Why You Need Practical Reliability Details To Define Life Cycle Costs For Your Products and Competitors Products!

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Abstract

High-grade products are difficult to sell because of price resistance—particularly when the high-grade products have much longer life and require less maintenance than lower grade products. Life cycle costs comparisons help decide the lowest long-term cost of ownership driven by a single estimator called net present value. The initial low sales price item usually forms a datum for procurement decisions, and the higher sales price item must be compared over the entire life of the project. The net present values require decisions about when and how much maintenance/replacement costs will be incurred which is driven by the time and modes for component failures found by using reliability technology developed during the past 60 years.

Grade Issues

Grade is a category or rank indicator of products, processes, or service intended for the same functional use, but with a different set of needs. You can consider class, rank, order, or degrees as synonyms for grade. Grades apply to things such as hardware and to features such as service. Grade is a ranking or sorting process for relative standing of products. One well-known merchandiser provides good examples of product grades listed for sale as “good, better, or best”.

Grade reflects planned or recognizable difference in product features. Grades reflect features that exist or don’t exist. Extra features for higher-grade products cost extra money. Price is the most widely used concept for judging difference in product grades and is constantly advertised by manufacturers of lower-grade products—much to the dissatisfaction of manufactures for higher-grade products defending features, functions, and benefits.

Consumers view products as over priced when product grades are too high for their needs. Consumers are silent when products have just the right grade. Consumers complain about “poor quality” when product grades are lower than expected. People talk “around” concepts of grade without directly discussing product grade issues. This indirect approach about real product grade delays actions within organization. Product grades must match consumer’s needs for customer satisfaction.

Product features define grade. Costs of the features substantially influence sales prices. Sales price, along with market share, define manufacturing volume. These market-place drivers influence product grades. The market place lacks a steady-state condition. Competitors will change products to gain advantages. Products right for today’s market are wrong for tomorrow’s market. Consumers change their needs for different grades of products as they search for the right value.

Ill-matched product grades in a market place carry stigmas. A manufacturer with products graded too high is tagged with haughty or arrogant names and potential customers reject their products. Employees associated with products graded too low hear of product rejections concerning issues of low quality.

Both low-grade and high-grade products must have quality. Quality is a different word than grade. Quality is the totality of all features and characteristics of a product or service and these traits and attributes all bear on the products or services ability to satisfy a given need. Consumers are more forgiving of low-grade products with quality problems than with the high priced, high-grade products. Again, society's communication problem arises from talking "around" grade issues rather than handling product grade issues directly.

Engineering, following marketing's product statements sets the grade of a product in their drawings. Manufacturing, following conformance to the drawings (a statement of manufacturing quality) does not enhance product grade—they only maintain the grade specified.

The biggest, heaviest, strongest, most reliable products made from stringent specifications will have very high product grades and high prices. High product grades block-out markets because customers only see over-priced products. Customers won't willingly pay for an abundance of higher-grade features unless they receive good value. If customers can't discriminate the feature values as an advantage, then market leverage is lost.

Product attributes and features require careful presentation for customer acceptance. Customers need information about working limits, capabilities, and product life so they can make wise decisions in the selection of higher-grade product for their own competitive situation.

Rarely does a product sell its self. Low-grade products with low prices are easier to sell than high-grade products because of one attribute—the sales price. For most products the first price paid (acquisition cost) is not the last money expended (sustaining cost).

Sellers of low-grade products priced at low sales values are often happy with their position until sellers of high-grade products priced at higher values infer to the buyer that their competitors have inferior product. Soon battle royal begins and the consumer is easily baffled by conflicting advertisements between high- and low-grade products.

Low-grade products with low prices rarely need a reminder for the buyer about sustaining cost, since acquisition cost is a key procurement element. Thus low prices require no apology.

Sellers of high-grade, high acquisition cost products, often have longer useful life which requires reminders to the buyer about lower sustaining costs. Fitting acquisition and sustaining costs together for total life cycle cost--this takes explanations and justifications.

Sellers of high-grade equipment and products must do the buyer's homework on high-grade equipment. Sellers must provide numbers for their comparing results to the low-grade competing product (where the low price constitutes their homework). The life cycle cost comparison numbers can be a value added product useful as a sales aid for products and projects. Life cycle costs can focus on issues of what can be spent for high-grade products, which compete with short life, low-grade products. Knowing the life cycle cost territory is helpful for setting target marketing efforts and avoiding wasted time and effort of both sales and engineering.

Below you will see light at the end of the tunnel for arriving at a single figure of merit to describe the first acquisition cost and sustaining cost, which occurs over time. The single figure of merit is net present value.

Life Cycle Costs

Life cycle costs (LCC) refer to all costs associated with acquisition and ownership of a product or system over its full life. (Fabrycky 1991) The usual figure of merit is net present value (NPV).

NPV is a financial tool for evaluating economic value added. It is the present value of an investment's future net cash flows, minus the initial investment for a given discount rate hurdle. The present values for each year of the project are summed for the net present value. Net cash flows are a measure of a company's financial health. Discount rates are the interest rate used in discounting future cash flows. For an entire project, the life cycle cost number requires a positive NPV. Bigger positive NPVs are better.

Project elements cannot easily show profits/savings for each component. Thus decisions are made in selecting equipment based on the **least negative** NPV. The least negative NPV is better.

All LCC task require comparisons of alternative**s**—note the word alternatives is plural. In every LCC task, conflicting issues are obvious:

- Project engineers want to minimize capital expenditures
- Accounting wants to maximize NPV
- Shareholders want to maximize dividends/share price
- Production wants to maximize uptime hours
- Maintenance engineers want to minimize repair hours
- Reliability engineers want to avoid failures

All parties want someone else to put the numbers together to justify their love affair with the project or equipment, which justifies their decisions.

Business is about:

- Time
- Money, and
- Alternatives.

Time and money are in short supply. A single alternative is without choice and thus unwise because the default position is to do nothing. A comparison of ridiculous alternatives is also unwise. Alternatives are often as numerous as fleas but give pros and cons for making selections. The LCC concept merges time and money together to arrive at a single indicator called NPV for each alternative. NPV numbers prioritize the projects to select the winner from the alternatives so you buy right rather than only buying cheap. The road map of elements going into the LCC is shown in Figure 1 as a memory jogger for the details used in the alternatives.

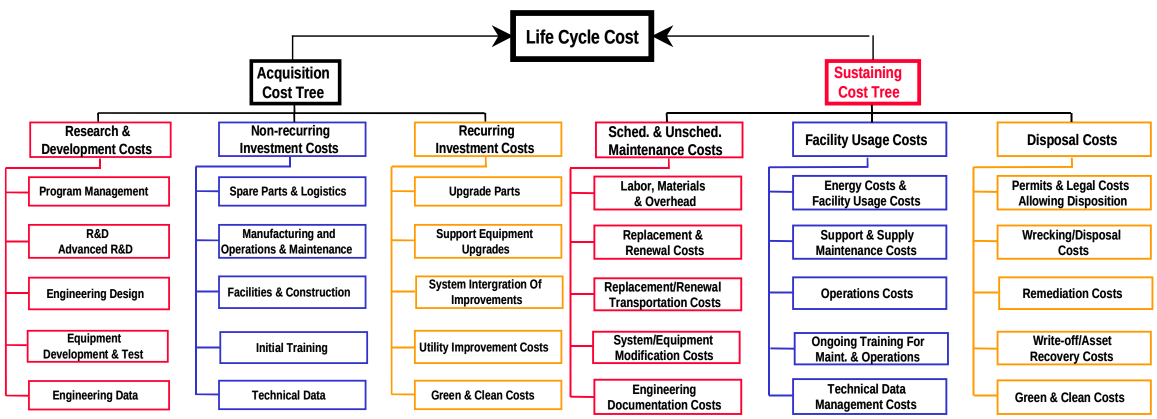

Figure 1: Details Required For Life Cycle Costs

Figure 1 shows items for inclusion in NPV calculations. Not all items are required for each evaluation—particularly if conditions are "same as but…" Cost details from Figure 1 are put into simple spreadsheets with elements by year of the expenditure. The spreadsheet calculations are simple additions, subtractions, multiplications, and calculations of the time effects of money.

Engineers should avoid writing NPV spreadsheets using built-in spreadsheet operators. Rather, make the spreadsheet entries in a "foot and tic" method learned by every accountant so as to build trust and rapport with the auditors who will validate the calculations. Many accountants will not validate the complicated build-in functions but they know how to "foot and tic" the results using old fashioned, time proven methods of accounting.

Consider these questions of acquisition and sustaining costs for two alternatives. Base the decisions on a 20-year project life and a discount rate of 12%. The scenario is easily reduced into a simple financial decision when the elements of Table 1 are put into the spreadsheet formation.

Table 1: Cost Summaries For Two Alternatives		
Alternative	**A**	**B**
Acquisition cost (year 0)	$100,000—one time	$175,000—one time
Annual sustaining cost	$20,000/year	$10,000/year
Turnaround (renewal) cost	$75,000 in year 5, 10, & 15	$65,000 in year 8 & 16
Total life time expenditures	$725,000 over 20 years	$505,000 over 20 years
Net present value	**-$228,282**	**-$219,325**

Table 1 shows how a few facts are reduced to a life cycle cost spreadsheet to arrive at NPV. Option A is a winner only for first cost. Option B is the life cycle cost winner where the NPV is 4% better even with a higher starting price—notice the NPVs are negative values and the least negative is a better choice for this simple case.

Table 2 shows only a portion of the life cycle cost spreadsheet because of space limitations.

Table 2: Typical Life Cycle Cost Spreadsheet

Life Cycle Cost Worksheet

Check with your accountant for local conditions requiring changes to this sheet.

Check with your accountant for local conditions particularly for capital expenditures in multiple years

See NPV results in cell "D44" **Use for instructional purposes only because of local accounting requirements**

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= input variables data

Input Information For NPV

The **worksheet** for NPV calculation below		Year	Year							
Cost Elements	**Year-->**	0	1	2	3	4	5	6	7	8
Acquisition Costs:										
Program Management	**Data Input**	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Engineering Design	**Scratch Sheet For NPV**	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Engineering Data	**Calculations--See "D44"**	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Spare Parts & Logistics		$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Facilities & Construction		$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Initial Training		$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Technical Data		$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Capital Equipment		**$ 175,000**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**
Documentation Costs		$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Sustaining Costs:										
Annual recuring costs			$ 10,000	$ 10,000	$ 10,000	$ 10,000	$ 10,000	$ 10,000	$ 10,000	$ 10,000
Periodic turnaround (renewal) costs		$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 65,000
Close Out Costs:										
Disposal			$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Total Costs (Less Capital Expenditure)		$ -	$ 10,000	$ 10,000	$ 10,000	$ 10,000	$ 10,000	$ 10,000	$ 10,000	$ 75,000
Savings (enter as a positive number)			**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**
Discount Rate Use For NPV		12%	<--Change as required							
Project Life (yrs)		20	<--Change as required							
Tax Provision % Used With Profit before Tax		38%	<--Change as required							

Net Present Value Calculations:

		Year	Year							
NPV Elements	**Year-->**	0	1	2	3	4	5	6	7	8
Capital	**NPV Calculations**	$ 175,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Costs	**See cell "D44"**	$ -	$ 10,000	$ 10,000	$ 10,000	$ 10,000	$ 10,000	$ 10,000	$ 10,000	$ 75,000
Savings (enter as a positive number)			$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Depreciation (straight line)			$ 8,750	$ 8,750	$ 8,750	$ 8,750	$ 8,750	$ 8,750	$ 8,750	$ 8,750
Profit b/4 Taxes			$ (18,750)	$ (18,750)	$ (18,750)	$ (18,750)	$ (18,750)	$ (18,750)	$ (18,750)	$ (83,750)
Tax Provision @ 38% of Pb/4 Tax			$ 7,125	$ 7,125	$ 7,125	$ 7,125	$ 7,125	$ 7,125	$ 7,125	$ 31,825
Net Income-Profit or (loss)			$ (11,625)	$ (11,625)	$ (11,625)	$ (11,625)	$ (11,625)	$ (11,625)	$ (11,625)	$ (51,925)
Add Back Depreciation			$ 8,750	$ 8,750	$ 8,750	$ 8,750	$ 8,750	$ 8,750	$ 8,750	$ 8,750
Cash Flow		$ (175,000)	$ (2,875)	$ (2,875)	$ (2,875)	$ (2,875)	$ (2,875)	$ (2,875)	$ (2,875)	$ (43,175)
Discount Factors @ Rate Above--net values		1.00	0.89	0.80	0.71	0.64	0.57	0.51	0.45	0.40
Present Value		$ (175,000)	$ (2,567)	$ (2,292)	$ (2,046)	$ (1,827)	$ (1,631)	$ (1,457)	$ (1,301)	$ (17,438)
Net Present Value->	**$ (219,325)**		<--Internal Rate Of Return (requires at least one positive number and one negative nu							
@ Discount Rate =	12%									

If\` the issue is **only** the lowest acquisition cost then why bother presenting any other alternative—even if higher first cost alternatives are more beneficial. If the issue is lowest long-term cost of ownership, then you need alternatives.

Equipment suppliers (or advocates for Option B) in Table 1 have a big hill to climb! Option B rarely sells without net present values. Bids for higher cost equipment should include two life cycle costs (Option A **and** Option B) and net present value or else sales and engineering effort is often wasted. Option B suppliers can't stay in the race without estimates for the low cost alternative. Equipment suppliers for lower acquisition cost Option A gain nothing by furnishing life cycle cost data—Option A suppliers can lose by being too frank with the facts.

Summarize NPV results for more multiple alternatives in ranked Pareto order by NPV value. This makes selection of the most desirable alternative easier to understand.

Should you always make decisions based on NPV? It depends—but generally yes. If you have the cash or can borrow the cash at a good rate of interest and you have confidence the business will continue for the long haul—then the answer is usually yes. If you don't have the cash for procurement of longer life equipment then the decision is made for you and is out of your span of recommendations or control—then the answer is usually no. Also you may need to add judgment to the NPV for issues concerning operability, maintainability, and reliability, which can alter effectiveness of the system. The list of "it depends" must be carefully considered AFTER you have found the NPVs.

Where Do You Find Data For Acquisition Cost?

Assembling data for acquisition cost is performed fairly well on most projects using the memory jogger of Figure 1. Often acquisition cost is the only number in the life cycle cost analysis, which is well defined by a bid price.

Other details of acquisition cost must be estimated from facts usually available within the business system. Scaling data up/down for specific cases is a well-established method. Assembling cost details by year of expenditure within the project life is never easy, but it must be done fairly meticulously as front-end money has greater impact than the same money spend in the last year of the project such as occurs with end of life issues.

Where Do You Find Data For Sustaining Cost?

Making the life cycle cost calculations is easy when you have the data. The difficult effort is how to resolve the chicken or egg dilemma for finding failure data, maintenance data, and other details involved in the sustaining cost section of Figure 1. You need reliability engineering details to find when things die. Failure data and repair time data can be converted into statistical format using WinSMITH Weibull software for use in reliability calculations. (Fulton 2000)

Few individuals claim knowledge of sustaining cost facts until someone else puts numbers on the table—then the critics are numerous for "correcting" the proposed numbers. Follow the scientific method: build a hypothesis for failures and their cost and then test the hypothesis. When in doubt about the failure data or cost, make an estimate and test the estimate for validity.

Much data needed for Figure 1 comes from operating costs (including electricity, etc.) and maintenance records which show times between failure and repair times. These details are often associated with the field of reliability and maintainability with a direct relationship with finding lower life cycle costs. (SAE 1999) The cost details should also include costs for lost gross margin for outages of systems when it is appropriate.

Reference lists for books and databases with extensive failure details are available on the Internet (Barringer 2000a) and training manuals (Barringer 2000b). Some of the failure data is from simple arithmetic calculations and other data follows the preferred method from Weibull databases. (Abernethy 1999)

Failures and failure costs can be influenced by operating conditions, installation conditions, and maintenance conditions. These are different grades of influences for or against longer life. Often variable conditions require Monte Carlo simulations to find how costs will vary with time and the different grades of influences. The Monte Carlo technique uses random numbers to solve the problems and spreadsheets are available at no cost to download from the Internet (Barringer 1999). More extensive models are available (Barringer 2000c).

Your can build simple, low cost Monte Carlo reliability models using software available from the Internet which are useful for driving life cycle cost decisions. (Barringer 2000d) The reason for building reliability models is to find where failure cost is occurring and to search for the lowest long term cost of ownership as shown in Figure 2 where system details, when priced-out, provide a clear leading alternative for solving the problems. The reliability models show what's affordable and the less desirable alternatives.

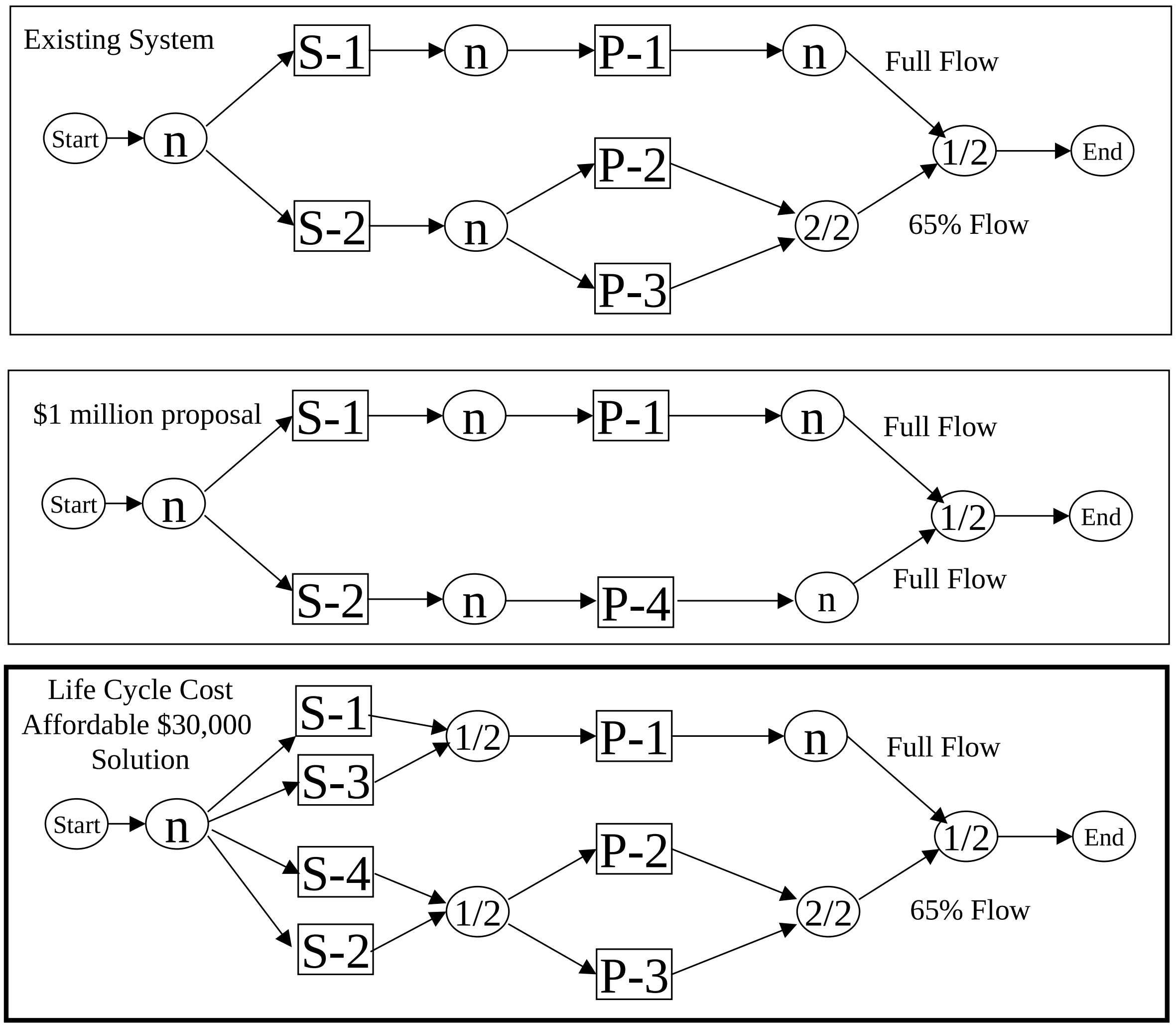

Figure 2: Life Cycle Cost Alternatives

Reliability models, using actual failure data and repair times give system availability, reliability, maintainability, and other operating system details which allows construction of costs and tradeoffs.

Of course the affordable solution did not solve all the problems of cutbacks in system output when failure of P-1 occurred. However, when life cycle costs numbers were used, it became clear the proposed high cost alternative for avoiding cutback losses was too heavy a financial burden to carry and a lower cost alternative was suggested from the reliability models. The alternative said we can afford to live with the cutback losses given the improvements we get by low cost additions of items S-3 and S-4. In short, life cycle costs give pragmatic solutions not ideal solutions.

The reliability models provide evidence for tradeoff boxes. Engineers need graphics for understanding what's happening to their systems. The tradeoff box has life cycle cost on the vertical axis and effectiveness on the horizontal axis. Effectiveness is the product of availability, reliability, maintainability, and capability of the system to perform. Complex items become simple when you see the results shown in Figure 3

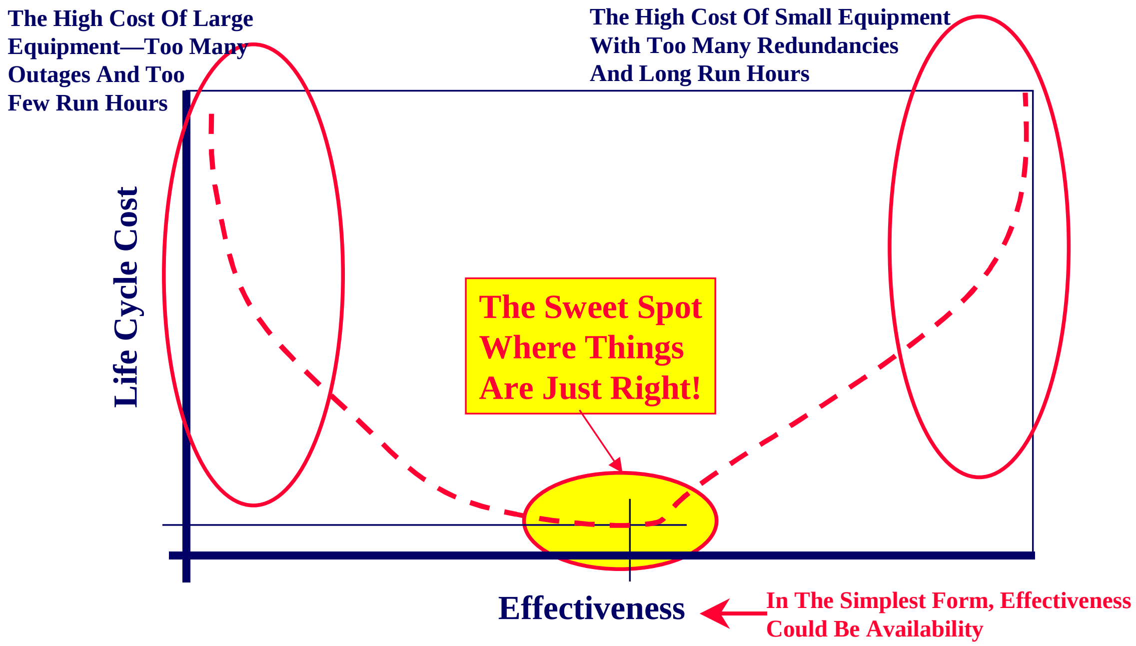

Figure 3: The Trade Off Box

What most companies need is the money and not perfect solutions! Life cycle cost helps provide the answers. When you have concepts and features on a product or process that generate value, the value must be quantified for inclusion in the life cycle cost model. Sometimes the view must be from the buyer's position and other times from the seller's position—the key issue is to quantify for inclusion into the model.

Summary

Life cycle costs merge engineering details into a cost format that considers the time value of money. The life cycle concept relies heavily on reliability and maintainability technology issues to convert ideas into hard, cold engineering facts so the results can be converted into a monetary value.

The first cost for procurement is not the last cost. Procurement cost may represent only a small fraction of the total cost during the life of an item, and in other cases, it may be a large portion of the total life cycle costs—general rules of thumb have much variance.

For high-grade products, the seller must produce life cycle costs to overcome buyer resistance to the higher initial cost. It is not in the interest of most low-grade products seller's to show life cycle cost, as the best story they have is the non-resistance threshold of low first cost.

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Biography

Paul Barringer, P.E. is a manufacturing, engineering, and reliability consultant with more than thirty-five years of engineering and manufacturing experience in design, production, quality, maintenance, and reliability of technical products. Experienced in both the technical and bottom-line aspects of operating a business with management experience in manufacturing and engineering for an ISO 9001 facility. Industrial experience includes the oil and gas services business for high pressure and deep holes, super alloy manufacturing, and isotope separation using ultra high speed rotating devices.

He is author of training courses: **Reliability Engineering Principles** for calculating the life of equipment and predicting the failure free interval**, Process Reliability** for finding the reliability of processes and quantifying production losses, and **Life Cycle Cost** for finding the most cost effective alternative from many equipment scenarios using reliability concepts.

Barringer is a Registered Professional Engineer, Texas. Inventor named in six U.S.A. Patents and numerous foreign patents. He is a contributor to **The New Weibull Handbook**, a reliability handbook, published by Dr. Robert B. Abernethy.

His education includes a MS and BS in Mechanical Engineering from North Carolina State University. He participated in Harvard University's three-week Manufacturing Strategy conference.

Other issues on life cycle costs, details are available at **http://www.barringer1.com.**

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