding if a Spar should be chosen instead of a TLP or a Semi. Then for each next phase of the project, a cost estimate is developed or updated to ensure that the project is still economically viable to then give the green light to management to continue to the next phase of the project. For this purpose and for many years, companies have developed powerful cost estimation tools and breakdown structures to ensure good cost predictability.

In addition, companies have been accumulating experience data from different own-operated and partner-operated projects worldwide. This combination of tools and database ensures the development of accurate cost estimates in early stages of a project, using limited data. However there has been an escalation in cost during the last decade for many reasons in particular the instability of oil prices. Cost is also is also strongly correlated with the location since technical requirements, legislation and best practices depend on where the offshore platform is engineered and installed.

All these factors make cost estimation a challenging task. Several internal and external studies have therefore been initiated and the results from these studies were implemented in cost estimation and benchmarking tools. The challenge that that most operators face today is cost efficiency and the reduction of capital expenditure without compromising on predictability.

This paper is organized in three sections; the first one describes cost estimation uncertainties that most oil companies are dealing with. The second section explains how a cost estimator can contribute to a predictable outcome of a project and the last section presents the methods that can be used by a cost estimator to contribute to setting more aggressive target cost estimates.

The Problem

Estimating cost aggressive Capex while maintaining high predictability has proven to be a challenging task due to many reasons such as market instability and project uncertainties especially at the early phase of the project. It is therefore important to understand the key cost drivers and establish tools and methods that help the cost estimator provide an accurate and aggressive Capex estimate.

Uncertainties of Cost Estimation

Uncertainty refers to the lack of certainty and knowledge while predictability means the ability to forecast something that will happen in the future. For a cost estimator, being predictable does not mean forecasting the exact cost of the project, but rather achieving a final cost that is within the accuracy level that is defined by the class estimate for each stage of the project [1]:

Estimate Class	Decision Gate *	Cost Estimate Accuracy At 80% Confidence
Class A	DG0	N/A
Class B	DG1	± 40%
Class C	DG2	± 30%
Class D	DG3	± 20%

Table 1 - Cost Estimate Class Accuracy

DG0, DG1, DG2 and DG3 refer to different project maturity stages

Mathematically, accuracy can be defined as:

$$\text{Upper Accuracy} = \frac{\text{P90} - \text{Expected cost}}{\text{Expected cost}} \times 100\% \qquad \textbf{equation 1}$$

$$\text{Lower Accuracy} = \frac{\text{Expected cost} - \text{P10}}{\text{Expected cost}} \times 100\% \qquad \textbf{equation 2}$$

Where :
The P90 value of a probability distribution, is a pessimistic value which is 90 percent certain not to be exceeded, in other words 9 out of 10 cases will have a lower cost.
And
The P10 value of a probability distribution is an optimistic value with a probability of less than 10 percent to go lower, that is only 1 out of 10 cases will have a lower cost.
To establish the accuracy, a "Cost Risk Analysis" session is performed [2]; this analysis uses a Monte Carlo simulation and the @Risk software.

The accuracy changes at each phase or decision gate of the project, the more mature the project becomes, the more accurate data the cost estimator gets and the more accurate the cost estimate should be.

By definition, a Capex estimate is the sum of several cost elements, and each cost element can be defined with a most likely cost, a low cost and a high cost. Based on experience, built costs from executed projects have a larger probability of being higher rather than lower, compared to the original estimate. Hence, a cost probability distribution based on experience will be skewed to the right, see figure 1.

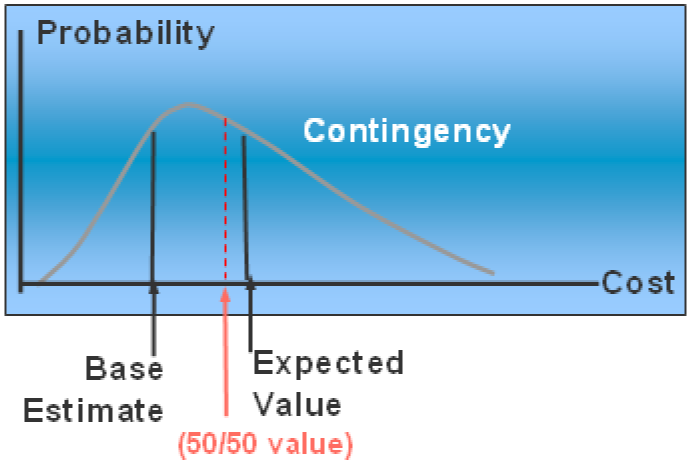

Figure 1 - Probability Cost Curve

The expected value for the entire cost estimate will not be the sum of each most likely value. Contingency is added to obtain the expected cost, which is the average or mean value. In other words the contingency is the “technical” correction to compensate for the effects of skewed (non-symmetric) distributions for each of the components in the estimate and to cover for unspecified cost elements. A cost risk analysis (CRA) is used to calculate the contingency.

Since uncertainty and predictability go in opposite directions, the best way for a cost estimator to increase predictability is to reduce the uncertainties and account for the unknowns when preparing a cost estimate. There are two types of unknown, those we can predict and those we can’t predict.
These two categories of unknowns were very well described by Donald Rumsfeld, the former US Secretary of Defense in 2002, when he said: “There are known knowns; there are things we know that we know. There are known unknowns; that is to say, there are things that we now know we don’t know. But there are also unknown unknowns; there are things we do not know we don’t know.”

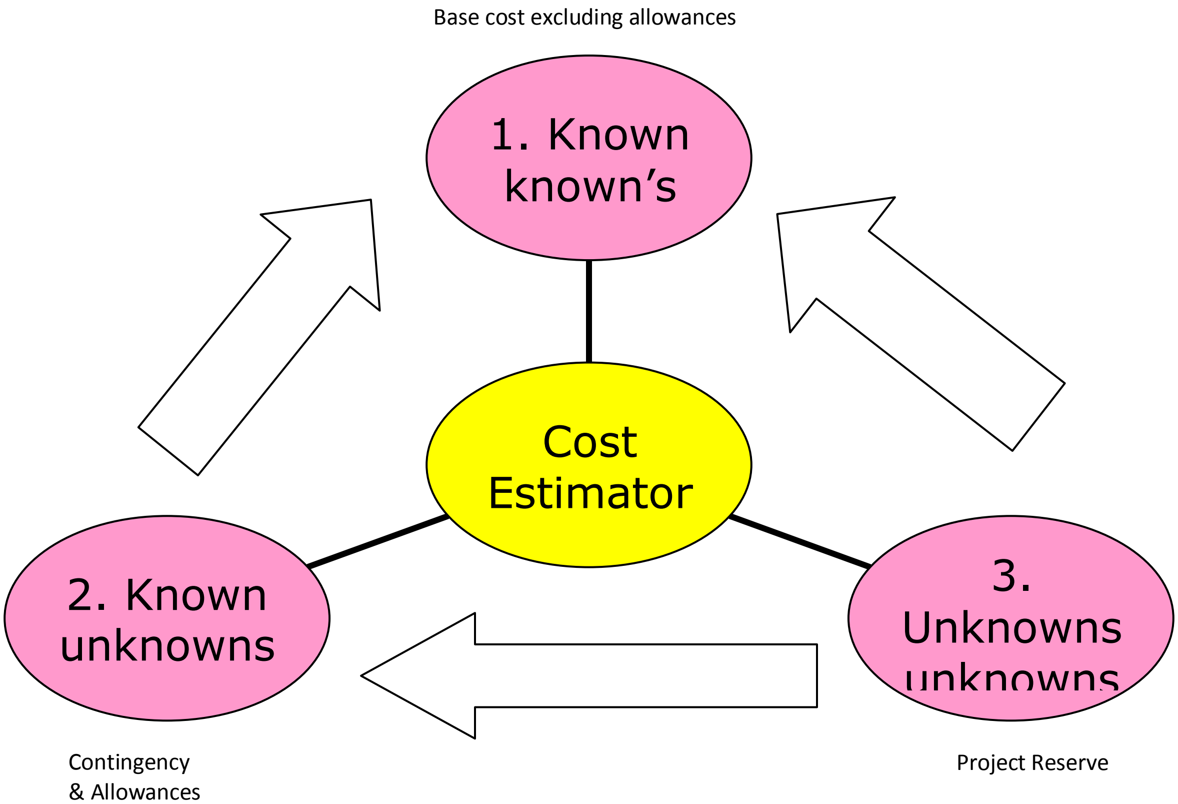

Figure 2 - The Different Known and Unknown Categories to a Cost Estimator

For a cost estimator, the first step in order to reduce uncertainties is to understand the second category and move it towards the first one. To do so, the cost estimator should take part in preparing the project risk register along with his colleagues from other disciplines. During the risk workshop, the project team from different disciplines identifies the risks and uncertainties and proposes actions to mitigate these uncertainties. They also draw pictures of best and worst scenarios and estimate their cost consequences.

In the Risk Register, risks are identified and sorted based on a probability and consequence, then the risks from the Risk Register, see figure 3, with possible effects on Capex are included in the cost risk analysis if they are significant: i.e., they are located in the red or yellow regions of the risk matrix.

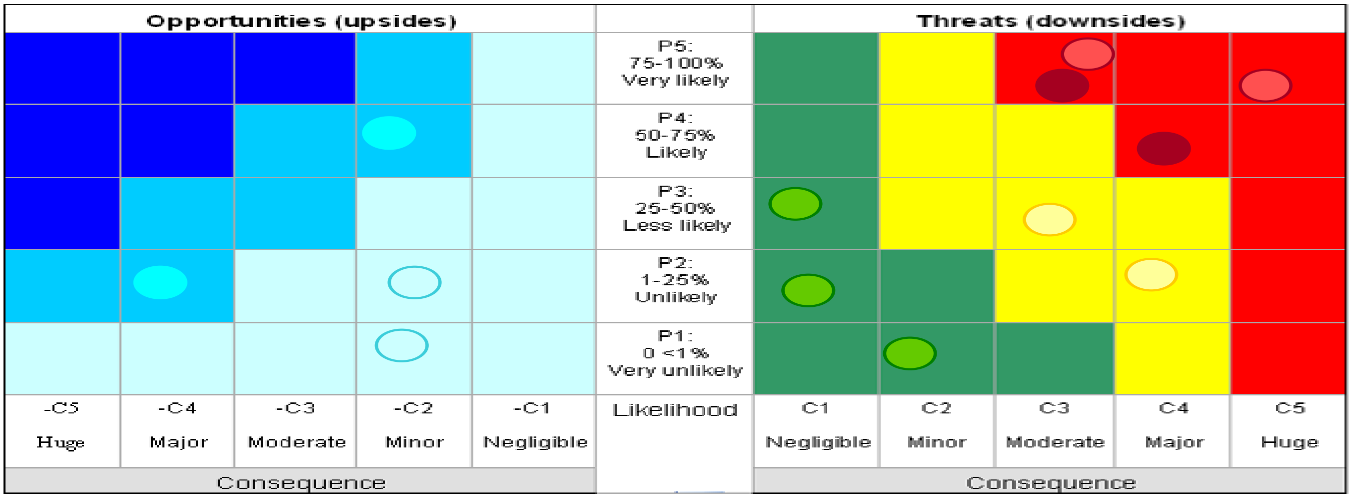

Figure 3 - Risk Register Matrix

Example of known unknowns could be risk related to project size and complexity, new technology, operating in a new environment.
Therefore, contingency will typically cover:

- design development within the agreed design basis;
- estimate adjustments;
- bias, omissions and errors;
- minor adjustments to execution schedules/milestones;
- normal market price variations; and,
- other risks within the control of the project team.

Allowance is also part of the known unknowns and allowance covers additions that, based on experience are required to reach an expected level for quantities and costs. The allowance is based on experience only and is not based on a cost risk analysis. However, it is more difficult for a cost estimator to move the 3rd category (the unknown unknowns) into the 2nd or the 1st, but he or she needs to understand that there are uncertainties that we are not aware of and act in consequence when establishing the project reserves. Learning from past experience is the best way to reduce the number of the unknown unknowns. The estimate of this last category is carried out by a cost estimator as a project reserve cost, not as a contingency, this estimate is added to cover uncertainties outside the expected cost, to increase the estimate confidence level and reduce the risk of overrun. The project reserve is also established during the CRA. The probabilistic definition of the project reserves depends on each company and the level of reserves they want to carry if something exceptional should happen in the project.

Factors Influencing Predictability

Cost estimators use cost estimating tools to prepare cost estimates. These tools incorporate experience from several projects as well as location factors for the different places in the world where the company is operating. When a company has an updated database from projects worldwide, and is able to incorporate this data along with market adjustment into cost estimation tools, it will strengthen their cost predictability and help management make the right decision regarding the level of profitability of the project.

An early phase cost estimation tool has limited input data such as capacity, number of wells, water depth, type of platform, etc. This is used to role in ranking the different concepts in terms of cost efficiency. Of course technical pros and cons should be taken into consideration along the way to minimize the HSE (Health, Safety and Environment) hazards and optimize productivity.

At a more advanced stage of a project, the cost estimation tools need to be more detailed to give the right cost estimate.

Market Adjustment

Market adjustments are also very important to obtain, calculate the right cost estimate, this has been especially challenging during the latest market development. The market adjustment is added to the cost estimate, as indicated in figure 4.

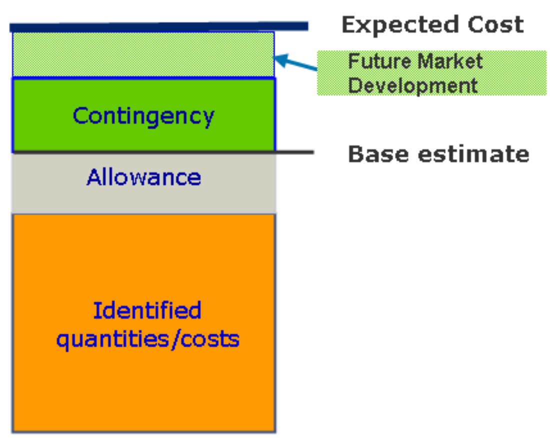

Figure 4 - Market Adjustment

To calculate the market adjustment, there are two methods:

1. Cost Risk Analysis, but this means that market data is needed for all disciplines.
2. Adding market adjustment as shown in the following equation:

$$MA = (\sum(IC + All + Cont)) \times \text{Forward index @ Cost Mid Point} \quad \text{equation 3}$$

MA = Market Adjustment
IC = Identified quantities/costs
All = Allowance
Cont = Contingency
Forward index = a multiplication factor based on future market development

If we were to assume that the project had a Capex mid point in 2015, i.e., the year we expect most of our costs to occur and that the internal future market evaluation group assumed an increase in topside costs of 5 percent, the forward index would be 1,05. An example is shown to indicate how this is done and presented in table 2.

SAB	DESCRIPTION	Topside KNOK	Sub structure KNOK	Mooring, Anchoring & Piles KNOK	Company Cost KNOK	Total KNOK
Sum Base Estimate		10 000 000	750 000	200 000	2 500 000	**13 450 000**
Contingency %		**15 %**	**15 %**	**15 %**	**15 %**	**15 %**
Contingency (KNOK)		1 500 000	112 500	30 000	375 000	**2 017 500**
Expected cost (excl. market effekt)		**11 500 000**	**862 500**	**230 000**	**2 875 000**	**15 467 500**
	Give in Market adjustment in %:	5,00 %	4,00 %	3,00 %	6,00 %	5,10 %
Market adjustment		575 000	34 500	6 900	172 500	788 900
Expected cost		**12 075 000**	**897 000**	**236 900**	**3 047 500**	**16 256 400**

Table 2 - Calculating the Market Adjustment

As can be seen from table 2, the market adjustment needs to be calculated only after adding the base estimate, contingency and allowance together.

Getting the market adjustment correct can be a challenge, but it is vital to use the latest market information when applying the adjustment. Market adjustment of Opex is also important in order to reflect the local operations and continuous development of Opex cost elements.

Cost Drivers Influencing Cost

Understanding key cost drivers is critical to setting more aggressive cost estimates and maintain predictability. Five key cost drivers are identified and presented below

- Material mix:

Material selection philosophy could change from one location to another. For example, in Location A, most oil companies choose to go with the least expensive material, especially for piping and fittings of the offshore platform topsides. More than 70 percent of the piping used in this location is carbon steel, (cf table 3), versus nearly 0 percent in the most recent offshore platforms in location B. (cf Location B, see able 4).

Platform/Materials	A - 1 *~2004*	A - 2 *~2007*	A - 3 *~2009*	A - 4 *~2010*	Average A projects
Carbon steel	57%	87%	82%	69%	74%
SS 316 / Duplex & Super Duplex	37%	7%	9%	18%	18%
Other (6Mo, Titan, Copper Nickel, GRE…)	6%	6%	9%	14%	9%

Table 3 - Material Piping Weight Distribution for Location A Projects

Platform/Materials	B - 1 ~1998	B - 2 ~2000	B - 3 ~2007	B - 4 ~2010	Average B projects
Carbon steel	37%	54%	2%	0%	23%
SS 316 / Duplex & Super Duplex	53%	36%	76%	88%	63%
Others (6Mo, Titan, Copper Nickel, GRE…)	10%	10 %	22 %	12 %	14%

Table 4 - Material Piping Weight Distribution for Location B Projects

Using more "sophisticated" materials such as stainless steel and super duplex may reduce the maintenance costs related to the wear and corrosion of the piping but a check needs to be done to make sure that the Opex savings are worth the Capex investments, this is also influenced by local tax regimes. Material mix depends on the well stream data and weather requirements, but each company should do its own life cycle cost (LCC) analysis for each region, and sometimes for each project, to determine the company's material selection strategy.

- Living Quarters:

Local regulations with respect to number of beds in each room of a LQ drives the size and thus the weight of the LQ, see figure 5. Also, the number of beds in a platform changes from one project to another depending on capacity, drilling facilities etc.

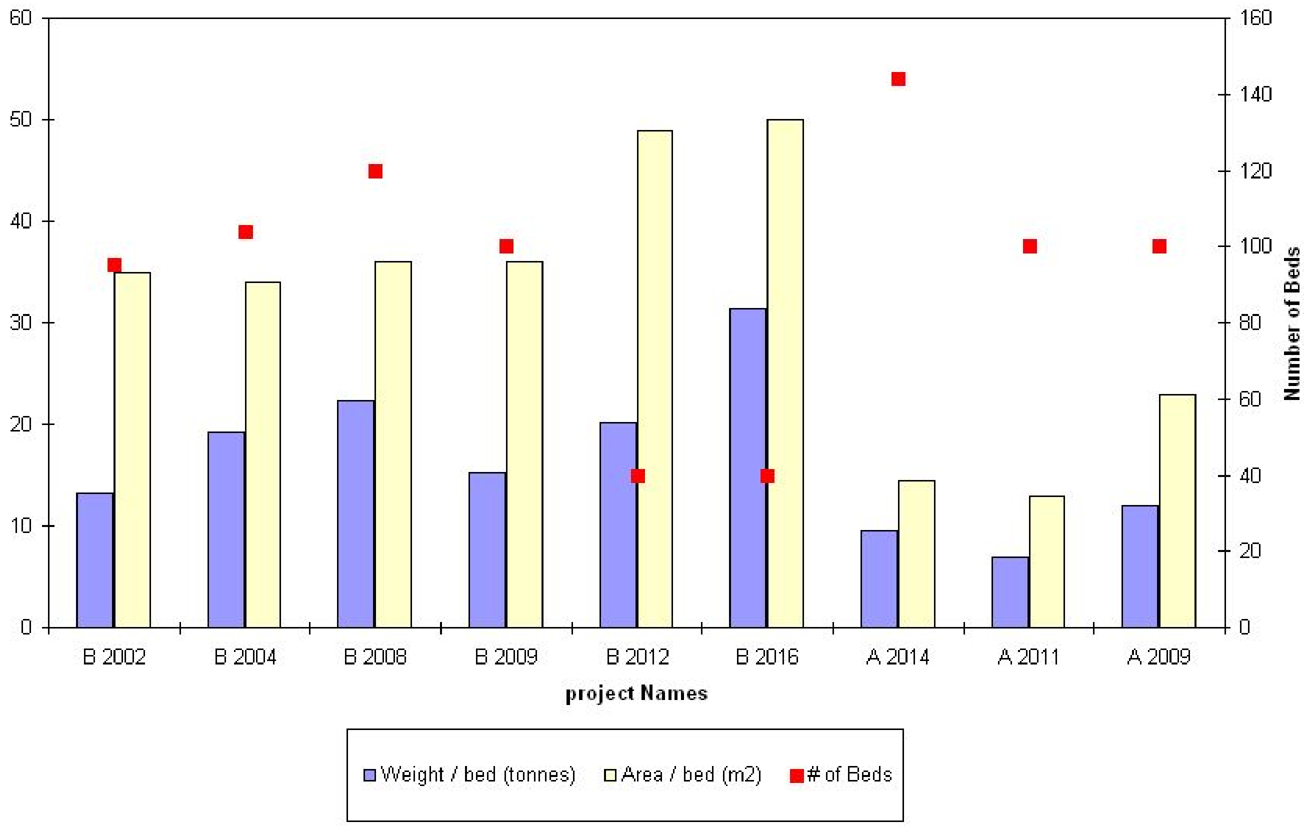

Figure 5 - LQ Weight and Area Comparison Between Location A and B

Figure 5 shows the development of area/bed for several projects in Location A and B project. It can be seen that the area/bed has increased for Location B since 1996, thus giving a rise in cost compared to Location A.

- Design life

Most Location A projects have a design life of 20 to 25 years. In Location B, the offshore oil platforms are designed for 30-40 years, which has an influence on the engineering design, the materials used and even the size of the platform. An area solution may result in a large platform with spare weight capacity for future tie-backs.

- Standards

Most of the requirements for offshore platforms in Location B are based on the Norsok standards, while API is dominant in Location A. This has implications on the way platforms are built in both locations.

- Project execution and contracting strategies

The contracting structure is a large driver for project size and organization. A large number of smaller contracts will mean larger project teams with more focus on interface management. Mega projects could also require large local organizations even when an EPC strategy is selected.

Historically, project execution in Location A has been different than in Location B in many ways. In Location A:

- There are typically EP + FC contracts as opposed to a few EPC type contracts.
- Contractors are not comfortable taking larger EPC contracts with interface risk.
- Companies often use framework agreements as opposed to competitive bidding to save time and choose among “known” vendors that are familiar with the company’s requirements. And,
- There are lower documentation requirements from contractors to company

The estimator should be able to establish cost differences between the different contract strategies and thereby contributing to an optimized execution strategy for the type of project and location.

Methods a Cost Estimator Can Use to Set Cost Aggressive Target Estimates

The cost estimator’s role goes beyond estimating the cost of the project with a detailed accuracy; he or she needs to help the project manager set aggressive cost targets and help the project teamwork towards them. In fact by setting a cost level that is easily achieved, no effort would be needed to improve the project profitability by reducing cost. This can be achieved through finding creative ways of engineering the platform or having successful negotiations with the contractors [3].

On the other hand, setting targets that are impossible to achieve can create more problems than it solves. In fact setting unachievable targets can generate issues within the project team and reduce work motivation.

To be able to produce cost target aggressive estimates and achieve competitiveness, the estimator needs to develop a commercial mindset. Mindset can be defined as a way of thinking or a disposition that predetermines a person's response to different situations. The following methods can help the cost estimator develop a commercial mindset:

- Use of benchmarks;
- Challenge the estimate through the use of a target estimate;
- Dare to challenge yesterdays thoughts and ideas; and,
- Be enthusiastic.

These methods shall not replace HSE or in any way increase the harm to the environment or to people.

Use of Benchmarks

Benchmarks are very valuable when it comes to verifying cost estimates and show uncertainties in the costs as well as showing potential target estimates. The use of benchmarks is a requirement for all estimate classes. When an estimate is prepared, the expected cost should be benchmarked against internal and external projects, both on overall project cost, by facility and discipline.

Level 1 benchmarks could include:

- Facility + Wells Capex vs. Recoverable reserves; and,
- Facility + Wells Capex vs. Design capacity.

Level 2 benchmarks could include:

- Equipment weight vs. Design capacity;
- Topside weight vs. Design capacity;
- Topside cost vs. Topside weight;
- Platform cost vs. Design capacity; and,
- Total topside unit cost vs. Platform name.

Knowing how to use these benchmarking tools is very important: in fact, when used properly benchmarking is a powerful tool to challenge the cost and concept solution. The benchmarking data needs to be escalated to the latest cost year, making it possible to compare old 'as built' projects with new projects.

The use of benchmarks is a valuable visual tool that will help identify areas where the estimate may be too high or even too low. As the following example will show, internal and external benchmark curves could be used to verify quality of identified cost reductions, see figure 6.

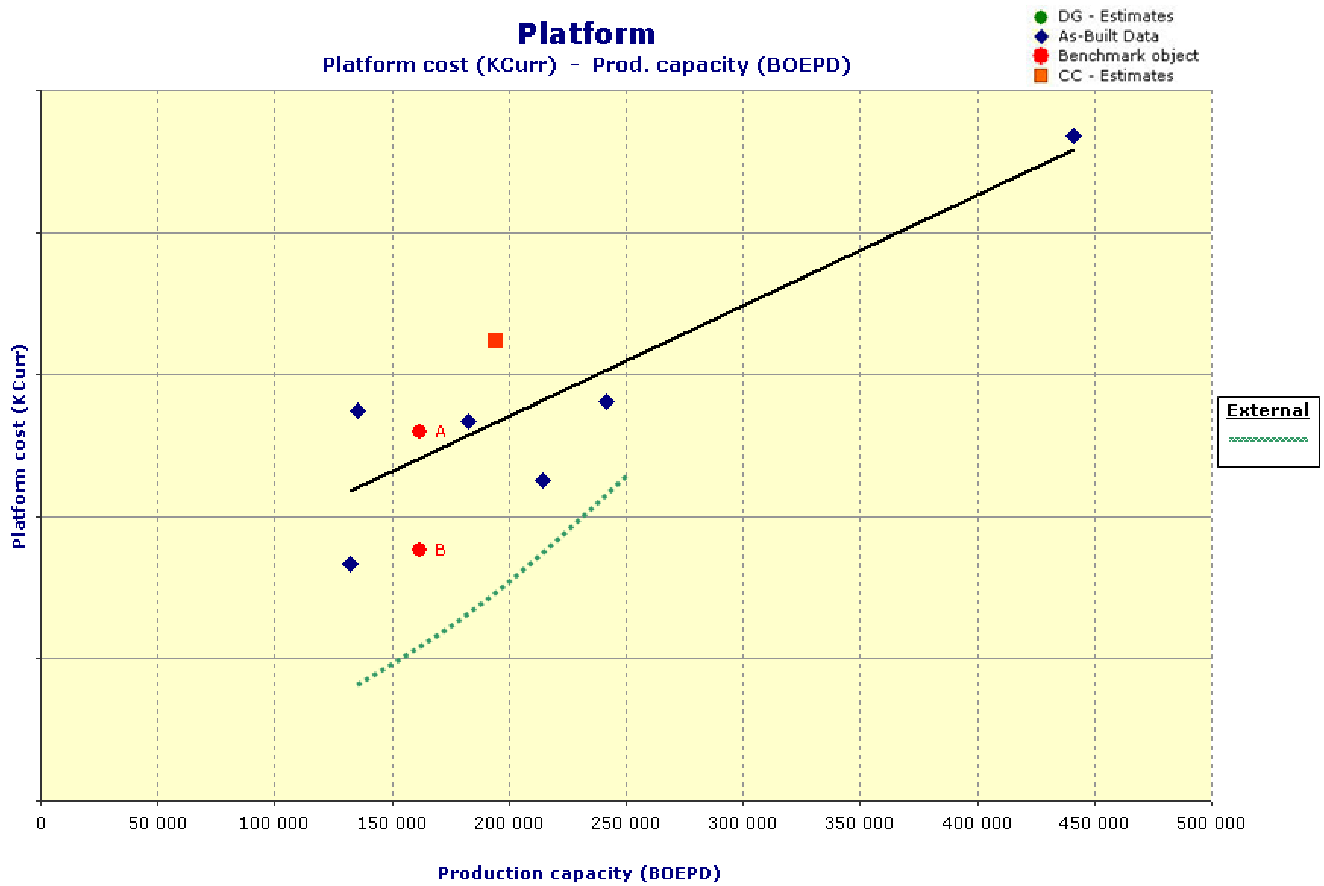

Figure 6 - Use of Level 2 Benchmark; Production Capacity vs. Platform Cost

The figure shows that is was possible to reduce the cost for a platform through an optimization of case A, while at the same time noting that we are well within what one would expect a platform with a similar production capacity to cost, i.e., we are predictable. The green dotted curve is based on external benchmark data and shows that for a given concept, a further decrease in cost could be achieved.

Another example shows how the topside weight (~ 30 000 t) seems to be very high compared to other data, (cf. figure 7) and the question arises if this high weight could be correctly cost estimated. The high topside weight can be due to several factors: heavy oil, high liquid capacity or other reasons. To follow up on this benchmark, topside cost is benchmarked in figure 8, which shows a correct topside cost for this weight.

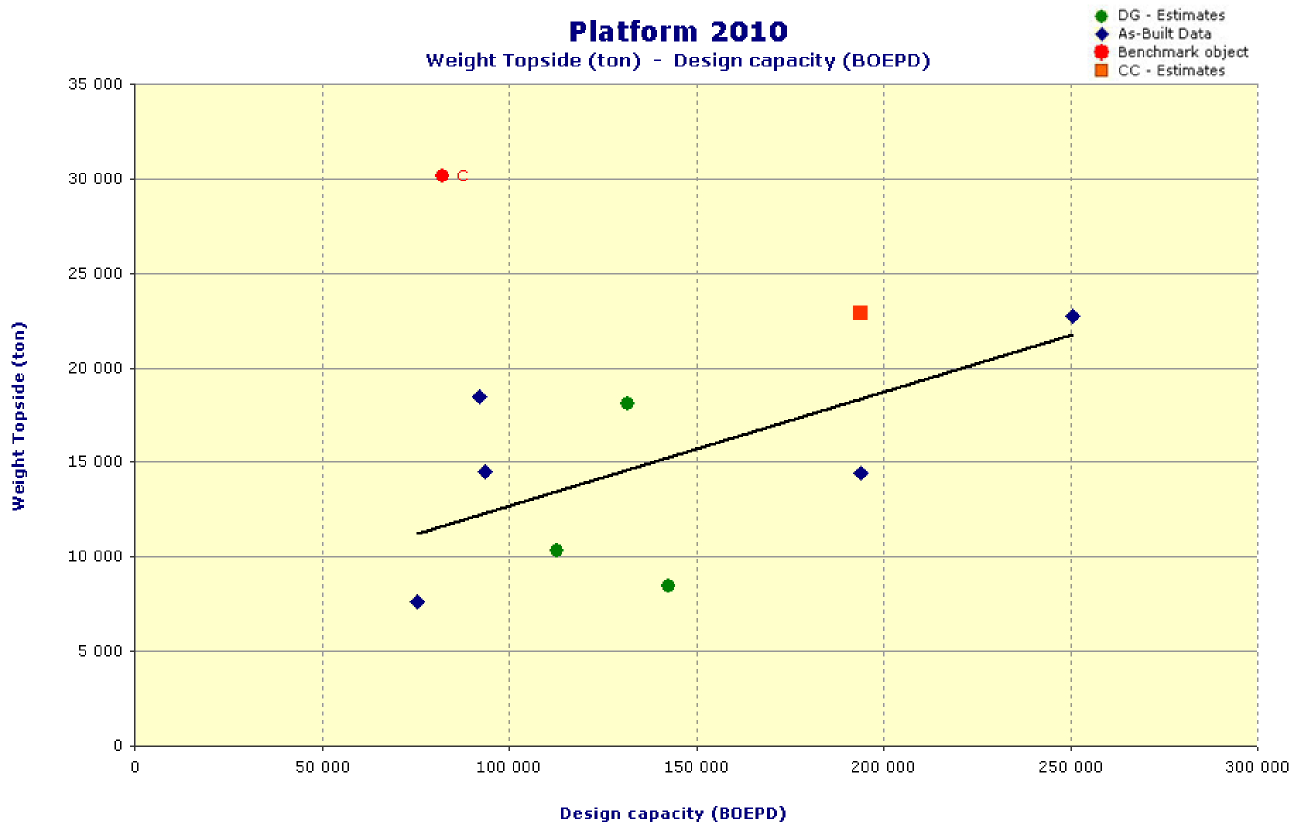

Figure 7 - Use of Level 2 Benchmark; Design Capacity Versus Topside Weight

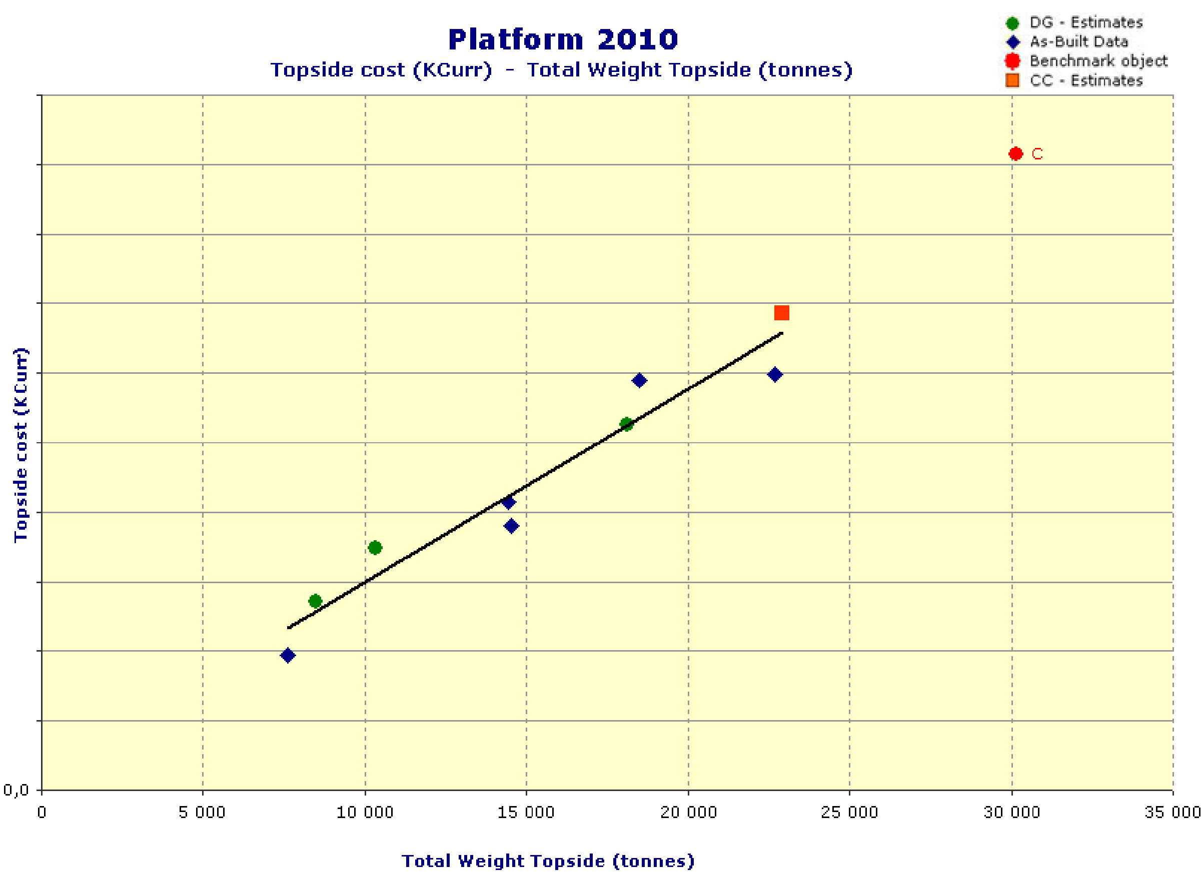

Figure 8 - Use of Level 2 Benchmark; Total Weight Topside Versus Topside Cost

Challenge the Estimate Through the Use of Target Estimates

A decision document usually only includes the expected costs. However, to achieve cost aggressiveness an additional cost estimate should be prepared. This estimate is referred to as target estimate.

A Target estimate is an estimate with a stretched target, but shall be feasible and based on a list of opportunities:

- Optimization of the execution strategy;
- Risk based manning;
- Increased team alignment and integration;
- Evaluation of key cost drivers (cf. Chapter 2);
- Use of benchmark curves to support discussion on targets;
- Risk reducing measures; and,
- Opportunity register – priced.

This additional estimate shall be part of the cost report and the saving potentials identified should be clearly defined in the project WBS (Work Breakdown Structure) when establishing the master control estimate, i.e., the first estimate for use during the execution phase. The targets are to be followed up monthly.

Dare to Challenge Yesterday's Thoughts and Ideas

Yesterday's thoughts and ideas need to be challenged, but the project team needs to make sure the challenged concept, cost or execution strategy is within the company's goals and core values. Oil and gas companies are especially careful when it comes to introducing new technologies or ways of doing things.

In new projects the project team needs to focus more on innovation within the boundaries set for a project. The estimator will play an important role in supporting optimization of the project and strategies.

As the market players become competitive, innovation is seen as a key factor between the different operators.

Be Enthusiastic

We believe that enthusiasm is a key asset for a cost estimator. He or she would perform a better job if they could see the whole cost picture of the project when preparing a cost estimate, and understand the implications of their estimate on the project economics and its feasibility and profitability as a whole.

Passion in cost estimating can come from different sources but the most common one is comparing cost estimates to as built data. Being able to predict the final cost of a project within the required accuracy level is very gratifying to a cost estimator. It can take several years before it is possible to validate a cost estimate, especially for long term projects, but doing so with details is very important. Analyzing historical data of completed projects is crucial to understanding how cost has developed, but also a key for developing comparable data as basis for analysis and benchmarking. A lot of work and patience is needed to go through this exercise, but with enthusiasm everything becomes easier!

Conclusion

This paper has shown that an experienced estimator with the right tools and mindset, has a key role when securing the right balance between cost aggressiveness and predictability. The methods of preparing both expected and target cost estimates presented should in most cases contribute to lower costs and higher profitability for projects.

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