

Systems Cost Engineering - Program Affordability Management and Cost Control

D. Shermon¹

¹PRICE Systems, PRICE House, Meridian Office Park, Osborn Way, Hook, Hampshire, RG27 9HY, United Kingdom. +44 1256 760012

Dale.Shermon@PRICESystems.com

Abstract – *The Cost estimating for major engineering hardware, software, service and IT projects is critical for ensuring a realistic evaluation of the project or program, to assess its affordability, and for managing the ongoing costs realistically. Traditional cost engineering methods are time consuming, expensive and occasionally irrational. Organizations are increasingly turning to parametrics as a means of managing cost and program affordability.*

This paper is based on 25 years of personal experience and many years of joint experience within the PRICE Systems team of the application of cost engineering principles in large engineering and aerospace projects and IT / Business transformation projects in financial services. This paper will explore different applications of parametrics, based on real-life case examples and provide attendees with a detailed guide to the rationale and value of these applications.

Systems Cost Engineering will help cost engineers, the project and program directors, and champions that support them, to understand and apply parametrics to ensure that their programs:

- *offer a credible analysis of alternative cost options;*
- *are never initiated with insufficient funding because of inaccurate estimates of cost or quantification of risks;*
- *are never diverted from their objective because of a lack of credible cost management;*
- *share and communicate knowledge of realistic and dynamic cost and productivity metrics amongst the program team;*
- *are never derailed by surprise cost overruns or schedule delays.*

Introduction

So you have seen the benefits of parametrics in early cost estimating (see Figure 1). When little information exists about a project, proposed program, competitors product or suppliers equipment a parametric model is able to generate an independent cost and schedule estimate. This method of estimating has an advantage over traditional estimating until a Bill Of Material (BOM) and detailed drawings are available when a bottom-up analytical estimate is possible.

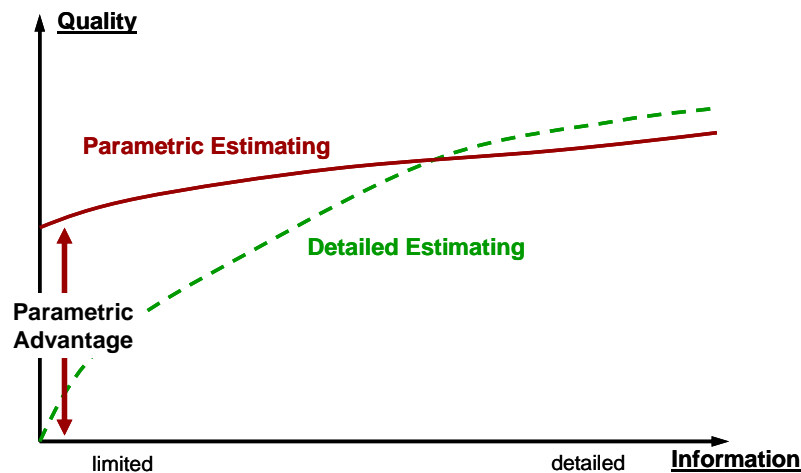


Figure 1 – Parametric Advantage

So your organisation has invested in a parametric model and training for their new Parametrician. You have spent two days out of the office learning how to;

- Create a project
- Build Product Breakdown Structure (PBS)
- Input parameters
- Output results
- Create charts
- Interpret functional relationships
- Customise escalation and labour rates
- Conduct Risk Analysis

So what's next? In PRICE Systems we have been promoting the parametric Start-up plan for the last few years. However this has been focused on the acceleration of the competencies which you have been taught. It helps students to speed up the implementation of their newly found skills. The Implementation plan teaches them to treat the roll-out of parametrics like a project with funded resources and a project plan. The calibration and analysis plan teaches them to focus on the benchmarking of their organisation.

It's a bit like when you take possession of a new car. You have a user manual which tells you about the maintenance, your comfort, tyre pressures, controls and so forth. In the class you have learnt that in a bidding situation detailed analytical estimating will get you to a bid or pricing review eventually, with little time to panic and chop your estimate until the bid prices are lower than the target budget. While with a validated and verified parametric estimating model you can quickly get to an estimate in days. There after it is possible to make a series of rational decisions regarding the design, performance and programmatic of the item to be bid resulting in a rational price below the target budget (Figure 2). It is conceivable that an early bid/ no-bid decision could be made and valuable resources saved.

There is more to learn, what else can you do with your new estimating knowledge and skills?

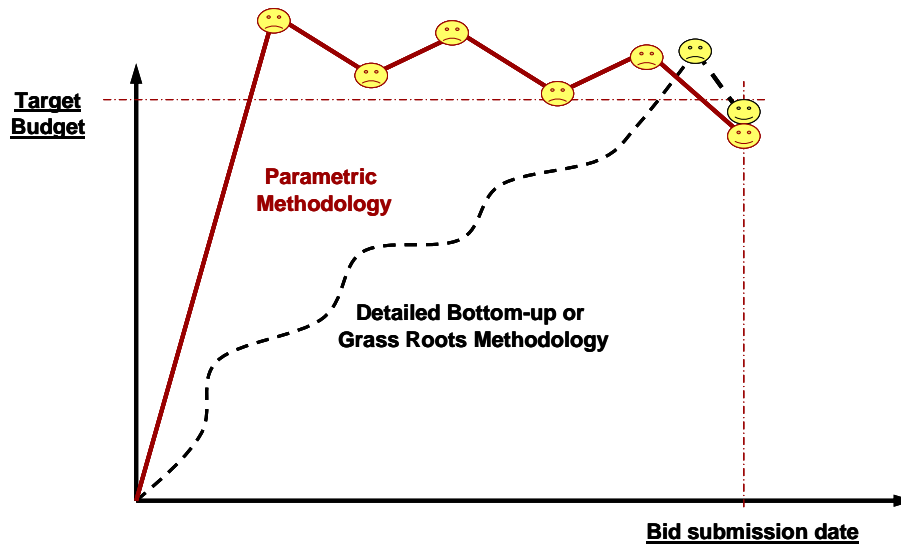


Figure 2 – Analytical and parametric methodologies

When you have a new car, instead of the car user manual, what you really crave is a book to tell you which roads to drive, what routes are prettiest at which time of year, the highway where you will have the best views, where to go for the best driving experience.

Cost engineers are not employed as a convenience but as a necessity, they are asked challenging and demanding questions from senior management and executives often prompted by external customer's demands and queries. These challenges are met by cost engineers in a variety of ways. When the cost engineering community are lucky, and the solutions to these problems are not commercially sensitive, these solutions are shared with other cost engineers at conferences and symposiums¹. The number of solutions which have been presented historically at the PRICE Systems European symposiums includes Bid/No Bid decisions, Knowledge Management, Cost validation (Supplier Assessment), Design To Cost (DTC) also known as Cost As an Independent Variable (CAIV), Make/Buy analysis, Risk analysis, Systems and software system acquisition and maintenance and many more.

Using these solutions my colleagues at PRICE Systems and I have created a book called 'Systems Cost Engineering' which has been compiled from past papers and solutions using parametric models. Not a user manual, more like a book of suggested good places to take parametrics in an organisation.

Cost Engineering

Cost Engineering requires the fusion of three elements; Processes, Cost Models and Skilled People. When these three elements are combined efficiently you achieve a capability that will profoundly influence the projects that your organisation embarks upon. When these elements are realised in the organisation then cost estimating naturally leads to project control, which enables you to develop your corporate knowledge and reuse what you have learned in the cost estimates of the future.



Figure 3 - Program Affordability Management (PAM)

Program Affordability Management (PAM) (see Figure 3) is a seamless union of these elements that results in what PRICE Systems call True Program Success. How do you know when you have achieved True Program Success? When you can confidently say, no Program will ever:

- Be conceived without a credible Analysis of Alternatives
- Be initiated with insufficient funding because of inaccurate initial estimates and inaccurate quantification of the risks
- Be deterred from its mission because of lack of credible cost analysis within the Program's Management
- Be deterred from its mission because of lack of integration between Earned Value Management and Cost Estimating and Analysis
- Be deterred from its mission because knowledge of cost and productivity metrics is not being shared among Program teams and with other Programs.
- Be deterred from its mission because of surprise cost overruns and schedule delays

Figure 4 illustrates a project that unfortunately did not benefit from Program Affordability Management. For years I have driven past this bridge that leads nowhere and marvelled at the engineering and considered the alternatives.



Figure 4 - Example of a project that would have benefited from PAM

Program Affordability Management is achieved through three elements of Cost Engineering;

TrueMethods: which are best practices in Advanced Planning, Bid and Proposal Development, Supplier Assessment and Selection and Project Cost Control. These are the processes which are applications of a cost model taught by experts and applied by your staff.

TruePlanning: is a comprehensive cost analysis and knowledge management tool. It is a cost model framework which can be applied to numerous applications following the right training and experience.

Parametricians are experts in building budgets, evaluating performance, identifying risks, analysing tradeoffs and continuously monitoring program value. They are able to customise standard processes to suit your environment with models that relate directly to your organisation. PRICE Systems can mentor your staff to achieve these tasks.

Purpose of this book

The purpose of this book is to describe how to achieve applications of cost and schedule models within an organisation. The applications described in its chapters have been evolved over many years until they have become elements of the philosophy of Program Affordability Management (PAM).

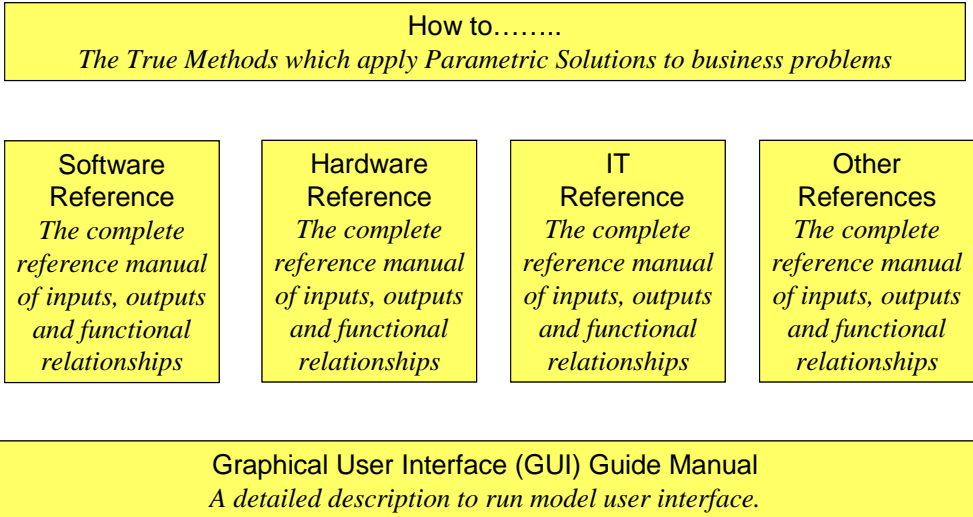


Figure 5 - Example of documentation structure

Figure 5 shows the structure of the documentation which parametric cost model vendors provide. The Graphical User Interface (GUI) Guide details the software and its use in terms of file storage, retrieval and screen manipulation. The model references are used to describe the characteristics of those models; their inputs, outputs and functional relationships – what makes them tick.

The ‘Systems Cost Engineering’ book is an over arching guide to the application of the individual cost models. Independent of the parametric model being used, the intention is to provide solutions to the cost estimating problems posed in businesses today; enabling you to obtain a return on the investment for a parametric model.

Each chapter tackles a different application of the parametric methodology of cost and schedule estimating. As such, it is independent of the specific cost model used.

Use of parametrics throughout the organisation

Commercial parametric models have many applications. They are able to solve problems at the top of the organisation for the decision maker and senior management (see Figure 6). At this level, senior managers can consider costs which influence their decisions much faster. Hence, bid or no-bid decisions can be made with a view to saving bidding resources. Market Strategy and Business plans can be assessed alongside benchmarked productivity, competitor analysis and productivity tracking.

At executive level, financial decisions can be speeded up with parametric estimates. Capacity planning will ensure best use of the available resources; supplier assessment employed to select the preferred supplier; and risk analysis used to consider the uncertainty in budgets and financial reporting.

At the operational level, parametrics can be deployed to deliver technology programs on the basis of effective consideration of alternative options and the tracking of the program throughout its life with Cost As Independent Variable (CAIV) and Earned Value Management (through the integration of parametric estimating).

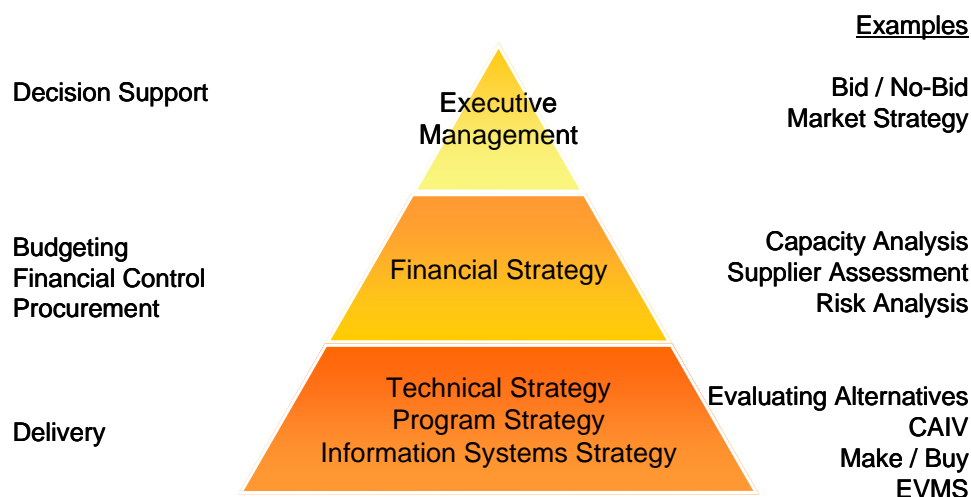


Figure 6 - Enterprise applications

Application of parametrics

So let's explore the landscape of parametric solutions and where you can take your new parametric knowledge. When considering the application of parametrics to programs it can be thought about in several different groups.

Credible Analysis of Alternatives

Prior to embarking on any program it is important that all credible alternatives are assessed to ensure that the program goes ahead on a sound basis. Many programs begin with a proposal which, following award of the contract, begin to consider if the proposed solution was financially the most economic. Utilising parametrics the Business Plan should be influenced in such a way that only technologies in which an organisation is confident that they lead industry will be proposed.

Considering the Technology Readiness Level (TRL) of the technical solutions available to satisfy the requirements is important at the beginning of a program. The cost of maturing and developing technology can cause problems during the execution of the program particularly if the budget is underestimated.

The acquisition strategy can be influenced with intelligent use of parametrics. Consideration of the delivery options can be established; can the program be delivered in one batch or would it be more economical to deliver several batches? What would the effect of parallel development and production mean to the cost of the program? These questions and more can be answered with the application of a parametric cost model.

At a more detailed level then alternative designs can be considered quickly when interfacing a Computer Aided Design (CAD) tool with a 3rd generation parametric model. For example, the linkage between Pro/Engineer and TruePlanning, shown in Figure 7, is called the Affordability Companion. Designers can evaluate the cost of their alternative designs in real-time, without the need for time consuming bottom-up estimating, then assess the most cost effective alternative design on an equitable basis.

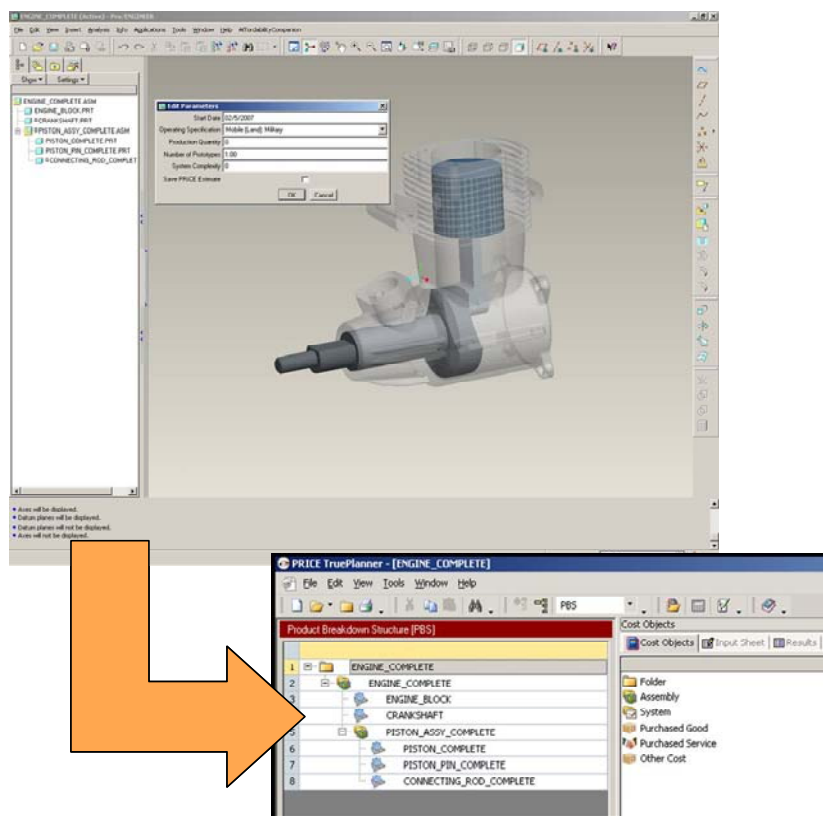


Figure 7 - Pro/Engineer and the Affordability companion

As a final example in this group, parametrics will swiftly assess the Level of Repair Analysis (LORA) to ensure that the most economic maintenance concepts are being considered from the outset, not just the best procurement strategy.

Inaccurate initial estimate and quantification of risks

Programs should not get into problems due to the inaccuracy of the original estimate or the lack of consideration of risks. Parametric analysts and parametricians have the opportunity to prepare estimates quicker with fewer resources, but they also have the chance to use different estimating methodologies to compare the results. As shown in Figure 8, if three different estimating methodologies are used when preparing the same bid and they all predict similar cost and schedule durations then your confidence in the estimate is greatly increased over a proposal based on a single estimate.

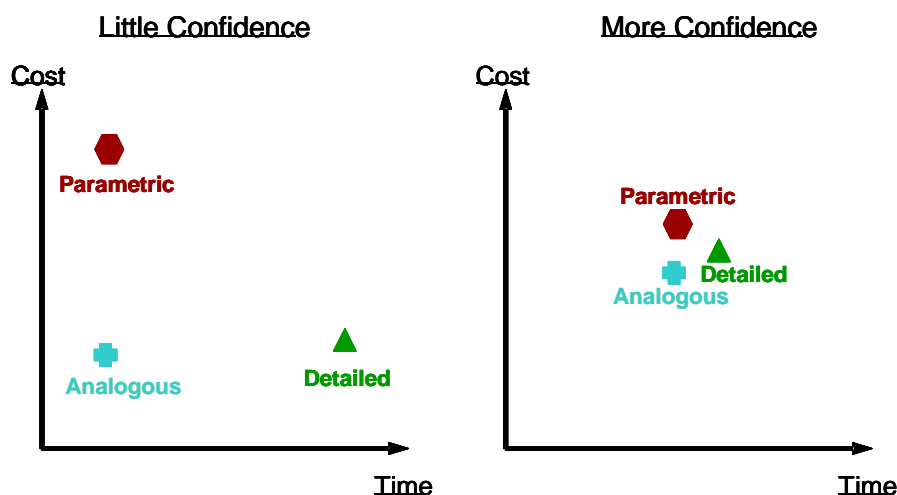


Figure 8 - Confidence in estimating

Calibration of the parametric model can be used to increase the accuracy of the estimates produced by customising the model to a specific organisation. This calibration process is sometimes viewed as time consuming and unnecessary, but if conducted correctly it can be very illuminating and provide insight into your organisations productivity, strengths and weaknesses.

In terms of risk analysis this can be considered in two ways. Firstly, parametrics can help to assess the quantification of program risk impacts. The maturity of the technology used, expressed by the Technology Readiness Level (TRL), can be a source of risk and parametric models can be used to determine the impact of implementing immature technologies for example. Another example would be the problem of novel acquisition strategies which might cause unforeseen cost impacts. Secondly, the parametric model has the ability to analyse the uncertainty in a program due to the inability of engineers to accurately assess the cost drivers at an early stage or even before a program begins. This risk analysis capability ensures that programs utilising parametrics experience an appreciation of their accuracy and less exposure to risk impact.

Lack of credible analysis within the Program's Management

Once the program is underway then parametrics continues to make a useful contribution and a valuable tool for the shrewd program manager. With a 3rd generation parametric model utilising a costing framework it is possible for the same model to employ analogous, parametric or analytical detailed cost models in one software system. This Estimating Through Life capability enables program managers to compare estimates, regardless of the estimating methodology utilised, on an equal basis.

Technology Insertion (TI) is an acquisition strategy which plans for technology refresh at stated periods during a program's life. The ability to analyse the optimum period for technology refreshment can make a financial difference for the program. Incremental acquisition is a strategy to ensure that budgets can stretch to acquire the platform with a plan to introduce capability in the future. Parametrics can help determine the priority of these capabilities, the optimum timing and cost of these increments.

In a program obsolescence is a concern during the later years and a time when budgets are perhaps tighter due to the degrading capability of the system. The quick analysis of credible

strategies to overcome obsolete electronics technologies with little interruption of the program can be very welcome by a program manager.

Figure 9 shows a typical disjointed cost estimating and cost control system compared to a harmonised joined up system. It is common for cost engineering to be engaged at the start of a program when bidding. Then to engage them again at discrete periods for Estimate At Completion (EAC) exercises throughout the program. It is usual that the program control and cost engineering functions are separate and distinct.

Product Life Cycle

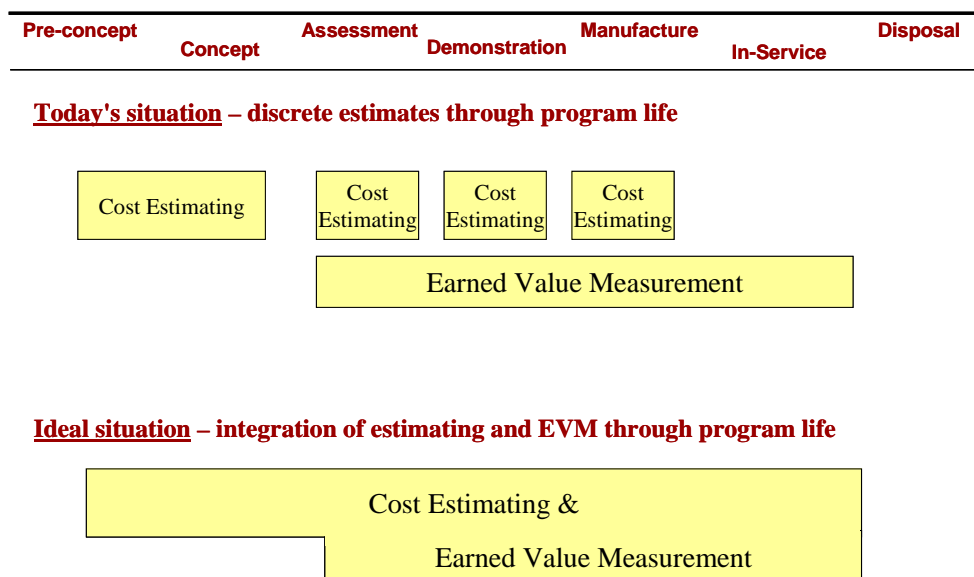


Figure 9 - joining parametric estimating and EVM

Ideally the cost engineering and Earned Value Management (EVM) functions should be harmonised to provide continued adjustment to the baseline cost and schedule. These result from technical, programmatic and schedule changes which evolve during the program.

All of these examples demonstrate application of parametric estimating to assist management of program's to make rational decisions based upon sound analysis.

Knowledge of cost and productivity metrics

Corporate knowledge is under valued. How many good cost engineers do you know who left the organisation or retired with their knowledge or 'little black book'? Parametrics provides a facility to capture that knowledge for future generations of engineers.

Metrics are important as they can provide valuable information about your organisation, your supplier and your competitor. Figure 10 is an example of manufacturing complexity metrics being used to benchmark electronic items against average industry complexity. Any difference in the complexity will provide an insight into the productivity of an organisation; either above or below average industry productivity.

The same productivity metrics can be used for software to determine the productivity of software development and maintenance teams. But why stop there? If these metrics are continually plotted over time it would be possible for management to track productivity

changes. Are the process changes, capital investments or procedure alterations actually having the desired impact of productivity improvement? These and more questions can be answered by tracking productivity trends.

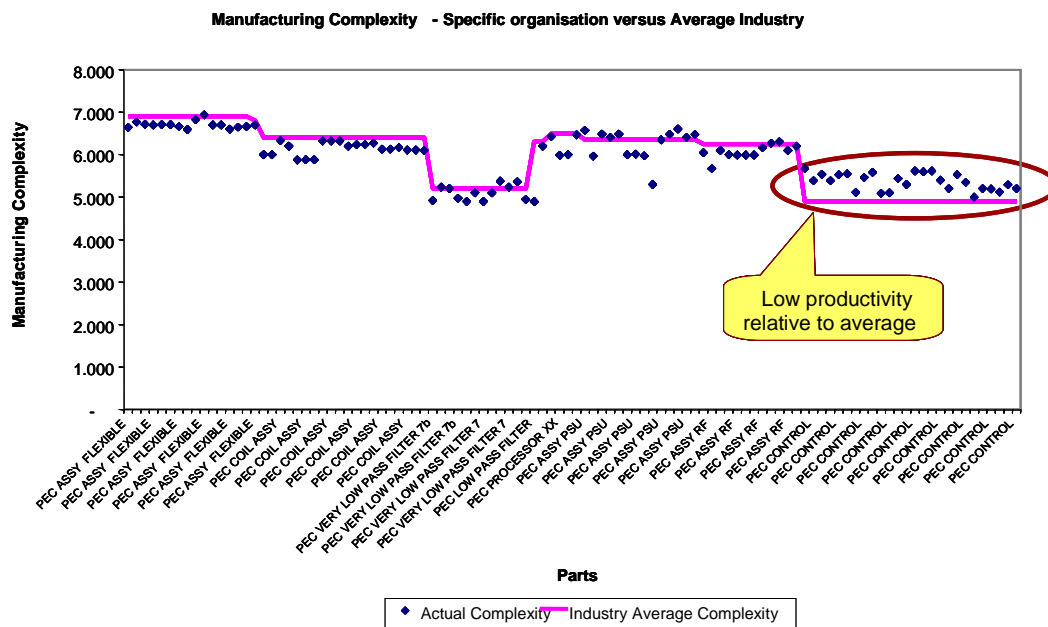


Figure 10 - Benchmarking productivity

If you are in the fortunate position to have a Knowledge Manager or Data administrator in your organisation, parametrics can provide a focus for their collection of historical program cost drivers. It is a daunting prospect to be asked to manage corporate knowledge and parametric cost models might not provide all the answers. However, start with these quantifiable parameters and add to them as your knowledge broadens.

The Systems Cost Engineering book provides guidance and insight into how your organisation can accomplish knowledge management efficiently. There really is no excuse for organisations not to have knowledge of cost and productivity metrics and not sharing them among program teams and other programs.

Surprise cost overrun and schedule delays

Parametrics can be utilised to assess supplier or vendors quotations. It is possible to produce an independent cost and schedule estimate of the equipment that is perhaps Military Off The Shelf (MOTS) or Commercial Off The Shelf (COTS). With an interpretation of a specification or knowledge of the inside of a piece of equipment like in Figure 11 it is possible to estimate the cost. This can be a useful source of negotiation material and help prevent cost and schedule overrun.



Figure 11 - validation of suppliers and vendors

In addition, parametrics is valuable to programs when establishing an acquisition and support strategy from a financial perspective. Establishing a good baseline cost for the whole program life which is realistic will ensure programs are not under funded in the first place.

The following applications of parametrics to programs like technology insertion, incremental acquisition and technology maturity all ensure that future uncertainty is considered at the outset and nothing is financially overlooked.

Summary

Parametric estimating is applicable when little information is available, as an estimating technique it consumes fewer resources and can be quicker than other estimating methods. Parametric estimating training is the end of the course and the beginning of providing solutions to many complex estimating questions.

Many applications of the parametric estimating methodology have been captured in past Symposium papers. Table 1 is a summary of the solutions which can be identified from this collective knowledge.

1. Credible Analysis of Alternatives					
2. inaccurate initial estimates and quantification of the risks					
3. lack of credible cost analysis within the Program's Management					
4. knowledge of cost and productivity metrics					
5. surprise cost overruns and schedule delays					
Prepare bids faster with fewer resources					
Prepare a focused Business Plan					
Validate quotations from suppliers					
Manage your program effectively					
Achieve accuracy in Cost Engineering					
Accomplish Quality Assurance					
Estimate Through Life					
Estimate technology maturity					
Assess software					
Analyse risk and uncertainty					
Consider Technology Insertion					
Develop cost effective alternatives					
Tackle the System of Systems Challenge					
Create home-grown parametric models					
Successfully conduct Life Cycle Costing					
Accomplish knowledge retention					
Present the results					

Table 1 - Applications of parametrics

No methodology or process will make a program profitable overnight. Program Affordability Management applications with parametric estimating can help to guide true program success. By moving on from macros' in excel spreadsheets, training professional cost engineers and preventing programs from being managed in isolation it is possible to transform the estimating department from an overhead cost centre into a positive contributor to an organisations success.

'Systems Cost Engineering'² published by Gower documents and captures many of the applications which have been usefully applied to programs. I would like to thank all the PRICE Systems consultants who contributed to it contents.

Reference

¹ “Applications of parametrics: A historical perspective” by Dale Shermon, ISPA conference 2008, Noordwijk, The Netherlands

² http://www.ashgate.com/default.aspx?page=637&calcTitle=1&title_id=10334&edition_id=11500