Oman Oil and Gas Cost Estimating vs the GAO's Best Practices in Capital Budgeting- a Benchmarking Study

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Abstract

CAPEX projects, ending over-budgeted or extremely under-budgeted, is considered as real issue in many of industrial companies as it leads to bad control on the overall budget for such projects. Hence, the importance of accurate estimate of project budget becomes very high. Here, the GAO's model "Best Practices in Capital Budgeting" is being discussed and used benchmarking procedures followed by existing petrochemical company. Recommendations are extracted based on the case study discussed.

Key Words: Budget Estimate, Real Cost, Estimated Cost, Work Breakdown Structure, Key Cost Drivers.

Introduction

When plants are commissioned and handed over to the client, small and major issues emerge which require rectification and modification. Of course, all of those changes talk the language of money. Those changes are referred to as CAPITAL EXPENDITURE PROJECTS, subjected to the amount of money spent and size of change. Therefore, shareholders allocate quite big budget for CAPEX projects as those projects are expected to enhance the productivity, facility reliability, employee welfare and reduce operation expenditure.

Unfortunately, that money is not well utilized in many cases as it is spent on projects which do not pay back in any measures. Moreover, some titled ''CAPEX'' projects cannot be evaluated on any criteria as their selection is not based on solid technical basis.

Hence, Budget estimate is very critical element in the process of any project. Accuracy verification has been done through well established technical methods and procedures. One of them is illustrated in the figure below and that method is adapted from GAO's "Best Practices in Capital Budgeting". This process is mainly four stages, initiation and research, assessment, analysis and presentation. Each one of these stages are detailed in coming sections and practical case study of Existing Petrochemical Company is used, by being benchmarked against this standard process to extract recommendations to improve further on existing procedures.

As this is a benchmarking research, the following question(s) are going to be explored and answers sought. Specifically-

Does Company follow the best practices as defined by the GAO?
And if NO, then what improvements to be made to Company processes?

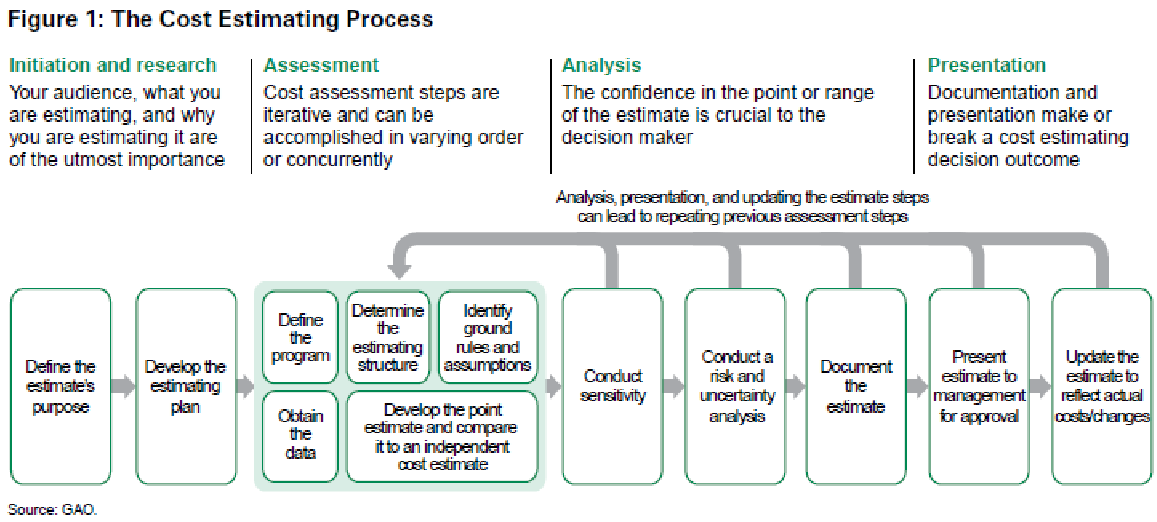

Figure 1 : The cost estimating process[1]

Capital Expenditure Projects Definition

Capital expenditures (CAPEX) are expenditures which are intended to create future revenues. A capital expenditure project is acquired when a business spends money to buy permanent assets or to add to the value of an existing permanent asset with a valuable life that defiantly extends beyond the taxable year. Companies use CAPEX projects to attain or promote physical assets ,which might be equipment, property, or industrial buildings.

Budget Estimate

As most of projects are out of control with regards to budget, better estimation of all costs is essential. For example, several vendors might be contacted for to price quotation. Quotation prices may differ significantly depending on the vendors, being contacted. Therefore, when the estimation is present to management, the price should not be the lowest price offered, instead, it should be much conserved using the highest probability (P=95). Hence, projects do not end up over-budgeted. In addition, many projects are necessarily accompanied by other projects which are not accounted for in the initial stage of concept such as installation of software and provision of monitors…..etc. The project should be well specified with all its requirements to be successful and implementable. Then, the price can be estimated. Estimation of cost is best done following scientific methods such as that is by GAO's "Best Practices in Capital Budgeting", which is discussed below.

As an example of budget rough estimation, the table below shows eight completed projects (within existing Petrochemical Company) with their actual cost versus the allocated budget. There is large difference between the original estimation and actual cost except for project D and that indicates a real existing problem in the process of estimation. If the estimated budget which is allocated from shareholders is by far higher than the actual budget, then the remaining budget will be a loss as it could be spent on other projects, which may look small but have more return on the long run of the plant such as addition of standby pumps or

[1] GAO-09-3SP A Reliable Process for Developing Credible Cost Estimates (p.8)

compressors to critical ones. In addition, the time value of that reaming money reduces as it is carried over to the coming years.

That money, being still during the course of project, is a loss by itself due to inflation rate and interest rate. On the other side, if the allocated/estimated budget is less than the actual budget, then, the natural result is either re-requesting money from the shareholder, which usually takes a lot of time and effort to justify your request for additional money, which leads to delay of the project or compromising on quality and de-scoping part of the project, which are both partially failure of project. The company owners get through a lot of troubles and end up in financial loss because of simply estimated figure of irresponsible cost estimator. Therefore Cost Estimators have to be held responsible financially and legally for the cost estimates they produce and sign off on, exactly like doctors and engineers, who are legally and financially held responsible for their omissions and errors.

S. No.	Project Description	Estimated Budget	Real Budget	Percentage of Actual Cost/ Budget [%]	Accuracy Range %	Class of Estimate
1	Project A	6889	2007	29	+71	5
2	Project B	1111	637	57	+43	5
3	Project C	1778	1012	57	+43	5
4	Project D	1889	1871	99	+1	1
5	Project F	889	1077	121	-21	4
6	Project H	444	174	39	+61	5
7	Project I	44	34	77	+33	3
8	Project J	889	318	36	+64	5

Table 1: CAPEX projects estimated budgets versus real ones[2].

[2] By Author

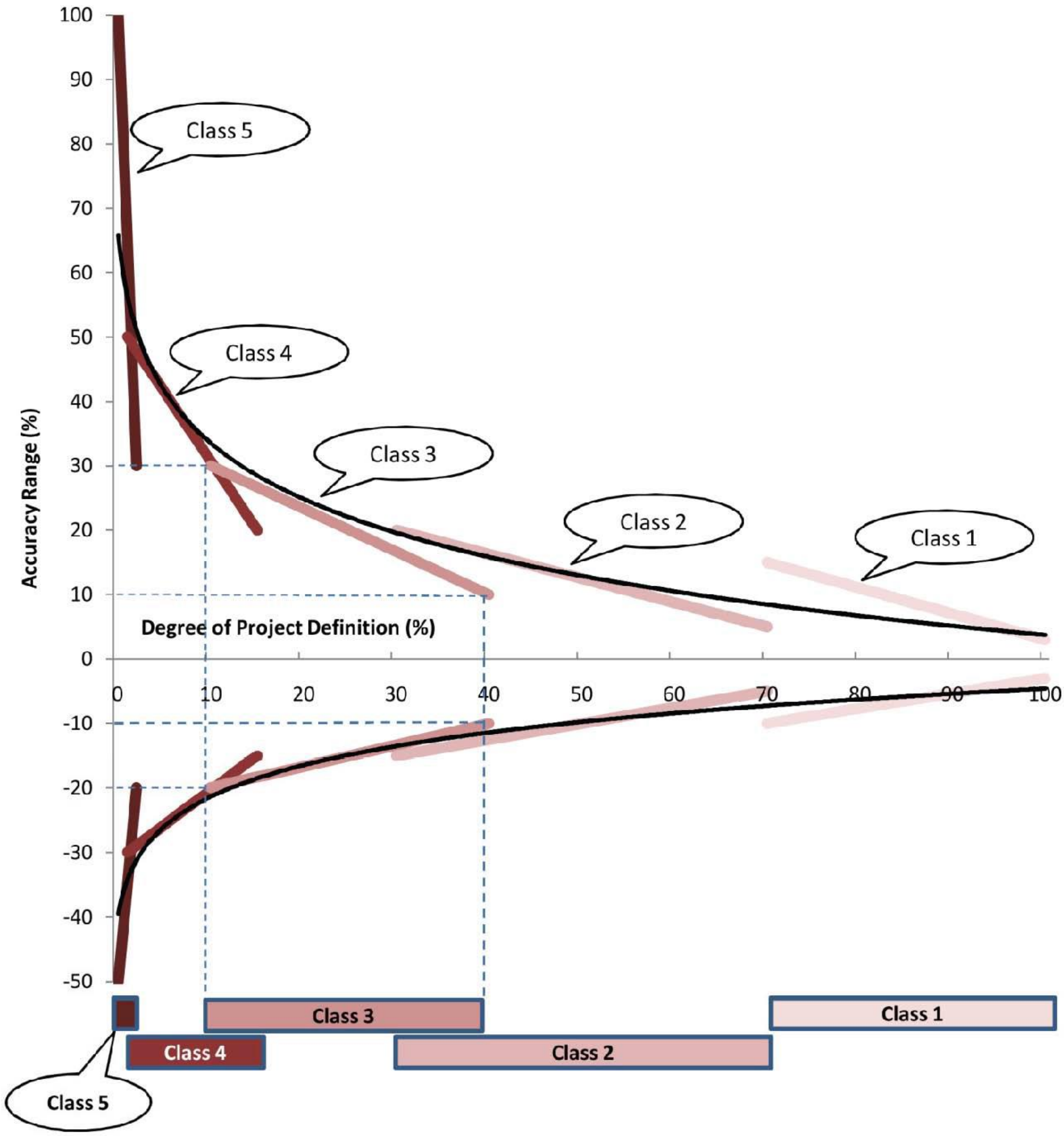

Figure 2: Example of the Variability in Accuracy/Uncertainty[3]

The graph above shows the relationship between the degree of project definition and accuracy range. As the project scope definition gets clearer, the estimate can be made more accurate. In general, especially for projects that are in the early stages of development, a group of estimate classifications should be used to develop the entire estimate. In such situations, estimators have to use a combination of well-detailed unit cost estimating techniques for work that will be executed in the near future and that is CLASS 1 estimate and I believe should be used in CAPEX projects budgets estimate as they are all near future projects, preliminary estimating (as for Class 3) techniques for projects that are currently in the setting up stages but still not well-defined, and order of magnitude estimating (as for Class 5) techniques for future work that has

[3] U.S. Department of Energy Washington, D.C. 20585, DOE G 413.3-21Cost Estimating Guide, page16, figure 4.1.

not been well defined. As a project proceeds through the Acquisition Management System (initiation, definition, execution, and transition/closeout phases) and the project development and planning get mature, the life-cycle cost estimate gets more definitive. This can be defined as "rolling-wave" planning, in which thorough planning of near future work is being done in small increments, or, as best described, waves as the project proceeds through phases.

Looking at the accuracy range for the CAPEX projects as presented in table 1, it can be seen that more than 60% of estimates are of CLASS 5 as if the projects are still in the planning phase which is not desirable in many cases as the CAPEX projects budget estimate is done one year earlier to project commencement. In a reality, CAPEX projects budget estimate should be done using techniques of CLASS 1 as they are implemented or executed in near future.

Plotting the class of estimate (%) versus accuracy range % is present below. The percentage range is close for most projects around 50%. For the data to be accurate, accuracy range has to be +/-5%. Therefore, budget estimates, as for the projects above, are not very accurate but remain as precise as it clearly appears below on the figure .These estimates are quite reliable as outliers can be identified. However, the reliability has no benefit as the estimates are not accurate in the first place. In following paragraphs, it is clarified the difference between accuracy, precision and reliability.

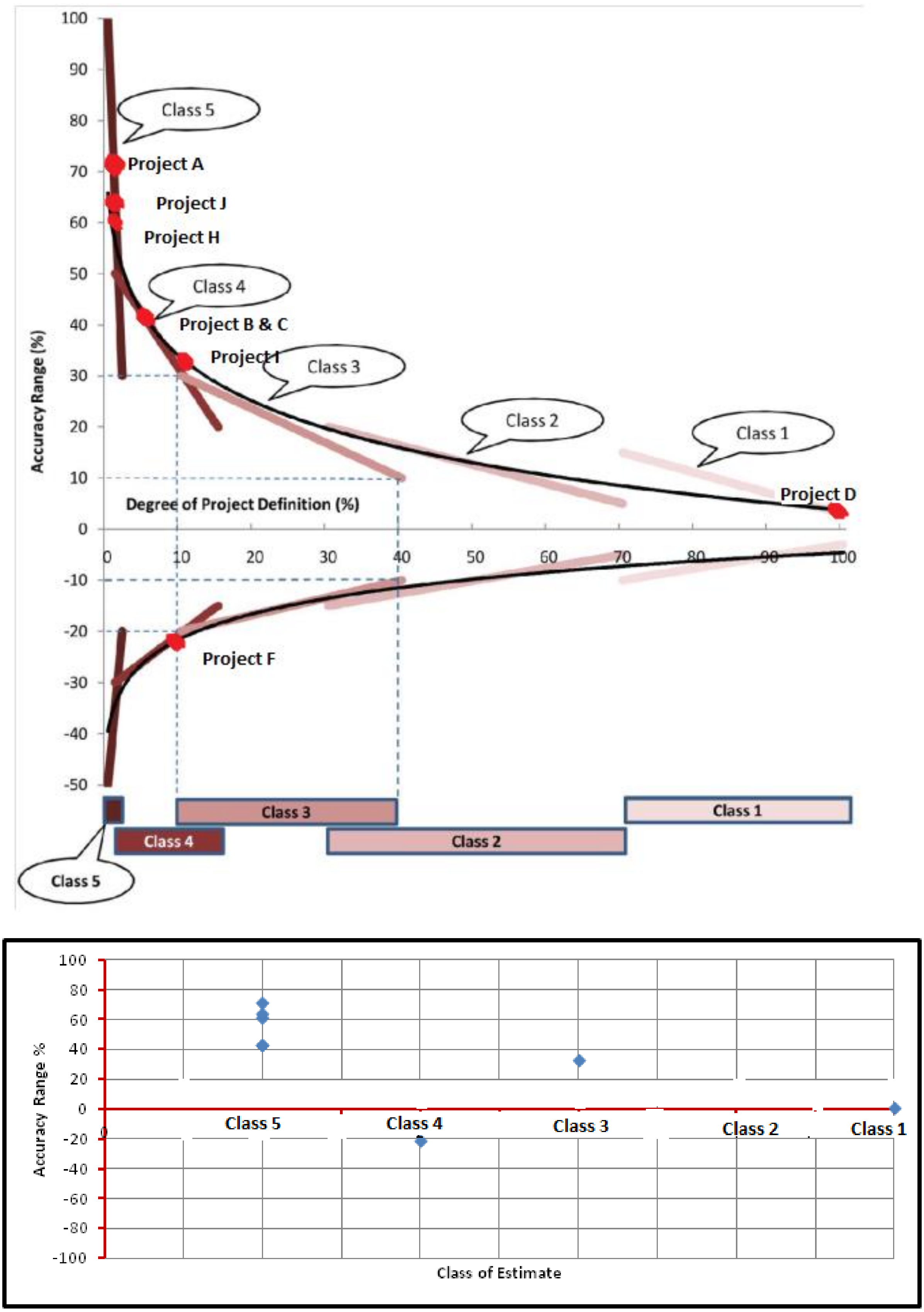

Figure 3: Accuracy Range % versus Class of Estimate[4].

[4] By Author

Precision is the degree of closeness that is displayed on repeated measurements of the same quantity, and hence it is used as a means of describing the extent of random error within measurements taken. Standard deviation is traditionally used to measure precision. Hence when measurements are closely grouped, it is said that they have a high precision as their random errors (spread of measurement arbitrary errors into the position results) are minute as illustrated in Figure 4. On the other hand, measurements that are extensively spread or discrete are said to have a low precision as their arbitrary errors (spread of measurement arbitrary errors into the position results), are huge as illustrated in Figure 4. Of course, the difference between high and low precision is simply a subjective judgment.

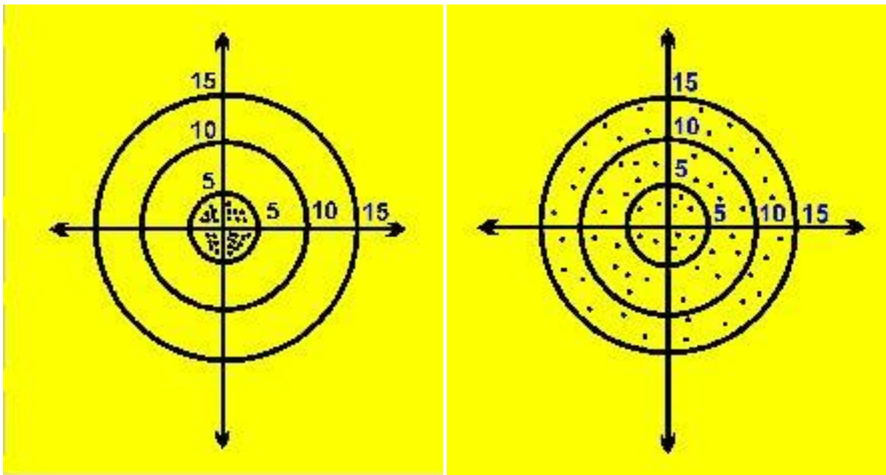

Figure 4: Measurement PRECISION[5].

Accuracy is simply defined as the degree of closeness and conformity of an arbitrary measurement to its true value. While the accuracy indicator can clarify all types of error, it is mainly useful for describing methodical errors. For instance, in Figure 5, the measured quantities are very precise but NOT accurate. Such a situation is unwelcome as the potential quality is high, which is because of small inbuilt noise. However, the actual quality is poor as the value of the quantity is influenced.

[5] Gmat.unsw.edu.au (2014). Precision, accuracy and reliability. http://www.gmat.unsw.edu.au/snap/gps/gps_survey/chap2/241relb.htm

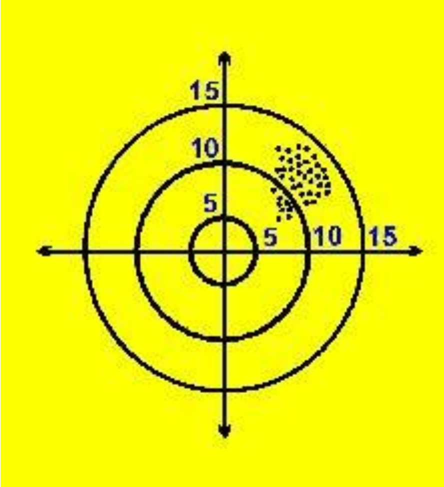

Figure 5: Measurement ACCURACY[6].

Reliability is frequently used in the context of sensitivity to presence gross errors. It is used as a measure of the simplicity with which gross errors can be identified. An extremely reliable position result is achieved when fairly small outliers can be detected and noticed. On the contrary, an unreliable position result does exist where large outliers do go unnoticed or undetected. Redundant (or extra) observations are an effective means of improving reliability. For instance, Figure 6 presents the situation in which distribution entails high precision, although there are quite a few quantities which are considerably different. It could be understood that these quantities are definitely outliers and hence they have to be cancelled.

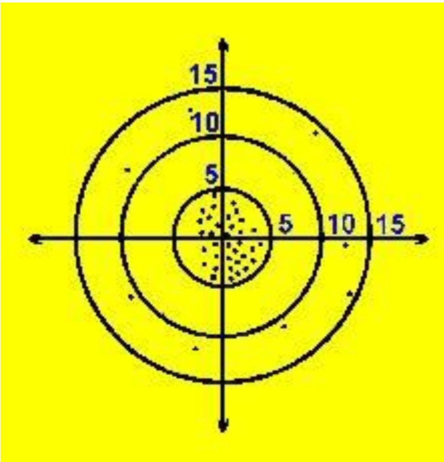

Figure 6: Measurement RELIABILITY

Using the above eight projects budget estimates as a sample, it has been noticed that the estimate process is immature as it is done as the projects are in the planning phase and their execution is going to be after long period (few years).For CAPEX projects, the estimate should not be done when they are in conceptual phase, instead, it should be done when the projects are very well-defined. The techniques, which are used in that company for budget estimate, are for CLASS 1,

[6] Gmat.unsw.edu.au (2014). Precision, accuracy and reliability. http://www.gmat.unsw.edu.au/snap/gps/gps_survey/chap2/241relb.htm

which are used for projects which are still not well-defined. Therefore, clear definition and well defined scope is a must before thinking of budget estimate. The budget estimates are not accurate for most CAPEX projects as accuracy range is ranging from -21% to 71%. Therefore, BENCHMARKING the process of one big Existing Petrochemical Company in Oman, where the sample of eight projects above is taken from, is done against the GAO model (which is available in appendices) and it has shown many things and steps that are supposed to be done but actually they are not. That shows negligence given to budget estimate for such project. The data on the company procedures are based on interview of employees and interaction with them, in addition to some available procedure, which they rejected to be attached to this paper. On the discussion of Benchmarking done, Purpose of estimate and its final objective should be known to the estimators. In many cases as per the case study here, the estimator does not know the complete process of the estimate approval cycle. Budget estimate is just estimated figure given by one of experienced staff or on the best case budgetary quotation from random vendor.

Moreover, individual estimator is not reliable in many cases as he is almost impossible to be matters expert in all aspects of the project; hence, it is better to form an integrated team to do estimate approach and its timeline. With respect to case study company, the estimate is arrived at by a single manager or engineer, which is against recommended procedures as GAO model.

With respect to the project program, the company CAPEX forms and procedures do not insist on comprehensive program, hence, it has to include all plans for project requirements even for later maintenance and post-execution .For comprehensive project requirement; Work Breakdown Structure is very critical element in estimation process and should be done in details for all projects. For the case study here, Work Breakdown Structure is never done in the phase of cost estimation and hence, that might be the main reason for putting a lot of contingency in the cost estimate as that is human nature to expect worse case from unknowns, in addition, many engineers believe as it is good things and apparently saving for the company, however, that is in reality a loss as keeping money with no investment is losing its value as described earlier in this paper. While the estimators are doing their jobs, they should have clear picture on the project rules and assumptions as what to be included and excluded. As per discussed case study, there are no comprehensive procedures and rules apart from one form to be filled as a request for NEW CAPEX.

Mostly, the data used for cost estimation is rough budgetary quotations, as practiced in case study of existing Petrochemical Company, which may give vague values. Therefore, unless enough data are available; the probability of accurate estimation remains low. Then, contacting different vendors, obtaining many data from sister companies and referring historical records for similar projects is vital to present estimate with more confidence. The process does not end with getting figure for total cost, as it is the case for many companies including the case study here, but goes further for re-checking, refining and looking at for errors and mistakes. Then, it should be compared against independent cost estimate, which may be done by a consultant or third party.

The total cost in any project is influenced by Key cost drivers, which should be determined to see their effects on overall cost and schedule. The accuracy of estimate is determined after final stage along with its accompanied risk. The process of estimation should be documented and presented to management for approval. When the project goes ahead, the cost should be updated to reflect the actual cost. That is being practiced in many companies including the case study here.

Conclusion

After BENCHMARKING the CAPEX Budget process of an existing petrochemical company against the GAO model, the following recommendations have been extracted:

- All cost estimators should understand the purpose of the estimate. Is it to allocate budget from the steering committee or the budget is already decided and hence the project with high cost might be cancelled or exactly what?

- The final objective should be known to all cost estimators.

- An integrated team should be formed to do the estimation. The leader can be from project department.

- The company should define all project requirements and that is best done through WORK BREAKDOWN STRUCTURE.

- It is essential to understand that without specific support (subject matter experts), many projects do not give fruitful results. Therefore, Two requirements are essential to prevent bad cost estimation, which are following:

    1. Create BETTER early estimates by real estimators, that includes all potential risks (both internal and external) ~ 50% of project cost increase is due to external factors. Add probabilistic allowance for true unknowns.
    2. Hold Project Managers responsible to original estimate. They will stop "spinning numbers" and will demand qualified estimators & credible numbers.

- The risky things, which might be encountered during project, should be identified and cost-estimated.

- Cost estimating checklist should be developed.

- There should be a plan to collect data from other sister companies by having mutual cooperation agreement.

- Independent cost estimate should be done by third party or consultant.

Appendices

Appendix I: BENCHMARKING the budget estimate process of existing petrochemical company against the GAO model.

Step	Description	Associated task	Existing Petrochemical Company	Recommendations
1	Define estimate's Purpose	Determine estimate's purpose, required level of detail, and overall scope	Yes but not very well	All cost estimators should understand the purpose of estimate. Is it to allocate budget from the steering committee or the budget is already decided and hence the project with high cost might be excluded or exactly what?
		Determine who will receive the estimate	Done but not very well as it is not well known the final destination of the estimate.	The final destination should be known to all cost estimators.
2	Develop estimating plan	Determine the cost estimating team and develop its master schedule	NO. There is usually one person doing the project estimate.	A team should be formed to do the estimation. The leader can be from project department.
		Determine who will do the independent cost estimate;	NO	
		Outline the cost estimating approach;	NO	
		Develop the estimate timeline	NO	
3	Define program characteristics	In a technical baseline description document, identify the program's purpose and its system and performance characteristics and all system configurations;	Yes	
		Any technology implications;	Not all time	The company should know all project requirements.

		Its program acquisition schedule and acquisition strategy;	NO	
		Its relationship to other existing systems, including predecessor or similar legacy systems;	Yes	
		Support (manpower, training, etc.) and security needs and risk items;	NO	The company has to understand that without specific support (subject matter experts), many projects do not give fruitful results.
		System quantities for development, test, and production;		
		Deployment and maintenance plans	NO	All those plans should be included in the project.
4	Determine Estimating structure	Define a work breakdown structure (WBS) and describe each element in a WBS dictionary (a major automated information system may have only a cost element structure);	NO	WBS should be done for all projects before cost estimation to get real estimate.
		Choose the best estimating method for each WBS element;	NO	
		Identify potential cross-checks for likely cost and schedule drivers;	NO	The risky things, which might be encountered during project, should be identified and cost-estimated.
		Develop a cost estimating checklist	NO	The company has to develop that checklist.
5	Identify ground rules and assumptions	Clearly define what the estimate includes and excludes.	NO	
		Identify global and program-specific assumptions, such as the estimate's base year, including time-phasing and life cycle;	NO	
		Identify program schedule information by phase and program acquisition strategy;	NO	
		Identify any schedule or budget constraints, inflation assumptions, and travel costs;	NO	

		Specify equipment the government is to furnish as well as the use of existing facilities or new modification or development;	NO	
		Identify prime contractor and major subcontractors;	NO	
		Determine technology refresh cycles, technology assumptions, and new technology to be developed;	NO	
		Define commonality with legacy systems and assumed heritage savings;	NO	
		Describe effects of new ways of doing business	NO	
6	Obtain Data	Create a data collection plan with emphasis on collecting current and relevant technical, programmatic, cost, and risk data;	Yes but only from VENDORS	The company should develop a plan to collect data from other sister companies.
		Investigate possible data sources;	No	The company can cooperate with companies of same business
		Collect data and normalize them for cost accounting, inflation, learning, and quantity adjustments;	NO	
		Analyze the data for cost drivers, trends, and outliers and compare results against rules of thumb and standard factors derived from historical data;	NO	
		Interview data sources and document all pertinent information, including an assessment of data reliability	NO	
7	Develop point estimate and compare it to an independent cost estimate	Develop the cost model, estimating each WBS element, using the best methodology from the data collected, and including all estimating assumptions;	NO	
		Express costs in constant year dollars;	NO	
		Time-phase the results by spreading costs in the years they are expected to occur, based on the program schedule;	Yes, but not accurate enough	
		Sum the WBS elements to develop the overall point estimate;	NO	
		Validate the estimate by looking for errors like double counting and omitted costs;	NO as the estimate is just assumed number based on quotations from vendors neglecting many tasks in the project.	

		Compare estimate against the independent cost estimate and examine where and why there are differences;	NO	The company should develop independent cost estimate.
		Perform cross-checks on cost drivers to see if results are similar;	NO	
		Update the model as more data become available or as changes occur and compare results against previous estimates	Yes	That should help in future estimates.
8	Conduct sensitivity Analysis	Test the sensitivity of cost elements to changes in estimating input values and key assumptions;	NO	
		Identify effects on the overall estimate of changing the program schedule or quantities;	NO	
		Determine which assumptions are key cost drivers and which cost elements are affected most by changes	NO	
9	Conduct risk and uncertainty analysis	Determine and discuss with technical experts the level of cost, schedule, and technical risk associated with each WBS element;	Yes, but there is no initial WBS	
		Analyze each risk for its severity and probability;	Not really applied	
		Develop minimum, most likely and maximum ranges for each risk element;	Not really applied	
		Determine type of risk distributions and reason for their use;	Not really applied	
		Ensure that risks are correlated;	NO	
		Use an acceptable statistical analysis method (e.g., Monte Carlo simulation) to develop a confidence interval around the point estimate;	No	
		Identify the confidence level of the point estimate;	The estimate is not given that much care. It is only based on vendor budgetary quotation.	
		Identify the amount of contingency funding and add this to the point estimate to determine the risk-adjusted cost estimate;	There is not contingency funding plan	
		Recommend that the project or program office develop a risk management plan to track and mitigate risks	There is no risk management plan	
10	Document the Estimate	Document all steps used to develop the estimate so that a cost analyst unfamiliar with the program can recreate it quickly and produce the same result;	There is no clear procedure to develop the estimate.	

		Document the purpose of the estimate, the team that prepared it, and who approved the estimate and on what date;	There is no documentation of the team prepared the estimate.	
		Describe the program, its schedule, and the technical baseline used to create the estimate;	There is no program description and its schedule.	
		Present the program's time-phased life-cycle cost;	Yes	
		Discuss all ground rules and assumptions;	Yes but few rules.	
		Include auditable and traceable data sources for each cost element and document for all data sources how the data were normalized;	Yes but not for elements.	
		Describe in detail the estimating methodology and rationale used to derive each WBS element's cost (prefer more detail over less);	NO	
		Describe the results of the risk, uncertainty, and sensitivity analyses and whether any contingency funds were identified;	Not really applied	
		Document how the estimate compares to the funding profile;	Not really applied	
		Track how this estimate compares to any previous estimates	Not really applied	
11	Present estimate to management for approval	Develop a briefing that presents the documented life-cycle cost estimate;	Yes but not very detailed.	
		Include an explanation of the technical and programmatic baseline and any uncertainties;	Yes but partially	
		Compare the estimate to an independent cost estimate (ICE) and explain any differences;	No	The company should develop independent cost estimate.
		Compare the estimate (life-cycle cost estimate (LCCE)) or independent cost estimate to the budget with enough detail to easily defend it by showing how it is accurate, complete, and high in quality;	NO	
		Focus in a logical manner on the largest cost elements and cost drivers;	Not really applied	WBS should be done for all projects before cost estimation to get real estimate.
		Make the content clear and complete so that those who are unfamiliar with it can easily comprehend the competence that underlies the estimate results;	Not really applied	

		Make backup slides available for more probing questions;	Not really applied	All should be allowed to question the change.
		Act on and document feedback from management;	Yes	
		Request acceptance of the estimate	Yes	
12	Update the estimate to reflect actual costs and changes	Update the estimate to reflect changes in technical or program assumptions or keep it current as the program passes through new phases or milestones;	Yes	
		Replace estimates with EVM EAC and independent estimate at completion (EAC) from the integrated EVM system;	NO	EVM concept is to be developed and implemented
		Report progress on meeting cost and schedule estimates;	Yes	
		Perform a post mortem and document lessons learned for elements whose actual costs or schedules differ from the estimate;	No but under progress now	
		Document all changes to the program and how they affect the cost estimate	Not really applied	

Appendix II: GAO model[1] (The twelve steps of a high-quality cost estimating process).

Table 2: The Twelve Steps of a High-Quality Cost Estimating Process

Step	Description	Associated task	Chapter
1	Define estimate's purpose	▪ Determine estimate's purpose, required level of detail, and overall scope; ▪ Determine who will receive the estimate	5
2	Develop estimating plan	▪ Determine the cost estimating team and develop its master schedule; ▪ Determine who will do the independent cost estimate; ▪ Outline the cost estimating approach; ▪ Develop the estimate timeline	5 and 6
3	Define program characteristics	▪ In a technical baseline description document, identify the program's purpose and its system and performance characteristics and all system configurations; ▪ Any technology implications; ▪ Its program acquisition schedule and acquisition strategy; ▪ Its relationship to other existing systems, including predecessor or similar legacy systems; ▪ Support (manpower, training, etc.) and security needs and risk items; ▪ System quantities for development, test, and production; ▪ Deployment and maintenance plans	7
4	Determine estimating structure	▪ Define a work breakdown structure (WBS) and describe each element in a WBS dictionary (a major automated information system may have only a cost element structure); ▪ Choose the best estimating method for each WBS element; ▪ Identify potential cross-checks for likely cost and schedule drivers; ▪ Develop a cost estimating checklist	8
5	Identify ground rules and assumptions	▪ Clearly define what the estimate includes and excludes; ▪ Identify global and program-specific assumptions, such as the estimate's base year, including time-phasing and life cycle; ▪ Identify program schedule information by phase and program acquisition strategy; ▪ Identify any schedule or budget constraints, inflation assumptions, and travel costs; ▪ Specify equipment the government is to furnish as well as the use of existing facilities or new modification or development; ▪ Identify prime contractor and major subcontractors; ▪ Determine technology refresh cycles, technology assumptions, and new technology to be developed; ▪ Define commonality with legacy systems and assumed heritage savings; ▪ Describe effects of new ways of doing business	9

Step	Description	Associated task	Chapter
6	Obtain data	▪ Create a data collection plan with emphasis on collecting current and relevant technical, programmatic, cost, and risk data; ▪ Investigate possible data sources; ▪ Collect data and normalize them for cost accounting, inflation, learning, and quantity adjustments; ▪ Analyze the data for cost drivers, trends, and outliers and compare results against rules of thumb and standard factors derived from historical data; ▪ Interview data sources and document all pertinent information, including an assessment of data reliability and accuracy; ▪ Store data for future estimates	10
7	Develop point estimate and compare it to an independent cost estimate	▪ Develop the cost model, estimating each WBS element, using the best methodology from the data collected,[a] and including all estimating assumptions; ▪ Express costs in constant year dollars; ▪ Time-phase the results by spreading costs in the years they are expected to occur, based on the program schedule; ▪ Sum the WBS elements to develop the overall point estimate; ▪ Validate the estimate by looking for errors like double counting and omitted costs; ▪ Compare estimate against the independent cost estimate and examine where and why there are differences; ▪ Perform cross-checks on cost drivers to see if results are similar; ▪ Update the model as more data become available or as changes occur and compare results against previous estimates	11, 12, and 15
8	Conduct sensitivity analysis	▪ Test the sensitivity of cost elements to changes in estimating input values and key assumptions; ▪ Identify effects on the overall estimate of changing the program schedule or quantities; ▪ Determine which assumptions are key cost drivers and which cost elements are affected most by changes	13
9	Conduct risk and uncertainty analysis	▪ Determine and discuss with technical experts the level of cost, schedule, and technical risk associated with each WBS element; ▪ Analyze each risk for its severity and probability; ▪ Develop minimum, most likely, and maximum ranges for each risk element; ▪ Determine type of risk distributions and reason for their use; ▪ Ensure that risks are correlated; ▪ Use an acceptable statistical analysis method (e.g., Monte Carlo simulation) to develop a confidence interval around the point estimate; ▪ Identify the confidence level of the point estimate; ▪ Identify the amount of contingency funding and add this to the point estimate to determine the risk-adjusted cost estimate; ▪ Recommend that the project or program office develop a risk management plan to track and mitigate risks	14

Step	Description	Associated task	Chapter
10	Document the estimate	▪ Document all steps used to develop the estimate so that a cost analyst unfamiliar with the program can recreate it quickly and produce the same result; ▪ Document the purpose of the estimate, the team that prepared it, and who approved the estimate and on what date; ▪ Describe the program, its schedule, and the technical baseline used to create the estimate; ▪ Present the program's time-phased life-cycle cost; ▪ Discuss all ground rules and assumptions; ▪ Include auditable and traceable data sources for each cost element and document for all data sources how the data were normalized; ▪ Describe in detail the estimating methodology and rationale used to derive each WBS element's cost (prefer more detail over less); ▪ Describe the results of the risk, uncertainty, and sensitivity analyses and whether any contingency funds were identified; ▪ Document how the estimate compares to the funding profile; ▪ Track how this estimate compares to any previous estimates	16
11	Present estimate to management for approval	▪ Develop a briefing that presents the documented life-cycle cost estimate; ▪ Include an explanation of the technical and programmatic baseline and any uncertainties; ▪ Compare the estimate to an independent cost estimate (ICE) and explain any differences; ▪ Compare the estimate (life-cycle cost estimate (LCCE)) or independent cost estimate to the budget with enough detail to easily defend it by showing how it is accurate, complete, and high in quality; ▪ Focus in a logical manner on the largest cost elements and cost drivers; ▪ Make the content clear and complete so that those who are unfamiliar with it can easily comprehend the competence that underlies the estimate results; ▪ Make backup slides available for more probing questions; ▪ Act on and document feedback from management; ▪ Request acceptance of the estimate	17
12	Update the estimate to reflect actual costs and changes	▪ Update the estimate to reflect changes in technical or program assumptions or keep it current as the program passes through new phases or milestones; ▪ Replace estimates with EVM EAC and independent estimate at completion (EAC) from the integrated EVM system; ▪ Report progress on meeting cost and schedule estimates; ▪ Perform a post mortem and document lessons learned for elements whose actual costs or schedules differ from the estimate; ▪ Document all changes to the program and how they affect the cost estimate	16, 18, 19, and 20

Source: GAO, DHS, DOD, DOE, NASA, SCEA, and Industry.

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Musallam Amer Al-Awaid is a senior process engineer working in a petrochemical company located in Salalah, South of Oman, TUV certified functional safety engineer, Certified Professional Chemical engineer PE by NCEES in the U.S.A, HAZOP leader by PrimaTech, BEng with honour in chemical engineer from Nottingham University in the U.K and Part-time lecturer in Chemical Engineering in Salalah College of Technology. He is specialized in process safety elements, such as HAZOP, SIL, PSR, PHA, PSSR, MOC and ALARM SYSTEM MANAGEMENT. He is excellent in process optimization and trouble shooting, as he saved his company around fifth million US$ once by implementation of only a simple but innovative optimization. He has excelled in equipment performance evaluation and sizing. His favorite area of chemical engineering is design and has fair knowledge on API codes. He has good knowledge on project life cycle stages of Petrochemical Plants, such as FEED, EPC, Pre-Commissioning, Commissioning and Operation. He has very good skills in communication, leadership, teaching, training and presentation. Musallam can be contacted through musallam.alawaid@gmail.com or musallam.alawaid@yahoo.com.