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Abstract: We attempted to find a hard definition of what TCO really does address in terms of analysis. We looked into a number of commercial products to gain that definition, and intended to input data to detect potential differences between the results. Almost from the start we saw that all commercial models require different types of input data, and all have their own spin on TCO. Subsequently, we decided to define the type of data we thought would be suitable for TCO and built a simple representative spreadsheet analysis. For benchmark comparison we generated a standard financial model.

Total Cost of Ownership (TCO)

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Group Project Report
Total Cost of Ownership (TCO)

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INDEX

1. EXECUTIVE SUMMARY

The PC has become a required tool in all businesses but there is not, as yet, an established methodology to define and measure the total cost of operation. ISO standards have been set for most mass-used and mass-produced products, but ISO standards for PCs are incomplete. The TCO conventions, based primarily Sweden, have begun the process of quantifying standards, some of which are more rigid than those defined by ISO. But there seems to be a long way to go which leaves a current window of opportunity for various TCO SW developers and marketers, who all have independent definitions of what TCO is. It is wise for any potential purchaser of such SW to thoroughly understand all options before making a commitment to buy, or before employing a TCO consultation service.

2. INTRODUCTION

TCO seems to be the latest "buzz-word" in the computing world. Some see it as another spin on CQI (Continuous Quality Improvement) that will have its day and evaporate just as other corporate crazes came and went. CQI applied to anything anybody wanted but TCO is more focussed in that, at least for the moment, it is peculiar to PCs and the systems that relate to PCs. That is where the TCO confusion begins because some analysts would say that only defined costs are relative such as HW and SW, whereas other analysts would consider a more global model to be appropriate that includes everything from the purchase of a floppy disk to electrical costs, asset lost opportunity costs, downtime costs, hidden costs, or whatever else may seem pertinent at the time [1][7].

We attempted to find a hard definition of what TCO really does address in terms of analysis. We looked into a number of commercial products to gain that definition, and intended to input data to detect potential differences between the results. Almost from the start we saw that all commercial models require different types of input data, and all

have their own spin on TCO. Subsequently, we decided to define the type of data we thought would be suitable for TCO and built a simple representative spreadsheet analysis. For benchmark comparison we generated a standard financial model.

3. WHAT IS TCO?

Total Cost of Ownership (TCO) is a model that helps corporations understand direct and indirect costs associated with owning and using equipment or service throughout its lifecycles [G].

3.1 TCO Differs From Other Cost Approaches

TCO differs in two important ways from conventional financial analysis models that look at the cost of doing business with a supplier. First TCO looks into the broader spectrum of acquisition costs form a supplier [8]. Secondly, TCO attempts to look at a life cycle costs, which consider costs associated with using a given item from given supplier during the entire life of the item, including costs incurred once the item is in use. For example, for capital equipment, post-purchase costs involve everything from maintenance, repairs, downtime, and obsolescence through to the ultimate disposal of the asset. For a component or material, total cost includes failure costs of the item once in use, such as warranty claim costs, lost goodwill, replacement, and similar costs.

3.2 Benefits

TCO benefits may be grouped into five categories [H]: 1) Performance measurement 2) Decision Making 3) Communication 4) Insight/Understanding and 5) Support Continuous Improvement.

3.2.1 Performance Measurement

Performance measurement addresses the quantitative measurement of supplier performance. It includes such issues as supplier performance improvement /quality

improvement efforts; and provides a tool for benchmarking. In benchmarking, TCO data can be used to compare suppliers, or to track changes in a supplier's cost performance over time.

3.2.2 Decision Making

For the decision-making category, TCO forces the quantification of tradeoffs in terms of dollars. It also provides a good basis for supplier selection decisions, because it provides complete cost data on important cost issues. Thus, TCO creates more informed decision making, in a structured, systematic way.

3.2.3 Communication

TCO can also help improve both internal and external communications for purchasing activities. It provides solid data to suppliers regarding their performance. It also represents an important way to get others within the firm involved in purchasing decisions by quantifying data, or identifying relevant cost considerations.

3.2.4 Insight / Understanding

The TCO approach also provides important insights and deeper understanding into the true nature supplier performance. The information developed using TCO regarding a supplier's total costs can be used to track the supplier's costs over time, or to compare with other suppliers. TCO helps purchasing personnel develop an awareness of the significant nonprice factors that affect their firm in the case of certain buys [9]. This insight can help in negotiation, and in determining which "hidden" cost elements a supplier should provide, and which can be foregone or obtained more economically elsewhere. Finally, TCO provides a better understanding of purchasing decisions by taking a long-term, big picture approach. It looks beyond price to explore how purchasing activity affects the firm's total costs both today and in the future.

3.2.5 Continuous Improvement Initiatives

The last category includes benefits that specifically aim at supporting a firm's continuous improvement efforts. By identifying various critical cost elements and their values, TCO helps focus a supplier's efforts in specific areas. TCO also uncovers cost saving opportunities by highlighting large cost elements. Internally, TCO allows firms to gain an understanding of how their requirements (delivery, inventory, unique specifications, and so on) may actually increase costs of ownership.

3.3 TCO Standardization

Since the early '90s efforts have been made to standardize TCO. The 1992 Conference (TCO'92) focussed on display criteria and set up standards for the reduction of electrical and magnetic fields [11]. TCO labels became available that a supplier could apply to a product if criteria were met. TCO'95 was backed by four organizations - TCO (The Swedish Confederation for Professional Employees), Naturskyddsforeningen (The Swedish Society for Nature Conservation), NUTEH (The National Board for Industrial and Technical Development in Sweden) and SEMKO AB (an independent subsidiary of the British Inchape group). TCO'95 included the complete personal computer which includes the display, system unit and keyboard [12]. For TCO purposes, the term PC includes work stations, desktop and deskside computers, servers and Macintosh computers.

TCO'97 met in Singapore and focused on the ROI and Total Value of Ownership of a PC system, and looked into the value that IT provides to corporations through simplified enterprise computing [13].

TCO has primarily focussed on IT technical developments but the theme for TCO'99 will be the four "Es" – Ergonomics, Energy Requirements, Emission values and Ecology requirements [14]. Ergonomics addresses tighter certification requirements for luminance, contrast, flicker, etc., and will introduce noise standards. Energy requirements will include standby power restart requirements. Emissions address the acceptable values as defined in TCO'95, but will establish tighter parameters. Ecology

addresses the use of environmentally safe materials, i.e. plastics, painting, waste disposal, etc.

4. GENERIC TCO APPROACH FOR PERSONAL COMPUTERS

There are many commercial TCO SW packages and "best" methodologies that claim to have the edge on other TCO approaches for corporate PCs. The commonality between them is that a Life Cycle approach is taken such that the maximum number of direct and indirect costs are identified and subsequently quantified in terms of costs.

4.1 A Life Cycle Approach

To reduce TCO of the PC, methodologies look at the entire life cycle from planning based upon an organization's technology requirements, through to the management of the deployed hardware in terms of business policies and asset management. Thus, TCO for corporate PCs based upon a generic approach is divided in to four categories [5].

1. Planning and Acquisition
2. Deployment
3. Maintenance and user support
4. Management

4.1.1 Planning and Acquisition

In this phase of the PC life cycle, organizations plan for upcoming technologies and PC infrastructure enhancements and upgrades. Subsequent PC acquisitions follow these high-level plans and consist of developing vendor relationships that balance appropriate levels of service with appropriate pricing.

Planning: Technology planning, and capacity & architecture planning have a big effect on as organization's TCO. Technology planning consists of identifying the information technology (IT), and organization's goals and strategies. The plan should

address appropriate technology transitions in order to minimize the impact on the organization. Poor technology transition will catalyze problems: such as incompatibility, interoperability degradation, and inefficient connectivity that will ultimately raise the TCO.

Quantification of actual spending related to this category is highly subjective. However, proactive, coordinated planning that reduces complexity and improves efficiency will yield cost benefits. An effective best-business practice is to synchronize technology transitions with the technology road maps of primary vendors. Close coordination with vendors improves planning and can supply relevant technology at best market prices.

Capacity and architecture planning consists of planning the enterprise-wide hardware and software infrastructures, as well as related expansions and upgrades. Companies that do not plan for increased system requirements may experience a higher TCO.

Acquisition: Selecting Software and hardware vendors and negotiating pricing are in the acquisition process. The resources required to select hardware and software will be considerable, especially if this process is not well coordinated and streamlined. These resources include evaluation teams that are often formed to evaluate and choose vendors, as well as the resources required to manage vendor bids and proposals. A key component of acquisition costs is the quality of vendor relationships. A close relationship with the PC vendor during the bid, proposal, and evaluation processes can lower the TCO.

Leasing: A lease program serves as a tool to manage the TCO of PCs because the organization can get the direct financial benefits of leasing to lower the acquisition and disposal costs. Leasing also forces a more disciplined, life-cycle approach to acquiring, deploying, and disposing of PCs, and increases technology planning and management flexibility . For example, the regular equipment replacement cycle built into a lease contract allows organizations to upgrade hardware and take acquire technology upgrades on a predictable schedule. The result is more orderly technology transitions, lower migration costs, and reduced risk of hardware obsolescence. Leasing can be an

economic alternative to the volume purchases in the case that an organization wants to standardize its computing environment by establishing a standard platform.

In addition, by matching the lease term to the asset's useful life, payment streams are more closely tied to the leased system's utility. Finally, a well-designed leasing program will include asset management services, such as the disposal and re-marketing of used equipment at the end of the lease term, which minimizes the disposal costs and maximizes the residual value of the PC to the customer.

4.1.2 Deployment

Deployment encompasses the costs associated with putting new hardware and software into service, and includes disposing of older systems. Deployment begins with receiving the equipment that is then installed. Often, there is existing equipment on the user's desktop that must be disposed of or rotated to another user's desktop.

Project management techniques are an effective method for asset deployment because it provides a systematic and disciplined approach to deploying assets. The costs associated with project management should be considered in the TCO.

Freight and Receiving: The logistical processes required to receive and route equipment efficiently plays a key role in overall TCO. Vendors can help by marking packaging with the customer's purchase order or equipment serial numbers, thus reducing handling time in the receiving department. In addition, freight charges for expedited delivery service can be significant when equipment is not ordered with proper lead time. When applicable, volume discounts for freight and delivery charges can also assist in reducing the TCO.

System Installation: System installation refers to the costs associated with installing a PC, including installing and configuring hardware and software, and establishing a LAN connection. If the new system is replacing an older PC, user data must be transferred.

Many organizations reduce installation and configuration costs by purchasing systems pre-configured with appropriate hardware and software, so that they may be used upon receipt. This includes factory installation of standard software applications and

network interface cards (NICs), as well as more complex custom configurations. Moreover, vendor factory integration services for testing and validating configured systems can reduce user technical support costs [5].

The cost of performing high-volume installations (or employee moves) can be lowered by using outside service providers, thus freeing up internal IT staff to perform other value-added activities [7].

When a worker's PC is replaced, the older system is often transferred to another worker's desktop. This can add costs to the PC's TCO, because support costs for older systems are usually higher. They often require hardware upgrades to accommodate new software and operating system (OS) versions. In addition, it is difficult and expensive to retrofit older equipment with new hardware and software instrumentation intended to improve manageability.

Disposal: Retirement alternatives include equipment sale through a broker in the secondary market, employee sale, charitable contribution, or storage. A thorough cost/benefit analysis of the alternatives must take into account environmental and legal requirements for equipment disposal. Asset recovery service providers, which offer equipment pick-up, EPA-compliant recycling of waste materials, and erasure of electronic data from the systems, are an alternative method for asset disposal.

4.1.3 Maintenance and User Support

Both formal and informal maintenance and user support costs are generally cited as the highest TCO factor. They are the day-to-day maintenance and support activities that keep the PC hardware and software operational with up-to-date hardware components and software versions. They include the costs of training and user support, hardware and software maintenance, upgrades, and user operations.

Hardware and Software Maintenance and Upgrades: The costs for hardware and software represent a substantial percentage of the TCO equation. By standardizing the IT environment, maintenance and upgrade costs are significantly reduced. In addition, a growing number of automated tools are available to assess the current base of

software and hardware, so that upgrades are planned appropriately. Electronic software distribution tools automate software distribution over a network.

Managing software and OS licenses can be complex and expensive. Hardware manufacturers authorized as volume license resellers by leading software publishers can help. Maintenance contracts are available that enable customers to upgrade software applications and OSs, while maintaining up-to-date licenses.

On-site maintenance agreements with hardware vendors can be used to augment internal hardware maintenance staff. Vendor technicians, with specialized hardware expertise, can often service equipment more efficiently and can be scheduled during off-hours to minimize the impact on employee productivity.

User Operations: User operations range from data management and application development to less quantifiable informal learning and support. User operations seem to be the least understood and most difficult to measure, and contribute to the TCO. Often hidden in other costs, they remain unidentified and, consequently, unbudgeted. Informal training and support costs can be addressed by targeted formal training and technical support for users.

Another factor in the TCO is with the diverse array of PC tools that allow users to develop productivity tools themselves. Complex databases and spreadsheets are often developed on an ad hoc basis outside the usual project planning and control processes. It is important to define internal processes and budgets for such data management and application development projects in order to manage their cost. By prioritizing application development needs, an organization also ensures proper analysis of the costs and benefits of development projects.

Training: Effective user training lowers support costs [5]. The return on training investment can be measured by assessing whether user demands for both formal and informal assistance have been reduced. To determine this, an organization should identify the various types and numbers of support requests, as well as the types of employees requesting support. With this information companies can develop specific training programs. Such training is equally important for IT employees who provide help

desk support or perform maintenance functions. Organizations can leverage these training programs with vendor maintenance contracts and technical support.

Help Desk: Help desk support costs are largely determined by the level of software and hardware uniformity in the organization and the quality of user training. When desktop software and hardware configurations vary widely, the complexity of the environment leads to higher support costs. In addition, effective user training lowers the demand for help desk support.

Centralized help desks that use automated tools can aid in the control of costs by analyzing the types of requests made. In some cases, out-sourcing help desk support may be the best alternative.

4.1.4 Management

Management practices and policies coordinate and streamline the activities in each stage of the PC life cycle, including procurement, vendor contracts, software licensing and metering, technology migrations, and equipment maintenance. This is intended to highlight the importance of evaluating the costs associated with managing business processes. These costs vary depending upon an organization's structure, business policies, and internal practices.

5.0 COMMERCIAL TCO SW PACKAGES

We considered many TCO SW packages to use as a specific example. The Microsoft-Interpose product seems to be the richest, and most appropriate since it evaluates the cost of migrating from a specific PC platform to another, a subject that is a common thread in generic TCO discussions, and one that is applicable to any person or organization that owns a PC [3][4]. It should be noted that the following TCO example is for discussion purposes only, and is not presented as product endorsement.

5.1 Microsoft-Interpose vs. Other Models

IT decision making varies from company to company, with no standard methodology to assess issues. An Information Week survey of IS professionals indicated [6]:

"Although 80% of respondents thought a quantifiable evaluation of technology products was useful, 68% of those surveyed did not utilize a formal evaluation process in making technology purchasing decisions. Many indicated that quantifiable evaluation was not implemented because it was difficult to measure the true economic benefits of IT, there was a lack of accurate accounting of IT returns, and that there were no metrics to use for comparison". Thus we decided to pay more attention to Microsoft TCO calculator that seemed to be more comprehensive compared to others, i.e.

The *GartnerGroup* focuses on Total Cost of Ownership, but does not provide the tools to consistently measure the costs over time or consider the benefits of proposed projects when making decisions.

Models from *Giga Group* criticize a cost only approach to decision making and use costs, benefits, flexibility, and risk in a decision making model, but do not provide the tools necessary to implement.

To provide a method for IT decision making, Interpose has developed a business process improvement model for reducing the cost and increasing the value from IT investments. The Microsoft and Interpose TCO Model consists of the following two components that carry equal weight in the Microsoft-Interpose model and are equally important in the decision making process.

1) Total Cost of Ownership -the efficiency of the IS organization measured by the direct and indirect costs associated with owning, managing, supporting, and using Information Technology.
2) Economic Benefit - the incremental gains provided by the IS organization measured by the quantifiable, tangible efficiency, profitability and revenue gains that can be achieved by the proposed project.

These two categories are then sub-divided into more quantifiable measures -

1) Total Cost of Ownership

1.1.1 Hardware and Software - the capital expenditures and lease fees for new installations, upgrades, and updates.

1.1.2 Management - the network administrative staff performing network, system, and storage management and related outsourcing fees.

1.1.3 Support - the help desk expenses, training labor and fees, procurement and purchasing labor, travel time and fees, maintenance and support contracts, executive management labor, administrative labor, and overhead labor and fees.

1.1.4 Development - the labor and fees in infrastructure related application and content development, test, and documentation including new developments, customizations, and maintenance.

1.1.5 Communication - the fees for communication lease lines and server access charges.

1.2 Unbudgeted (Indirect) Expenses

1.2.1 End User IS Costs - the end user labor spent on peer and self support and casual learning.

1.2.2 Downtime - the lost wages from planned and unplanned outages

2) Economic Benefit

2.1 Increased Productivity - A measurable reduction in the time it takes for a user to do specific processes or tasks, resulting in a resultant gain in the time they can spend on knowledge oriented work, or a resultant reduction in headcount.

*Example: The new e-mail system provides a capability for on-line scheduling of meeting rooms and meeting coordination across team members. Currently, five administrative assistants spend 4 hours per week scheduling and coordinating meetings and meeting rooms. The new e-mail system can eliminate all dedicated meeting scheduling time, a savings of 4 hours per week * 5 administrative assistants * 50 weeks per year = 1000 hours per year. Because scheduling will still need to be performed by users, and not all of the saved time will be used productively, a percentage of the savings can be used in the decision making analysis.*

2.2 Organizational Efficiency - A measurable improvement in the collective processes and procedures utilized by the business. Typical organizational efficiency metrics include an increase in inventory turns, and reduction in requisite inventory. These should be quantified to business metrics, and translated as much as possible into the overall economic gain to the organization due to the improvement.

Example: A new inventory management system and electronic ordering system automatically tracks inventory and maintains the correct inventory levels, minimizing necessary inventory on hand. This reduction in inventory will save the company $1M per month in extra inventory that would be otherwise ordered using today's manual processes. The organizational efficiency gain is $1M per month.

2.3 Cost Avoidance - A measurable reduction in current or future spending, outside of the TCO model, particularly the elimination of fees and expenses or the elimination of a planned future expense.

Example: The new imaging system is projected to save document storage space. Currently 1,000 square feet are dedicated to hard-copy document archives, a month to month expense of $2,000. The hard copy documentation, and hence the warehouse space, could be eliminated with

the imaging system, and the cost of the month by month lease can be claimed as a benefit of the new system.

2.1 Revenue Gain - A measurable and directly attributable gain in business revenue, whereby the profit (revenue * profit margin) from the revenue gain can be viewed as a benefit of the new solution.

Example: A sales force automation system indicates that sales cycle times can be reduced by 20% on average through better team, time, contact, and opportunity management. Your team believes the 20% figure to be very achievable. The sales cycle has been measured and tracked to be 12 months per sales opportunity, each deal being $1M in revenue with $250K in profit on average. A total of 1 deal per month is expected to close this year and next year. By reducing the sales cycle time of 12 months by 20%, the revenue that is planned for the first two months of next year's first quarter can be moved to this year, a revenue gain of $2M, and a profit gain of $500K.

5.2 5 Steps in TCO Decision Making According to Microsoft-Interpose

The Total Cost of Ownership and Economic Benefits (Steps 1 and 2) above can only be measured after a starting point is determined. Microsoft-Interpose recommends the following 5 steps to acquire this baseline [6].

Step 1) Measure current Total Cost of Ownership and the current Business Benefit of the IT environment

- Current TCO = Direct Costs + Indirect Costs
- Business Benefit = Weighted Averages Rating (Capability + Competitive Advantage + Flexibility + Performance + Risk + Mitigation + Service)

Step 2) What projects should we consider for where we want to be?

- Compare the Current TCO to Industry Average TCO to determine where costs are higher and lower than average.
- Compare Business Benefits to Industry Average Business Benefits ranking to determine how business unit managers from other companies perceive IS meeting their needs.
- Generate a list of projects that reduce costs and increase business benefits (TCO Drivers = people, process, technology).

Step 3) What costs and savings are expected from the planned project(s)? Calculate a Return on Investment for the planned project, the tangible costs and benefits:

- ROI% = (TCO Savings + Economic Benefits) / Implementation Cost
- TCO Savings = Current TCO * Predicted Savings from Solution
- Economic Benefits = Increased productivity + Cost avoidance + Increased revenue

Step 4) What value will the planned project(s) deliver?

Calculate a Value Assessment for the planned project, a measurement of the on-going impact of the project on the business, factoring the annual TCO with the intangible Business Benefits of the solution:

- Value = TCO vs. Business Benefits

Step 5) Did we achieve our goals?

Measure TCO and Business Benefits on regular intervals to determine if projects are delivering projected benefits and value, identify issue, and document improvements.

Interpose Tools and Services

6. TCO ANALYSIS EXAMPLE / MODEL

We developed the cash flow statement to demonstrate the total cost of ownership of a personal computer system. This system consists of 10 windows 95-based computers. The financial data is divided into two categories -- investment costs, and the expense costs.

The Investment cost category contains

1. Hardware cost
2. Software cost
3. Installation cost (
    3.1 Freight and delivery
    3.2 Hardware setup
    3.3 Software installation

The expense category contains

1. Training cost
2. Support cost
    2.1. Help desk support cost
    2.2. Operation labor
    2.3. Operation fee
3. Downtime lost
    3.1. Planned
    3.2. Unplanned

The first example assumes a school administrator wants to purchase a computer system to use for academic work. Before the school administrator applies the TCO approach, the administrator considers only the cost of hardware, software, training, and installation. This case the net present value will be only $63,045.63.

The second scenario is when the school administrator applies the TCO approach which includes administrative costs such as downtime and helpdesk support. Cost data is as follows:

1. The cost of computer is $2,000 per unit
2. The cost of software is $11,300 for the whole system
3. The training cost is $27,357
4. The installation cost is $1,952
5. The help desk cost is $1,557
6. The operation labor cost is $4,595
7. The operation fees is $2,600
8. The planned downtime is $1,166
9. The unplanned downtime is $4,502

Note: The source of information is the software "Interpose TCO and ROI calculator."

The third scenario is when the school administrator applies the life cycle approach and standardizes the computer system. Furthermore, he selects a vendor who applies TCO concepts that are discussed above. The school could reduce the cost of the computer system as follows:

1. The cost of computer system is $2,000 per unit
2. The cost of software is $11,300 for the whole system
3. The training cost is $27,357
4. The installation cost is $1,500
5. The help desk cost is $128
6. The operation labor cost is $3,116
7. The operation fees is $1,886
8. The planned downtime is $1,166
9. The unplanned downtime is $2,476

Note: The source of the information is the software "Interpose TCO and ROI calculator."

Thus, at the 15% MARR, the net present value of the second case is $95,788.97, and the second case is $81,557.41. The approaches described above can reduce the TCO of this system about 14%..

SCENARIO 1

Year	0	1	2	3	4	5	6
Income Statement							
revenue		0.00	0.00	0.00	0.00	0.00	0.00
expenses							
Training	27357.00	0.00	0.00	27357.00	0.00	0.00	0.00
depreciation		4000.00	6400.00	3840.00	2304.00	2304.00	1152.00
tax income	(27357.00)	(4000.00)	(6400.00)	(31197.00)	(2304.00)	(2304.00)	(1152.00)
income tax	(10942.80)	(1600.00)	(2560.00)	(12478.80)	(921.60)	(921.60)	(460.80)
net income	(16414.20)	(2400.00)	(3840.00)	(18718.20)	(1382.40)	(1382.40)	(691.20)
Cash Flow Statement							
net income	(16414.20)	(2400.00)	(3840.00)	(18718.20)	(1382.40)	(1382.40)	(691.20)
depreciation	0.00	4000.00	6400.00	3840.00	2304.00	2304.00	1152.00
Investment Activities							
System							
Hardware	(20000.00)						
Software	(11300.00)			(11300.00)			
Installation	(1952.00)			(1952.00)			
salvage							1000.00
gains tax							400.00
A/T Net Cash Flow	(49666.20)	1600.00	2560.00	(28130.20)	921.60	921.60	1860.80

NPV	(63,045.63)
	1.15
MARR	0.15

SCENARIO 2

Year	0	1	2	3	4	5	6
Income Statement							
revenue		0.00	0.00	0.00	0.00	0.00	0.00
expenses							
Training	27357.00	0.00	0.00	27357.00	0.00	0.00	0.00
Support							
Help Desk		1557.00	1557.00	1557.00	1557.00	1557.00	1557.00
Operation Labors		4595.00	4595.00	4595.00	4595.00	4595.00	4595.00
Operation Fees		2600.00	2600.00	2600.00	2600.00	2600.00	2600.00
Downtime							
Planned		1166.00	1166.00	1166.00	1166.00	1166.00	1166.00
Unplanned		4502.00	4502.00	4502.00	4502.00	4502.00	4502.00
depreciation		4000.00	6400.00	3840.00	2304.00	2304.00	1152.00
tax income	(27357.00)	(18420.00)	(20820.00)	(45617.00)	(16724.00)	(16724.00)	(15572.00)
income tax	(10942.80)	(7368.00)	(8328.00)	(18246.80)	(6689.60)	(6689.60)	(6228.80)
net income	(16414.20)	(11052.00)	(12492.00)	(27370.20)	(10034.40)	(10034.40)	(9343.20)
Cash Flow Statement							
net income	(16414.20)	(11052.00)	(12492.00)	(27370.20)	(10034.40)	(10034.40)	(9343.20)
depreciation	0.00	4000.00	6400.00	3840.00	2304.00	2304.00	1152.00
Investment Activities							
System							
Hardware	(20000.00)						
Software	(11300.00)			(11300.00)			
Installation	(1952.00)			(1952.00)			
salvage							1000.00
gains tax							400.00
A/T Net Cash Flow	(49666.20)	(7052.00)	(6092.00)	(36782.20)	(7730.40)	(7730.40)	(6791.20)

NPV	(95,788.97)
	1.15
MARR	0.15

SCENARIO 3

Year	0	1	2	3	4	5	6
Income Statement							
revenue		0.00	0.00	0.00	0.00	0.00	0.00
expenses							
Training	27357.00	0.00	0.00	27357.00	0.00	0.00	0.00
Support							
Help Desk		128.00	128.00	128.00	128.00	128.00	128.00
Operation Labors		3116.00	3116.00	3116.00	3116.00	3116.00	3116.00
Operation Fees		1886.00	1886.00	1886.00	1886.00	1886.00	1886.00
Downtime							
Planned		1166.00	1166.00	1166.00	1166.00	1166.00	1166.00
Unplanned		2476.00	2476.00	2476.00	2476.00	2476.00	2476.00
depreciation		4000.00	6400.00	3840.00	2304.00	2304.00	1152.00
tax income	(27357.00)	(12772.00)	(15172.00)	(39969.00)	(11076.00)	(11076.00)	(9924.00)
income tax	(10942.80)	(5108.80)	(6068.80)	(15987.60)	(4430.40)	(4430.40)	(3969.60)
net income	(16414.20)	(7663.20)	(9103.20)	(23981.40)	(6645.60)	(6645.60)	(5954.40)
Cash Flow Statement							
net income	(16414.20)	(7663.20)	(9103.20)	(23981.40)	(6645.60)	(6645.60)	(5954.40)
depreciation	0.00	4000.00	6400.00	3840.00	2304.00	2304.00	1152.00
Investment Activities							
System							
Hardware	(20000.00)						
Software	(11300.00)			(11300.00)			
Installation	(1500.00)			(500.00)			
salvage							1000.00
gains tax							400.00
A/T Net Cash Flow	(49214.20)	(3663.20)	(2703.20)	(31941.40)	(4341.60)	(4341.60)	(3402.40)

NPV	(81,557.41)
	1.15
MARR	0.15

7. EXPLANATION OF VARYING RESULTS

Results vary amongst TCO analyses, and between TCO methodologies and conventional financial analysis techniques. The type of data used in TCO is highly subjective to what the analyst decides is pertinent. There is no agreed upon methodology within the industry to establish what is correct or incorrect. Our three scenarios show the level of subjectivity in terms of TCO modeling.

To further emphasis this we found an example where four companies prominent in TCO SW usage were asked to analyze PC costs. Responses varied based upon the SW package employed. All had unique definitions of which costs were direct or indirect, or what activities should or should not be included in the analysis. The companies were asked to analyze the annual cost of ownership (ACO) for a Windows 95 package and hardware [14]:

> Gartner Group Inc. -- $9,784 for networked Windows 95 PC, $6,010 for Java workstation, $7,267 for Microsoft/Intel NetPC. This analysis did not include opportunity costs, useful life, or risk factors.
>
> Forrester Research Inc. – Annual Cost of Ownership was not provided, however, the annual cost of support was calculated as $2,680 for a networked Windows 95 PC, $800 for a Java Workstation, $1,480for Microsoft/Intel NetPC. Forrester did not provide ACO data because not enough data exists that compares NCs to PCs.
>
> Zona Research Inc. -- $2,859 for networked Windows 95 PC with NT server, $1,231 for Boundless Technologies NC with WinFrame Server, based on five-year TCO for 15 PCs ($214,411) vs. 15 Boundless Technologies NCs ($92,292.
>
> Giga Information Group – TCO results were not returned because Giga does not see TCO analysis as an appropriate tool for investment decisions based exclusively on the potential cost of reduction

8. CONCLUSION

TCO has two branches – first is the standardization of physical aspects of the PC as outlined in TCO'92, TCO'95. These address areas such as electrical fields, magnetic fields, power requirements and safety requirements. TCO'99 while continuing to focus on these operational parameters, will also set standards for the manufacture of PCs that aim at environmentally friendly production regarding plastics, components and recycling. This branch of TCO is not company specific and appears to have benefits for PC users and for the PC production industry.

TCO'98 addressed the industry's second leg – the economic quantification in terms of the ROI of a PC system. This area is at the moment undefined. Many SW companies are developing their own definitions but none are consistent with the other. When trying to find clear definitions we hit a commercial barrage of companies ready to sell their SW packages, but their baseline equations were not available for us to make comparisons.

We feel that for the moment the best tool for PC cost evaluations is via conventional engineering economic analysis [10]. This allows the analyst to identify and quantify elements that he feels are most critical to the his financial /operating environment and thus accuracy is available based upon the competence of the analyst. The use of today's commercial TCO packages is dangerous because they seem to be biased toward marketing more of their own products, and less interested in providing a objective service for their customers.