Through Life Estimating (TLE) – the need to estimate through program life

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Abstract *– The objective of this paper is to introduce the concept of using one estimating tool to estimate hardware, software, services and IT programs consistently from cradle to grave using appropriate estimating methodologies.*

This paper will define the term "Through-Life Estimating" and describe the challenges of estimating an aerospace or defence program over the typically long gestation period of 20 to 30 years – estimating Through-Life.

Amongst other ideas the paper will consider:

- *What is Through Life Estimating (TLE)?*
- *Why is Through Life Estimating (TLE) important?*
- *The impact of TLE on the estimating community*
- *TruePlanning 2009 delivery of Through Life Estimating*

The value of this paper is providing an understanding of the advantages of using one estimating framework for program life. Readers will learn how bid and proposal teams can work more quickly together to generate estimates and consider how an estimate evolves from a concept to implementation. The paper will consider what saving of time and resources are achieved with Through Life Estimating and the ability to obtain Quality Assurance.

To demonstrate this capability the paper will consider a case study and track its cost estimating progress from initial conception through to the final design. The paper will effectively walk through a multi-discipline estimate.

Introduction

The definition of Through Life Estimating (TLE) is "the ability to generate repeatable cost and schedule estimates in a way that is traceable and scalable throughout the life of a Program utilising the most appropriate methodology at each stage of the estimate."

This is a challenging objective. By their very nature, projects evolve over time. In the case of aerospace and defence projects this can mean many years. In other industries the

time period may be shorter, but the challenge is not diminished due to the number of alternative designs that can be considered over the life time.

Swapping the estimating tool part way through a project is like swapping the Operating Systems of the computer. The fundamental basis of the estimate has been eroded and thus the confidence has been impaired. But more seriously, it is difficult if not impossible to trace the differences between the estimate created with one estimating tool and that produced by another.

Problem

As a philosophy the concept of estimating through life throws up many obstacles; from tools, to staff through to the estimating methodology employed. Maintaining a consistent professional estimating staff with appropriate knowledge of the industry, product and estimating processes necessary is a constant challenge for any organisation over a short period. When projects span decades, as in the case of aerospace or defence projects the problem is compounded. It means that providing a consistent estimating service to customers is difficult. Knowing the internal or external customer needs and providing deliverables and processes that satisfy those needs is a challenge.

Using the appropriate estimating methods during the maturing of the product or service such that the methodology matches the level of detail and information that is available at each stage of the life cycle is never easy. In the past spreadsheets provided a flexible solution, but they are time consuming. Staff spend much of their time learning how to program macros or use advanced functions, rather than concentrating on the task in-hand which is estimating. This in turn leads to complications in the ability to re-estimate as requirements emerge, being responsive to the changes in the end customers needs as well as those of the internal management needs.

Through Life Estimating involves ensuring quality assurance of estimates by using independent estimating methods to verify the estimate. Usually one method is difficult enough to assure under bidding conditions. It would certainly ease the situation during a frantic proposal if technology was available to establish a collaborative environment to communicate effectively and efficiently without the need for excessive paper. In such circumstances it will be more efficient for the Cost Engineer to be proactive and propose an estimate to the organisational functions rather than cross checking the estimates produced by the organisation.

As the life cycle of the product changes and different estimating methodologies become relevant the ability to use validated and verified estimating models through the life of the project without swapping the estimating environment is attractive. Likewise the ability to capture historical data consistently will lead to the monitoring of efficiency changes and the justification of any investments made throughout the project life. Finally, the integration of the estimating suite with the tools used throughout the life cycle of a program will provide an efficient environment in which to work; integration stemming from CAD and design optimisation tools through to operating and support tools.

The challenge

It is possible to frame the challenge when you consider the diagram in Figure 1.

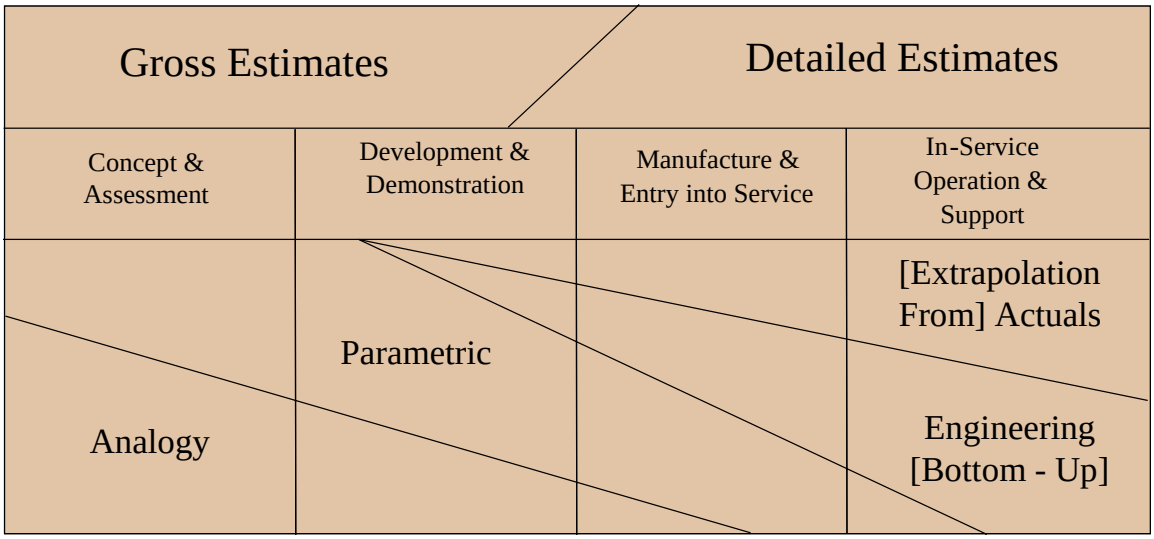


Figure 1 - Through Life Estimating methodologies

Over the lifetime of a program, the level of detail and information about the program deliverable changes. At the beginning of the program during the concept and assessment phase, little detail is available, and the significant focus is on finding revenue or a funding stream for the program. As such parametric or analogous estimating techniques are employed; these could be referred to as gross estimating methods.

As the program matures the level of information increases until the detailed estimates are desired. During the phases of manufacturing and entry into service, bottom-up estimates are required and actual costs become available. These actual costs are substituted for the estimates that have been used previously.

This is not a clean process and during the maturity of the program hybrid estimates will occur which use a mixture of estimating methodologies.

Spreadsheets are an obvious choice for solving the Through Life Estimating problem. Due to their infinite flexibility they can be used to assist a Cost Engineer in the process of preparing an estimate using any methodology. But this flexibility is also their short coming, as they are not designed for cost estimating explicitly. They are used for budgeting, calendars, expense reports, inventories, invoices, purchase orders, evaluations, games, ledgers, tests, menus, reports, the list is endless. What is required is an estimating framework, as flexible as a spreadsheet in terms of its ability to accommodate different estimating, methodologies, but designed specifically with cost estimating in mind.

Generations of commercial parametric models

Commercial parametric models can be categorised as beginning with *first generation models* adopting the earliest mainframe computers. Prior to the adoption of computers

using graph paper, pencil and slide rule it was possible to derive parametric models, but the distribution of that knowledge for commercial use was difficult unless published in a book. With the adoption of computers in estimating it was possible to make a modest material gain from the licensing of commercial parametric models which supported further research and more importantly effortlessness sharing of parametric solutions across the aerospace and defence community. The life time of these early parametric models spanned from 1975 to 1990.

Early Parametricians needed to be taught text editor and keyboard skills as part of the commercial parametric courses. Coming from the early 1970's cost engineers were still marvelling at the electronic calculator when the cream of the youngest, most talented cost engineers had their productivity slowed to a grinding halt by one finger and a keyboard. Estimates were prepared and processed overnight on the mainframe, only to find in the morning that a vital input was missing and the whole estimate would need to be run again the next night. However, the intellectual property in the form of the trade secret algorithms contained within the commercial models were deemed sufficiently valuable that management and cost engineer were prepared to accept mainframe computers as an imperfect solution.

Second generation parametric models began to arrive with the embracing of personal computers in industry in 1988 and are still used today. As personal computer became powerful enough to deal with the thousands of mathematical calculation required in the parametric models the software of the first generation models were ported onto these computer platforms. The second generation models also had the advantage of graphical user interfaces (GUI) and easier dialog with the user. This lead to more efficient usage of commercial parametric models and the further expansion of their application. The commercial parametric model became portable and could be taken to subcontractor or customer sites for negotiations.

Where as the processing of the first generation parametric models was done centrally with dumb terminal using 1,200 bytes per second or 2.4k bps modems to retrieve the results. The second generation commercial parametric models had to deal with the issue of protecting the trade secret equations within the programming. The software was compiled to run faster on the personal computers and leading to the trade secret equations becoming scrambled which in term led to the challenges of validation and verification for these models. The term "Black-box" was commonly used by staff who found commercial parametric models unfathomable. In these second generation models the users were ultimately unable to see the mathematics or parametric algorithms; they had to depend on the quality assurance of the commercial parametric models vender.

Finally, in the turn of the millennium *third generation parametric models* have emerged in the market, taking advantage of the latest client server computer architectures combined with open parametric estimating frameworks. Third generation parametric models enable commercial parametric models vendors to port their models into this framework and implement bespoke organisation specific models. Within the open parametric framework these models (from different origins) can use the common cost

engineering features of the framework like labour rates, escalation, risk analysis, reporting and so forth.

Cost savings on third generation models are realized when the same user interface is used for all the models whether software, IT, service or hardware. Training can be modular, needing framework training to be conducted once and then model specific training to follow, providing a more pleasurable user experience. Validation and verification of the models is simpler as the open environment can be scrutinised by any authority to review the implementation of the cost estimating relationships.

Solution

A well-developed third generation parametric model, such as TruePlanning (see Figure 2) is an example of such a framework with cost estimating methodologies appropriate to each phase of a program.

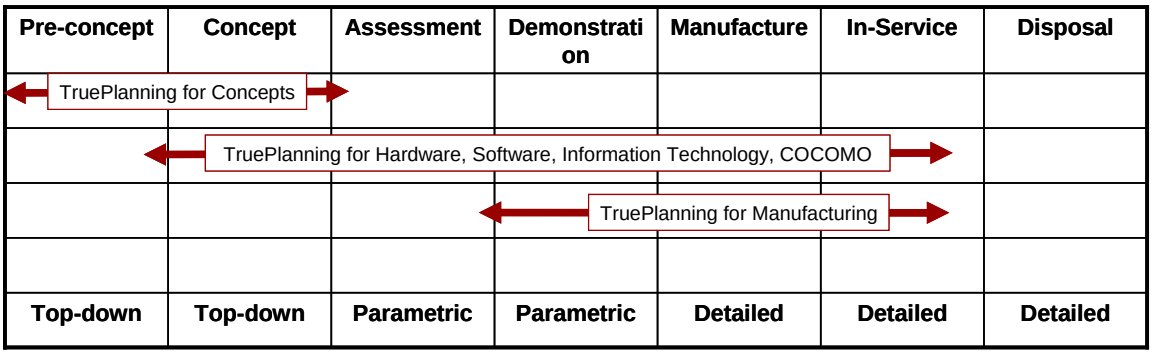


Figure 2 - TruePlanning adoption of different estimating methods

A third generation parametric cost model is an estimating framework which addresses Through Life Estimating challenges by providing a consistent approach to risk analysis, escalation, labour rates, input parameters, reports, and so on. It will involve a collaborative, client server environment to enable the sharing of the paperless information throughout an organisation:

- Using a parametric cost model will boost productivity since scalable cost modelling is available in portable form on a laptop or corporately adopted on an enterprise server installation. Through Life Estimating with a third generation parametric model allows the user to create their own custom cost models which can be validated and verified by their organization. This will facilitate credible, traceable estimates for equipments, systems and systems of systems.
- Commercial parametric tools have sophisticated knowledge management features to enable the retention of corporate or individual knowledge. With the addition of an affordability companion, knowledge management is still further enhanced by interoperability with other enterprise tools such as design and design optimisation tools.

- Tutor based training can be augmented by web based training to ensure that staff learn at their own pace and have the ability to revise their learning when required.

A Through Life Estimating solution provides a series of cost and schedule estimates as shown in Figure 3

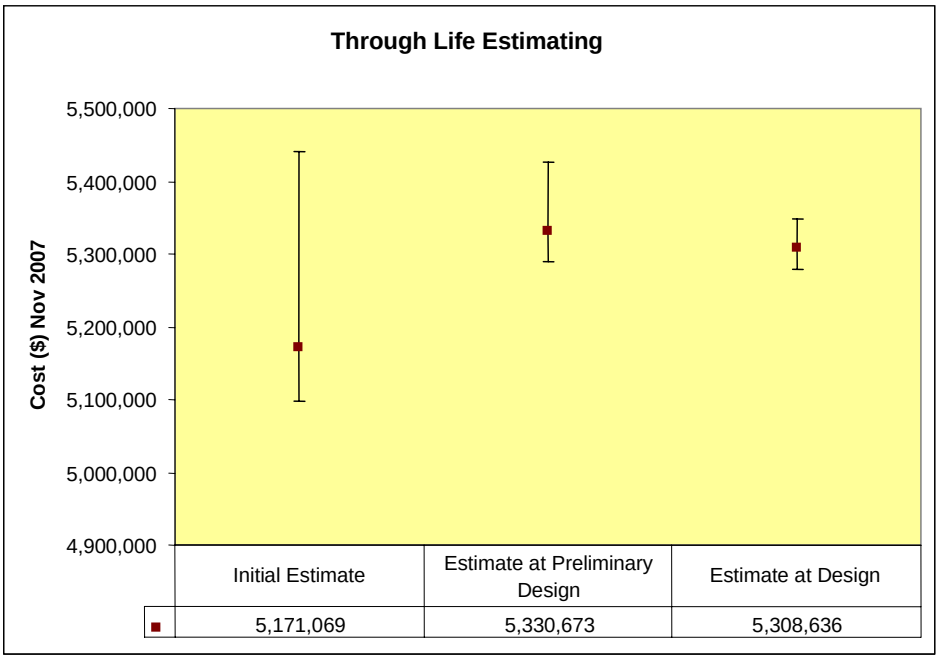


Figure 3 - the desired outcome of Through Life Estimating

Through Life Estimating ensures that estimates can be reproduced as requirements emerge. This is dependent on the estimating framework accommodating appropriate estimating methodologies throughout the life of a Program, from cradle to grave.

Ideally, the Cost Engineers will have their skills maintained using Web and Tutor based training to professional standards to ensure a consistent professional estimating staff Through Life. This will enable them to provide a consistent estimating service to customers in terms of deliverables and process

Cost models established in a collaborative environment ease communication effectiveness and encourage capturing historical data consistently thereby helping monitor efficiency changes. Senior management and decision makers can monitor the effect of their improvement initiatives, rather than pondering if the difference was caused by a change in estimating model.

Finally, the Through Life estimating implemented in an open framework architecture provides easy validation and verification of estimating models. When implemented in an enterprise environment the model creates opportunities for integrating estimating with other Product Lifecycle Management (PLM) tools thus saving time and resources.

Case Study

This case study involves the integration of technologies and the development of the project estimate from a simple top level estimate for a speculative proposal to a detailed estimate to secure funding and authorisation to proceed.

The case study is based upon the XYZ Company, which has been experiencing dramatic growth over the last two years. It has been very successful through its innovation and novel solutions.

Growth has resulted in XYZ employees being located in many geographical locations with frequent travel between company sites. As a family friendly company with a modern outlook on employee terms and conditions many also work from home, this also reduces the overhead.

This growth and distributed work force has created a concern for the accounts and Human Resources departments regarding book to projects for direct booking staff. Put simply; time card compliance is increasingly a problem.

This might not seen too worrying, however because much of their work is billable any failure to book all hours worked or delay in submission of written time cards has implications. This problem could threaten the business

A joint memorandum from the HR and Finance Director's reminding staff of their duty to complete accurate and timely time cards did have an effect for a short while. But it also caused some bitterness amongst the staff. This crackdown was successful but employees are unhappy and much time is wasted with enforcement, a more permanent solution is needed.

Engineering have raised the idea of an integration of time cards with a hand held devise. The Chief Executive Offices considers this a potential solution and a business opportunity, the CEO therefore sanctions a short concept study with cost estimate.

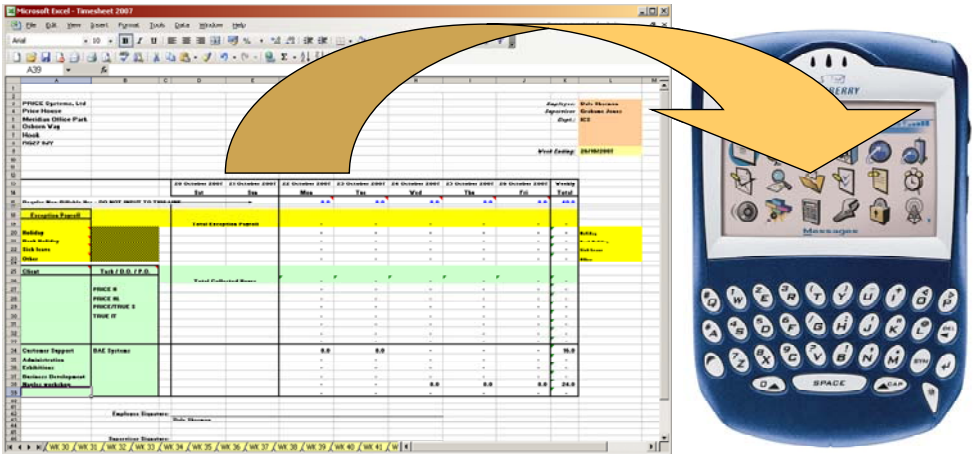


Figure 4 - integration of time card and hand-held devise

Using a third generation parametric model capable of estimating hardware, software and IT the conceptual architecture is quickly described as a Product Breakdown Structure (PBS) like Figure 5.

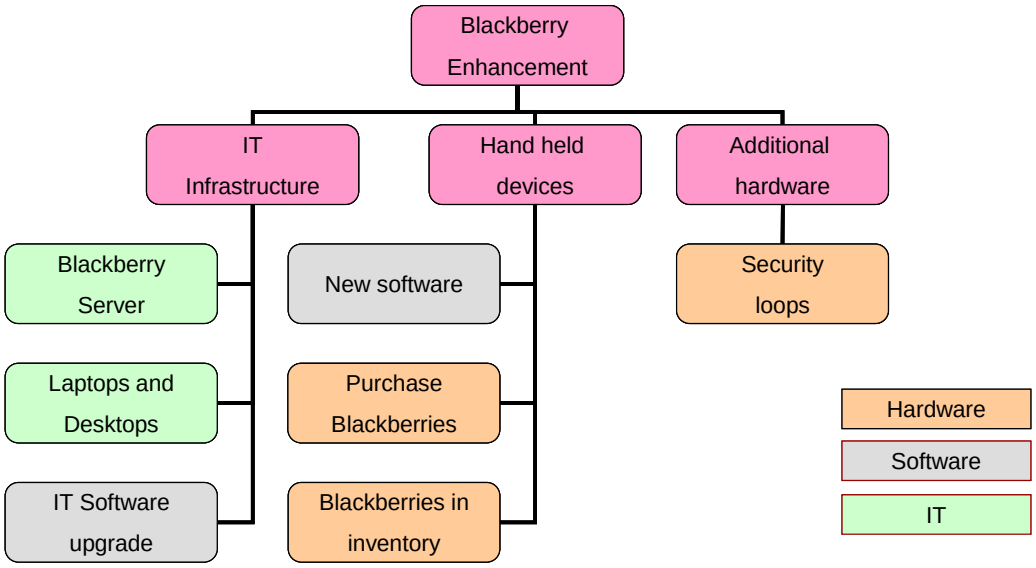


Figure 5 - Conceptual level Product Breakdown Structure

This PBS is easily interpreted into the TruePlanning framework (Figure 6) and the input parameters from the model are determined.

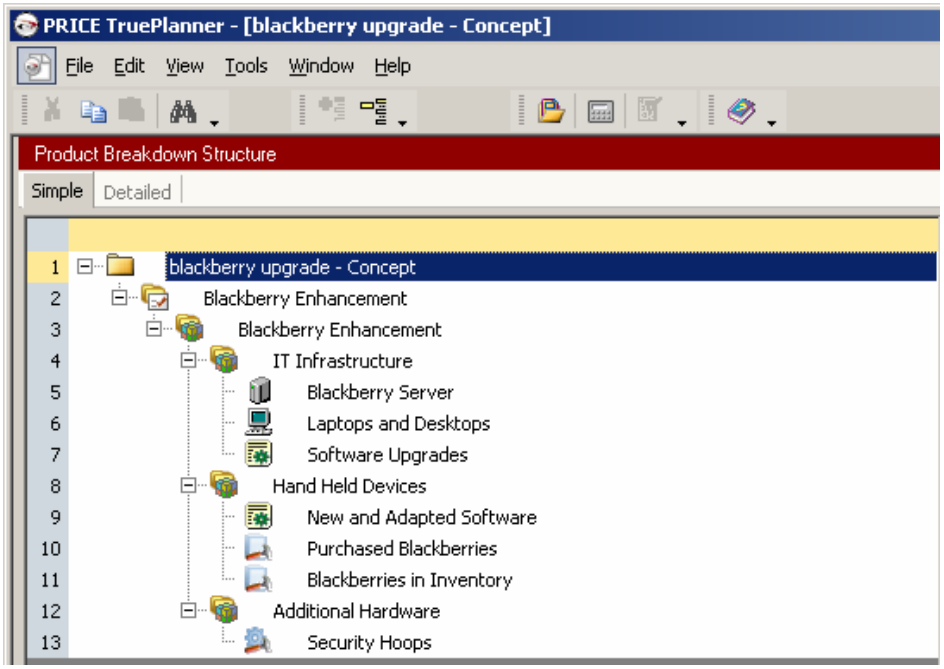
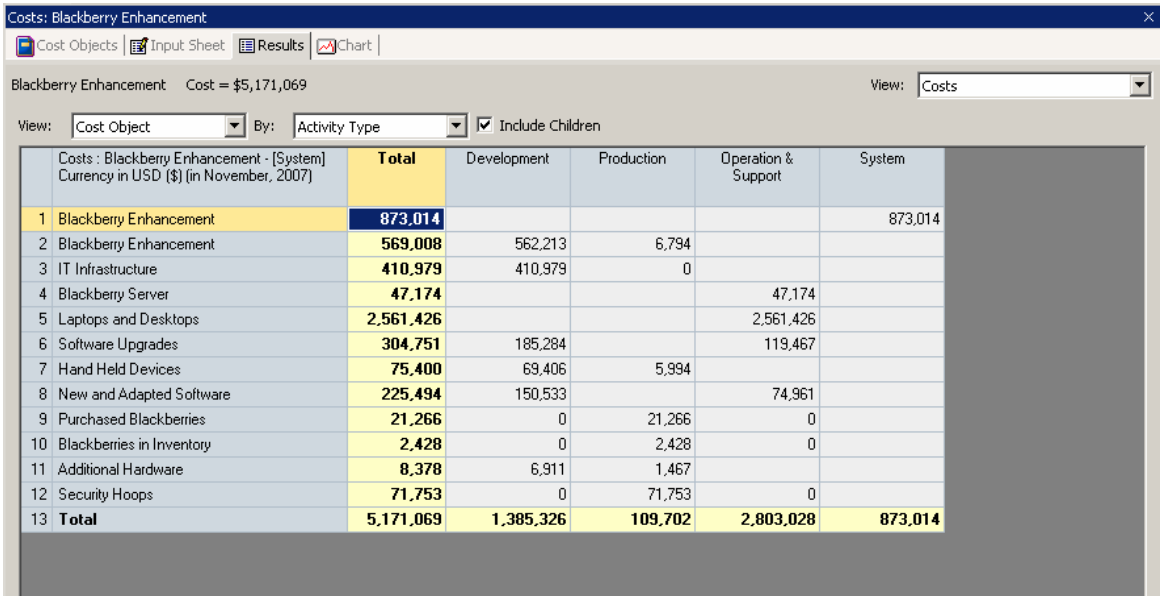


Figure 6 - TruePlanning PBS

When calculated the conceptual estimate (Figure 7) and technical solution is presented to the CEO. Realizing that this is a Rough Order of Magnitude estimate, the CEO is also presented with a risk analysis, which at this stage is naturally a wide tolerance.

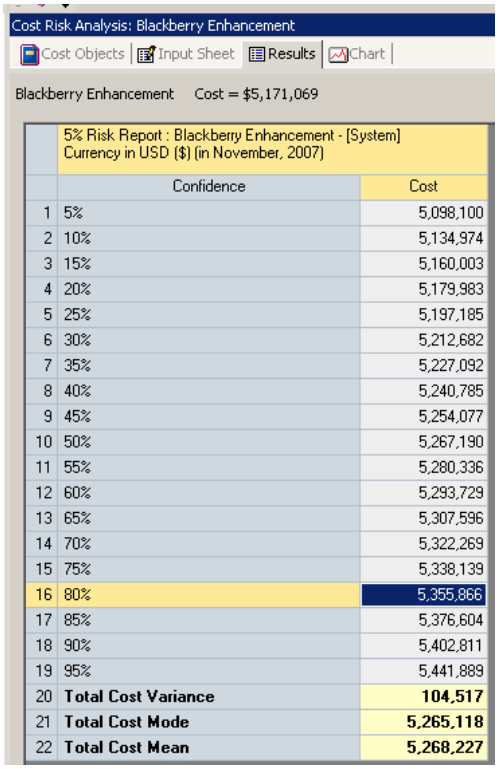
A review and discussion ensues with sales and commercial and it is considered an interesting proposition. Serious funding is found for a preliminary design and more detailed cost estimate.

The original two operating scenarios have an additional two operating scenarios added. The engineering department is encouraged to think of cost and performance by the CEO. A date for a review and report is set in the diaries of all concerned.



	Costs : Blackberry Enhancement - [System] Currency in USD ($) (in November, 2007)	Total	Development	Production	Operation & Support	System
1	Blackberry Enhancement	**873,014**				873,014
2	Blackberry Enhancement	**569,008**	562,213	6,794		
3	IT Infrastructure	**410,979**	410,979	0		
4	Blackberry Server	**47,174**			47,174	
5	Laptops and Desktops	**2,561,426**			2,561,426	
6	Software Upgrades	**304,751**	185,284		119,467	
7	Hand Held Devices	**75,400**	69,406	5,994		
8	New and Adapted Software	**225,494**	150,533		74,961	
9	Purchased Blackberries	**21,266**	0	21,266	0	
10	Blackberries in Inventory	**2,428**	0	2,428	0	
11	Additional Hardware	**8,378**	6,911	1,467		
12	Security Hoops	**71,753**	0	71,753	0	
13	**Total**	**5,171,069**	**1,385,326**	**109,702**	**2,803,028**	**873,014**

Figure 7 - Concept cost estimate



5% Risk Report : Blackberry Enhancement - [System]
Currency in USD ($) (in November, 2007)

	Confidence	Cost
1	5%	5,098,100
2	10%	5,134,974
3	15%	5,160,003
4	20%	5,179,983
5	25%	5,197,185
6	30%	5,212,682
7	35%	5,227,092
8	40%	5,240,785
9	45%	5,254,077
10	50%	5,267,190
11	55%	5,280,336
12	60%	5,293,729
13	65%	5,307,596
14	70%	5,322,269
15	75%	5,338,139
16	80%	5,355,866
17	85%	5,376,604
18	90%	5,402,811
19	95%	5,441,889
20	**Total Cost Variance**	**104,517**
21	**Total Cost Mode**	**5,265,118**
22	**Total Cost Mean**	**5,268,227**

Figure 8 - Concept risk analysis

At the second review a more details PBS and estimate is presented with the technical solution. The CEO is dismayed (but not surprised) to learn that his words have not been heeded and that the project costs have increased. The tolerance of the estimate has tightened due to the increased technical knowledge and estimating methodology being employed within the TruePlanning framework as seem in Figure 9.

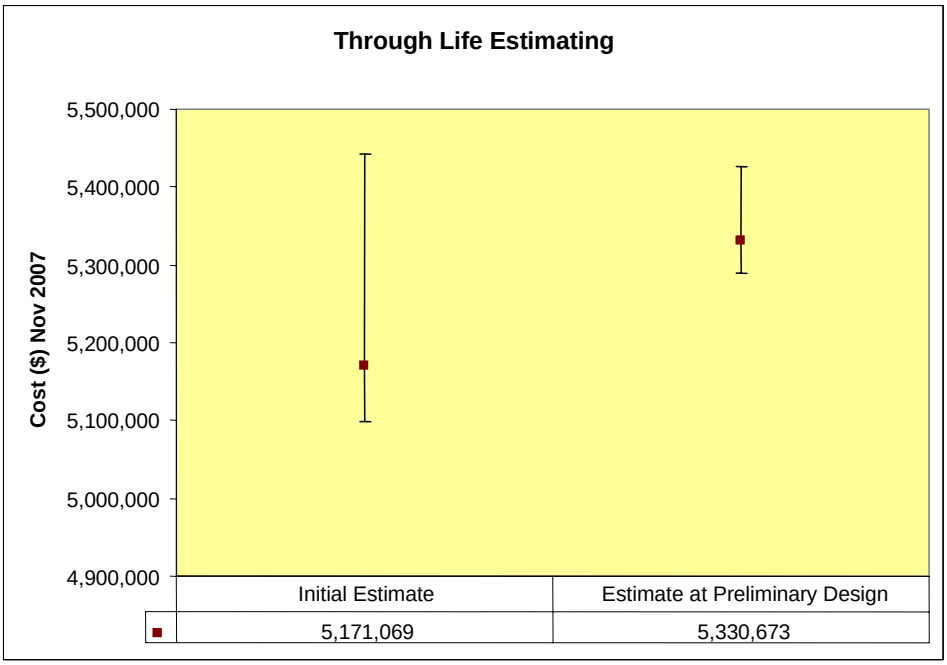


Figure 9 - Summary of two reviews

With news of a market survey conducted by the marketing department showing a gap in the market for this type of application, the CEO authorises a full detailed design.

The engineering department produces a full Pro/Engineer Computer Aided Design (CAD) model. Utilising their Affordability Companion and TruePlanning for Manufacturing cost model a detailed estimate is produced (see Figure 10). The characteristics of the CAD model are automatically transferred into TruePlanning, estimated and returned to the designer for refinement.

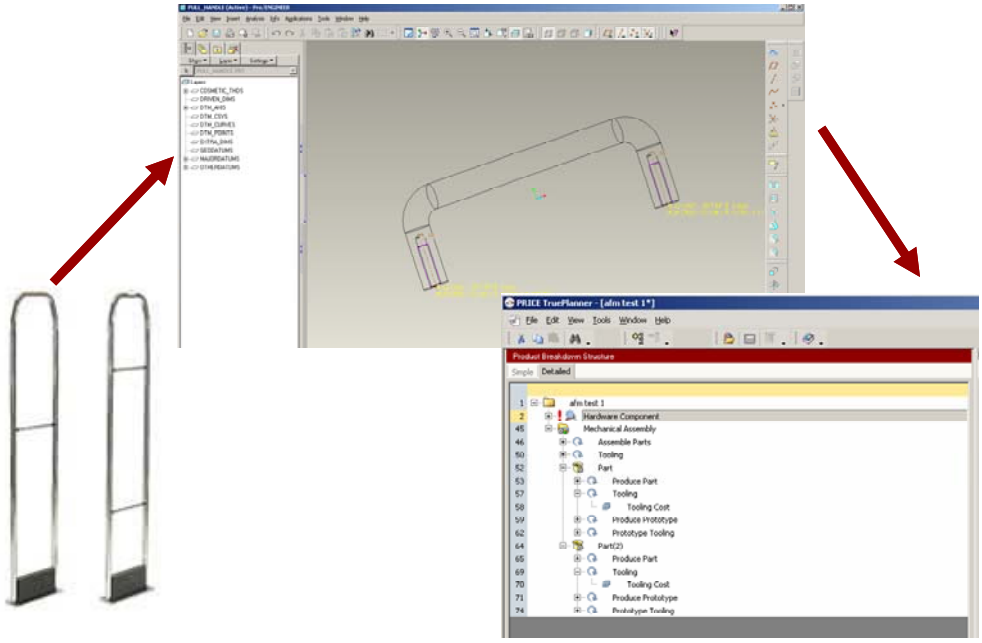


Figure 10 - Detailed CAD model and detailed estimate

At the final review with the CEO the third detailed cost estimate is presented (Figure 3) and full scale development began. With complete traceability through the life of the three estimates produced.

Summary

Estimating is not a one off exercise, having conceived a program of work there will be numerous obstacles to pass before the system is successfully accepted by the end customer. These obstacles will require consistent estimates to be produced to track the cost. In this chapter you have learnt that;

- Through Life Estimating can structure this application with cost modelling methodologies appropriate at each phase of the program
- Using a cost framework ensures that changes of requirements can be tracked over the program life providing justification in a consistent manner for cost changes.
- The problems of a single point failure, validation & Verification, training and configuration management associate with spreadsheet models can be overcome by adopting third generation parametric models.
- Through life estimating encourages corporate knowledge retention formally leading to cost and time saving in the estimation of the next generation of your systems and programs