CONCEPTUAL ESTIMATING AND TARGET COSTING

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ABSTRACT

In an earlier paper, the first author argued that project budgets should be set based on the worth to the client of the asset to be designed and constructed, adjusted as needed for capital availability. However, cost estimates also play a role in the process of feasibility assessment and budgeting. When the client's allowable cost, what they are willing and able to pay is less than what the asset is expected to cost, the project's feasibility must be assured. The first step is to estimate the gap between allowable cost and expected cost.

The accuracy of conceptual estimates, estimates made from programmatic data, prior to design, are generally assumed to be around +/- 30%. Yet target costs are set prior to design. How can achievable target costs be set when cost estimates are so inexact?

This paper reports on research currently underway to document conceptual estimating processes that are substantially more accurate than +/-30% and explains the role played by conceptual estimating in the process of determining a project budget. It is proposed that estimate accuracy is in some degree a misleading conceptualization, encumbered as it is by the implicit assumption that the estimator does not act to cause the estimate to be achieved.

KEYWORDS

Cost management, conceptual estimate, lean project delivery, project definition, target cost, target value design.

INTRODUCTION

This paper reports initial research findings from efforts to identify and validate methods for conceptual estimating more accurate than the generally accepted +/- 30% (AbouRizk, et al., 2002). Conceptual estimates are understood to be based on programmatic data prior to design. Programmatic data includes what is wanted (functionalities, capacities, and features of the desired asset), where the asset is to be located, and when it is to produced. What we measure in the research:

1. Conceptual estimating accuracy: The accuracy of the conceptual estimate relative to cost at completion, adjusted for approved change orders.
2. Conceptual estimating and steering accuracy: Where conceptual estimates were used to set target costs (budgets), then efforts were made to steer design

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and construction to those targets, what was the difference between the target cost and the actual cost at completion, adjusted for approved change orders?

3. Conceptual estimating and scope fixity: Where conceptual estimates were used to set target costs, then efforts were made to steer design and construction to those targets, what was the percentage change in the budget?

Our hypotheses are that 1) the accuracy of conceptual estimates can be improved to at least +/-10%, with a confidence level of 95%, 2) the use of the target value design methodology to define and deliver scope (what's wanted) within client constraints (cost, time, location, etc.) increases the accuracy of conceptual estimates, and 3) the percentage change in budget from scope changes decreases in projects managed using target value design.

We are collecting data from a number of companies whose conceptual estimating processes appear to yield more accurate estimates than +/-30%. This paper describes the application of target costing by Haahtela, a project management and cost consultancy based in Helsinki, and compares the cost at completion of 20 of their projects to the project cost budgets.

Following this Introduction, the sections of this paper are, in order, a description of the factors influencing conceptual estimate accuracy, the role of cost estimating in determining a target cost (project budget), presentation and evaluation of the cost performance of Haahtela's projects, and finally Conclusions regarding the implications for target costing and conceptual estimating of the findings reported in this paper, together with recommendations for future research.

FACTORS IN THE ACCURACY OF CONCEPTUAL ESTIMATES[3]

The literature on cost estimating is in general agreement that the level of accuracy of estimates increases with the specification (and eventually production) of the asset. The earlier the estimate in the life of the project, the lower its accuracy. Consequently, assessments of conceptual estimate accuracy are quite low. An extreme example: "…at this stage [prior to design], almost nothing is likely to be known about the building except its general size, and therefore it is pointless to go into detail about the cost before any designing has been done." (Ferry, et al., 1999).

As a result of incomplete specification of the asset to be constructed, the industry has historically accepted high levels of variance between the estimated and the actual total installed cost. Customarily, during pre-design, the industry has accepted a standard of +/-30% of variance from estimates, after adjustment for changes in scope. Figure 1 shows the findings from a quantitative study of estimate accuracy in Canadian public sector projects (AbouRizk, et al., 2002).[4] Experts assert that this variance allows conceptual estimates to be useful for determining feasibility but not for establishing a control budget (Dysert & Christensen, 2003).

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[3] Portions of this section are taken from an unpublished research report by graduate student researcher Gabriella Aquirre Perez.

[4] It is not clear if "concept design" in this paper actually includes design or rather only understanding what is to be delivered; i.e., programmatic data. To be conservative, we assume that the authors would expect the accuracy of conceptual estimates based only on programmatic data to be +/-30%.

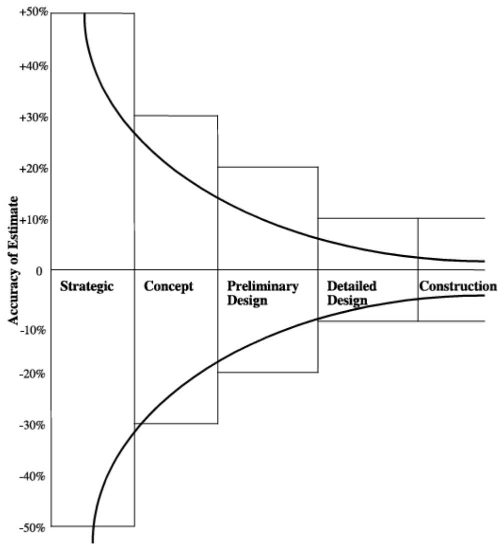

Figure 1: Accuracy of cost estimates at different stages of the design (AbouRizk, et al., 2002)

Skitmore and Picken (no date) are even more pessimistic, despite having found conceptual estimates considerably more accurate than +/-30%. In an extensive study of U.S. data, the most accurate estimates averaged 5.19% over costs at completion, with a standard deviation of 8.23%. They question if this level of accuracy is sufficient to support project capital planning, but offer no solutions.

Various factors are understood to affect the accuracy of conceptual estimates. Oberlender and Trost (2003) list the following five factors as primary in conceptual cost estimating of industrial projects, together with their relative impact on estimate accuracy:

1. Basic process design (23.2%)
2. Team experience and cost information (13.3%)
3. Time to estimate (12.1%)
4. Site requirements (11.5%)
5. Bidding and labor climate (10.2%)

Liu and Zhu (2007) divide factors into idiosyncratic and control factors. The first group, which includes market conditions, project complexity, design concept (programmatic and technical uniqueness), construction processes, weather, size of contract, site constraints, resource availability, type of procurement system, and contract work type affect the estimate but have traditionally been outside the control of the estimator. Control factors, on the other hand, can be determined by estimators to increase the performance of their cost models. These factors are project information, team experience, cost information, estimating process, team alignment and estimation design factors (Table 1).

Finally, accuracy is challenged by the fact that traditionally estimators have lacked the capacity to steer design development after their cost predictions have been made[5].

Table 1: Control Factors (adapted from Liu and Zhu, 2007)

PROJECT INFORMATION	Project scope definition	ESTIMATION PROCESS	Schedule control
	Estimation assumption accuracy		Increasing cost planning and control activity
	Clarity of owners requirements		Formally defined estimating process
	Completeness of project design	TEAM ALIGNMENT	Involvement of resource (labor, cost) in preparing estimate
TEAM EXPERIENCE	Experience in local market		Level of team integration and alignment
	Experience in similar projects		Level of involvement of project manager
	Experience in similar contract type		Effective communication
COST INFORMATION	Historical data for similar job	ESTIMATION DESIGN	Formal structure to categorize and prepare cost estimation
	Historical data quality		Estimation methodology
			Standard procedure for updating cost information
			Time investment

To summarize our findings from the literature, conceptual estimating involves programming (defining what is to be estimated), translation of that program into elements for which cost data is available (cost modeling), and applying that cost data. The more unique the object to be estimated, the more speculative the application of cost data, and hence presumably the less accurate the resulting estimate. The less well defined the program, the less accurate the cost data. Further, actively steering design and construction to target costs has proven to be effective (Pennanen, et al, 2005; Ballard 2008). Therefore, estimate accuracy would reasonably be expected to improve if we could:

1. Better define program
2. Better link program to elements that can be estimated
3. Use better cost data
4. Make better judgments
5. Steer design and construction to target costs at or less than what the client is willing and able to spend

The first two factors look to be affected by methods that allow buyers to specify what they want and to visualize (understand) the consequences of their choices. The third factor is not impacted by the conceptual estimating method, and the fourth is a property of the estimator, not the method. The fifth is a property of project management. So we should look for methods that impact the first two and the fifth factors.

[5] Haahtela (1980) and Niukkanen (1980) argue that conceptual estimates cannot be more accurate than +/-10% without steering design to target cost, and can easily be +/-25%, which aligns with empirical reports.

ROLE OF COST ESTIMATING IN DETERMINING A TARGET COST

The role proposed for cost estimating in determining a target cost, and hence a project budget, is shown in Figure 2. Cost is a constraint to which 'wants' (ends, purposes) must be aligned to assure project feasibility. The process of reaching alignment may differ, but all involve a conversation between 'wants', 'worth', 'cost', and 'ability to pay'.

What is shown in Figure 2 is typical for an investor's approach to project definition. The worth of the prospective asset is determined based on forecast revenues and other benefits, from which the buyer can determine what they are willing to pay to acquire it. That potential return on investment is dependent, however, on being able to make the investment, so what the buyer is willing to pay may be reduced, based on what they can fund. What the buyer is willing and able to pay is called the allowable cost for what's wanted. Note that an allowable cost is matched to a specific deliverable.

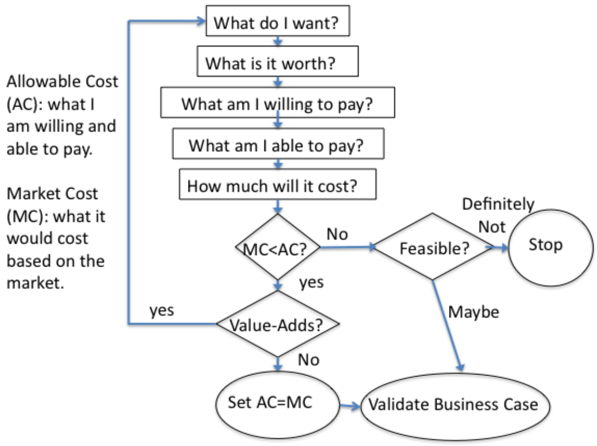

Figure 2: Process for Determining Project Budget (from Ballard, 2012)

This is where conceptual cost estimating enters into the process. The estimated cost of acquiring what's wanted in the market, here called the market cost (MC), is compared to the allowable cost (AC). MC is expressed as an interval estimate, calculated as two standard deviations from the point estimate. There is a 95% probability that the true value lies within two standard deviations of the point estimate. If what the buyer is willing and able to spend is equal to or greater than the upper end of the interval estimate, the project is considered financially feasible, and the project budget is reduced to that amount. However, if AC<MC, project feasibility is questionable. If the gap is too great, what's wanted must be adjusted or the project abandoned. If the gap is considered reducible through innovation in design or improvement in execution, the project budget is set equal to AC.

If the standard deviation between conceptual estimates and costs at project completion is 8.23%, as reported by Skitmore and Picken (no date), and a 95% confidence level is desired, a point estimate of $100 would be represented as the range between $83.50 and $116.50. If the project budget is set at $116.50 to protect delivery of the asset to be constructed, more capital will be reserved than if the point estimate was a more accurate predictor.

HAAHTELA'S CONCEPTUAL ESTIMATING

Haahtela's process for conceptual estimating is one of several identified as potentially yielding more accurate estimates than +/-30%. Haahtela engages buyers in specifying what they want and understanding the consequences of their choices (Whelton, 2004; Pennanen & Ballard, 2008). Once project scope and budget are aligned, Haahtela steers design and construction to deliver scope within budget; i.e., what the client expects to get for what the client is willing and able to pay. In Haahtela's process, the first step is to input into the cost model what the client wants in order to calculate that project cost. The determination of allowable cost is not made directly from an estimate of worth, but rather results from a confrontation of desire and cost consequences, together with suggestions for reconciliation between them, such as increasing the utilization of spaces, and so decreasing the total space required without reducing value to the client. The Market Cost is an output from the cost model. The Allowable Cost is that model output that the client finds acceptable; i.e., they are willing and able to pay that amount and are assured that they will receive in return what they want.

Haahtela's process has no distinction between budget and target, and does not use shared risk and reward to drive improvements in performance. The goal is not to deliver more value for the money, but rather to deliver what the client expects to receive for the cost they expect to pay. Haahtela is confident they can deliver the project for the budget, recognizing that different designs have different costs and that steering the design process toward the scope and budget is the key.

Haahtela manages projects as a construction manager (CM), responsible for all project phases, managing project definition, design, and construction, and contracting with cost risk for all design and construction services. Less frequently, Haahtela serves as Main Contractor (MC), in which role they are not responsible for site management or for procurement of subcontractors. Table 1 lists 20 Haahtela projects, a mix of CM and MC, and shows the relationship between costs at completion versus the budget for each project.

The actual/budget percentage and the difference between the two is shown in Column D. For example, for Project A, the actual/budget ratio is 22800/25060, which equals 90.98%, and the difference between them is 9.02%. A negative difference, as in the case of Project D, indicates a budget overrun. There was only a single instance of scope increase in the 20 cases, amounting to .07% of the original budget, so changes in scope are not shown in the table[6]. 13 of the 20 projects were completed under budget, ranging between .07% to 15% under. 7 of the 20 projects were completed over budget, ranging between 1.77% and 11.58% over. The average ratio between actual and budget was 0.01%, meaning cost at completion was .01% above budget. The standard deviation was 6.27%.

[6] According to Haahtela, smaller increases in scope are not tracked when clients are privately held or otherwise not obligated to justify cost increases above project budgets within a certain amount. More extensive analysis of the projects included in the sample is needed in order to adjust costs at completion for increases in scope. Such adjustment would improve the accuracy of Haahtela's conceptual estimates, but exactly how much remains to be determined.

Table 2: Costs at Completion vs Budget

A	B	C	D		E
Project	Budget	Actual	Actual/Budget % & Delta		
A	25060000	22800000	90.98%	9.02%	CM
B	12900000	12500000	96.90%	3.10%	CM
C	5600000	5550000	99.11%	0.89%	MC
D	17100000	18600000	108.77%	-8.77%	CM
E	11300000	11500000	101.77%	-1.77%	MC
F	38700000	40100000	103.62%	-3.62%	CM
G	21900000	21380000	97.63%	2.37%	CM
H	16700000	17500000	104.79%	-4.79%	CM
I	13200000	14100000	106.82%	-6.82%	MC
J	14700000	14500000	98.64%	1.36%	CM
K	4750000	5300000	111.58%	-11.58%	CM
L	8115000	8100000	99.82%	0.18%	CM
M	5750000	5746000	99.93%	0.07%	CM
N	46500000	46400000	99.78%	0.22%	CM
O	12000000	10200000	85.00%	15.00%	MC
P	5650000	5400000	95.58%	4.42%	MC
Q	27600000	26600000	96.38%	3.62%	CM
R	11150000	10410000	93.36%	6.64%	MC
S	9840000	9670000	98.27%	1.73%	CM
T	14700000	15700000	106.80%	-6.80%	CM
	285292960	286791300		0.224%	

Range: Actual to Estimate	11.58% over	15% under
Average Delta	0.01%	
Standard Deviation	6.27%	

These numbers compare quite favourably to measures of conceptual estimate accuracy in the literature (AbouRizk, et al., 2002; Skitmore & Picken, no date). Assuming a conceptual estimate of $100 and a standard deviation of 6.27%, the actual cost should lie within two standard deviations above the estimate 95% of the time. In other words, the maximum expected cost would be $112.54. If the client chooses to further protect the achievement of project objectives, three standard deviations would yield a maximum expected cost of $118.81. If the client's allowable cost equals or exceeds $118.81, the project is considered economically feasible.

Haahtela's process for getting a client to a project budget consists essentially in confronting the client with the cost consequences of their desires and offering the client alternatives they may not have previously considered. The process is supported by a cost model that takes owner desires as input and produces a cost estimate (Pennanen, et al., 2005). The cost model is based on historical costs, and is recalibrated semi-annually to reflect changes in market conditions. Table 2 below is data from a 2011 recalibration, in which 20 projects completed by others, without

Haahtela's involvement, are estimated using only programmatic data, and the cost estimate from Haahtela's cost model is compared to the tenders. Note that these projects may or may not have involved proactive steering of design to target cost.

Table 3: Haahtela Calibration of Cost Model against completed projects (from Pennanen, 2011)

No.	Type of Building	Budget (x 1000 Euros)	Lowest Tender	Tender vs Budget
1	Residence	4078	4318	5.9%
2	Church	4600	4989	8.4%
3	Residence	6450	6999	8.5%
4	Office	15056	15279	1.5%
5	Residence	2087	2332	11.7%
6	Service bldg for elderly	2972	3024	1.7%
7	Residence	3026	3580	18.3%
8	School	5235	5231	0%
9	Store/Shop	4890	5270	7.8%
10	Service bldg for elderly	7215	7106	-1.5%
11	Office	15653	13068	-16.5%
12	Office	11170	11184	-4.5%
13	Service bldg for elderly	2971	2605	-12.3%
14	Service bldg for elderly	2853	2707	-5.1%
15	Residence	3313	4056	22.4%
16	Residence	6307	7776	23.3%
17	Store/Shop	9458	9436	0%
18	Residence	5740	6363	10.9%
19	Office	16510	18877	14.3%
20	Residence	5332	5626	5.5%
				Mean=5.0
				Std. Dev.=10.4

CONCLUSIONS

The Haahtela conceptual estimating process appears to be substantially more accurate than generally accepted norms. Having only 20 data points limits the strength of claims that can be made, but the data is encouraging that greater accuracy can be achieved. That accuracy may be even better if adjustment is made for increases in project scope.

We assume and will attempt to show in future research that the increase in estimate accuracy is driven principally by Haahtela's process for:

- defining and aligning scope and cost (for simplicity, we neglect other constraints than cost, but recognize their presence and importance)

- steering design and construction to deliver that scope within the project budget, and
- frequently adjusting their cost model to current market conditions.

The findings reported in this paper advance our research goals for both measurement and for hypothesis testing. We have measurement data on the accuracy of conceptual estimates relative to cost at completion—in this case not adjusted for approved change orders because they were almost non-existent.

As regards the hypotheses to be tested in the research, we found support for the feasibility of improving the accuracy of conceptual estimates to +/-10% with a confidence level of 95%. Haahtela's sample was within +/-12.5%, without adjustment for scope increases. We also found support for the second hypothesis; namely, 2) the use of the target value design methodology to define and deliver scope (what's wanted) within client constraints (cost, time, location, etc.) increases the accuracy of conceptual estimates. We did not find explicit support for the third hypothesis: the percentage change in budget from scope changes decreases in projects managed using target value design. Further analysis of the data is required to adjust conceptual estimate accuracy for scope increases in the sample projects.

In the future, we will attempt to incorporate scope changes into the analysis and to expand the Haahtela data set. We will also extend descriptive research to other conceptual estimating processes that may be substantially more accurate than prevailing norms.

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