DETERMINING REQUIREMENTS AND SPECIFICATIONS OF ENTERPRISE INFORMATION SYSTEMS FOR PROFITABILITY

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Abstract: A company's profits may be defined as the positive difference between its income revenues and operational costs. Today, most companies use traditional costing methods and/or traditional Activity-Based Costing (ABC) to determine their operational costs with a view to direct operational and business process changes so that profits are realized. A tripartite approach is presented towards determining requirements and specifications of enterprise information systems for profitability (EISP). In the first part, an understanding of the nuances of traditional costing and ABC as is currently practiced in enterprises is presented to point the shortcomings of these current costing practices. The second part provides a case study that vividly demonstrates the problems in the current costing methods and clearly points their inadequacies towards profitability. The third part presents a framework for the specifications of enterprise information systems for profitability through ontology-based enterprise modeling, EABEM and Temporal-ABC for the attainment of improved knowledge about costs.

1 INTRODUCTION

A company's profits may be defined as the positive difference between its income revenues and operational costs. Today, most companies use traditional costing methods and/or traditional Activity-Based Costing (ABC) to determine their operational costs with a view to understand and direct operational and business process changes so that profits are realized.

If Enterprise Information Systems for Profitability (EISP) are to be developed, first, the determination of requirements and specifications for such systems must be based upon a clear understanding of current costing methods and the shortcomings of such methods towards profitability.

Second, achieving systemic profitability must begin with improved knowledge about costs. From production floor worker, to office clerk and administrator, to chief executive officer – there must be actionable and unambiguous cost knowledge to guarantee a superior return on capital investments, to ensure fewer operational mistakes, to make better use of resources, and to ensure profit generation. These challenges are interdependent and evolving operational problems that enterprises need to solve on an ongoing basis towards achieving systemic profitability. Thirdly, one way to effectively access and share information towards costs of products, services, processes and systems of an enterprise is to represent and reason about costs using ontology-based enterprise models [Kosanke, 1997].

A tripartite approach towards determining requirements and specifications for EISP is presented. In the first part, an understanding of the nuances of traditional costing and ABC as is currently practiced in enterprises is presented to point the shortcomings of these current costing practices. The second part provides a case study that vividly demonstrates the problems in the current

[1] EABEM is a trademark of Nulogy Corporation.
[2] Temporal-ABC is a trademark Nulogy Corporation.

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costing methods and clearly points their inadequacies towards profitability. The third part presents a framework for the specifications of enterprise information systems for profitability through ontology-based enterprise modeling, EABEM, and Temporal-ABC for the attainment of improved knowledge about costs.

2 EXPLAINING THE NUANCES OF TRADITIONAL COSTING AND ABC

Traditional costing systems use volume-driven allocation bases such as direct labour hours, direct machine hours, direct labour dollars, direct material dollars, and sales dollars as the primary means of assigning organizational expenses and overheads to individual products, services and customers. However, many of the resource demands by individual products and customers are not proportional to the volume of units produced or sold. Thus, traditional cost systems do not measure accurately the costs of resources used to design, to produce, to sell and to deliver products to customers.

In general, according to Cooper [1988a][1988b] and Kaplan [1988], *the apportionment of indirect and overhead costs to products and service products based on volume related units such as direct labour or machine hours according to traditional or conventional cost systems provide irrelevant costs for decision making and for the determination of product or service profitability.*

Kaplan and Cooper of Harvard Business School developed the ABC Principle as an approach to product or service costing as a means to overcoming some of the problems with traditional costing systems. These problems are exacerbated in that existing enterprise modeling frameworks provide a modeling infrastructure that tend to support traditional cost systems [Tham & Fox, 1998].

The traditional ABC Principle includes the assignment of costs to activities based on their use of resources, and the assignment of costs to "cost objects"[3] based on their use of activities [Cokins, 2001]. Since ABC assigns costs to activities based on their use of resources, the logical formulation of ABC *must* be premised upon the existence of some given or identifiable costs of resources.

Nothwithstanding this obvious rationale, the fundamental question then that begs to be asked at the macro level is :- "From where and how does one get the costs of resources for ABC?" At the more micro level, and definitely from an ABC implementation perspective, two fundamental questions arise relevant to ABC:- (i) What unit resource costs are associated with a resource? (ii) How does one deduce unit resource cost(s) so that direct, indirect and overhead costs are accounted for within the costs of a resource?

According to the ABC concept, costing of cost objects proceeds with the assignment of cost to activities based on their use of resources, and the assignment of costs to cost objects based on their use of activities. First, the question is: *From where and how does one get the costs of resources for ABC?* Second, ABC emphasizes *the need to obtain a better understanding of cost behaviour and thus ascertain what causes the overhead costs*. However, towards solving the question and fulfilling this need, there are some problems that influence the feasibility of ABC being applied to enterprises.

Let us examine the current costing process in ABC as is done in existing ABC related softwares. ABC is typically accomplished in a two stage process. In the first stage, the cost assignment of resources to an activity is accomplished through a resource cost assignment phase through "resource drivers". In the second stage, the cost assignment of activities to cost objects is accomplished through "activity drivers". A resource driver is a measure of an activity's resource consumption. It is used to determine the portion of the total cost assigned to each activity that uses the resources. Resource drivers take cost from the general ledger and assign it to activities. An activity driver is a factor used to assign cost from an activity to a cost object. Activity drivers are the mechanisms for assigning the costs of activities to products. An activity driver is a measure of the frequency of activity performance and the effort required to achieve the end result. In short, various factors referred to as resource drivers, are used to assign cost to activities; whereas activity drivers are methods for assigning the cost of activities to cost objects.

Besides contending with the confusing selection of resource drivers and activity drivers, the current ABC user must also contend with the concept of "cost drivers". Cost drivers are associated with the *input* of activities towards cost objects. Cost drivers are supposed to reflect what causes an activity to be

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[3] Within the ABC literature, the term "cost objects" refers to the reasons for which activities are performed in enterprises. Products, services, and customers are considered cost objects as they may be the reasons why activities are performed.

performed and what causes the cost of performing the activity to change. An ABC system achieves improved accuracy in estimation of costs by using multiple cost drivers to trace the cost of activities to the products associated with the resources consumed by those activities. Hence, this leads to an ABC user involved in an "art" towards ABC implementation rather than a "science". The "art" attempted involves making two separate but interrelated decisions about the number of cost drivers needed and which cost drivers to use. The "art" gets further confusing because the cost drivers selected changes the number of resource drivers and activity drivers needed to achieve a desired level of accuracy.

In summary, the current state of the "art", or perhaps, better stated as the problems in ABC implementations today have led to the following conclusions:-

1. Based upon the "artful" selection of cost drivers, resource drivers and activity drivers, "overhead and indirect costs" get allocated and included into the cost of a cost object through cost pools.
2. According to the Armstrong Laing Group [Armstrong, 2002]:- *"One of the most difficult parts of ABC implementation is the identification and selection of suitable drivers…..you need to be open to the idea that you may have to change your assumption about driver assignment, and so choose a solution that allows this easily."*
3. According to Babad & Balachandran [1993]:- *"An ABC system achieves improved accuracy in estimation of costs by using multiple cost drivers to trace the cost of activities to the products associated with the resources consumed by those activities. In this respect, a cost driver is an event, associated with an activity, that results in the consumption of the firm's resources."*
4. According to Cooper [1988a][1988b]:- *"The art of designing an ABC system can be viewed as making two separate but interrelated decisions about the number of cost drivers needed and which cost driver to use. These decisions are interrelated because the type of cost drivers selected changes the number of drivers required to achieve a desired level of accuracy."*
5. Due to the increasing costs of overheads, current ABC softwares and implementations use cost pools for overheads drawn from the traditional General Ledger cost accounting systems for the allocation of overheads to products and services. However, according to Gary Cokins [1996]: "*In effect, traditional general ledger cost accounting systems act like thick cloud covers. The clouds prevent any observation, and eventual understanding, of the locations and rates at which the enterprise uses resources to enable the creation of value or to actually create value for customers."*

The aforementioned statements express a need to operationalize the cost assignment with better consistency, better accuracy, better traceability of "overheads and indirect costs", and less ambiguity. With regard to ambiguity, notice the confusing usage of terms – *resource driver, activity driver, cost driver, event* and *drivers.*

Given that there can be several different resource drivers and activity drivers, the cost of the activity is only as good as a resource driver, and the cost of the cost object is only as good as an activity driver. This inconsistent costing situation is further aggravated depending upon cost driver selections, which in turn, influences resource driver and activity driver selections. Indeed, a sorry state of affairs – ABC, as a means to a more accurate and consistent cost system for better decision making, has been basically reduced to the confusing art of driver selections!

3 CASE STUDY: TRADITIONAL COST ACCOUNTING (TCA) VERSUS (TRADITIONAL) ABC

Traditional Cost Accounting (TCA) and traditional ABC as implemented and practiced today is applied to the following company data to vividly illustrate the inadequacies of TCA and traditional ABC in a company's quest towards profitability.

Company X Data:-

- Produces 100 units of product A and 500 units of product B for year
- Direct labour for product A is 3 hours and for product B is 2 hours
- Labour cost is \$20 per hour and total labour hours is 2000 hrs per year
- Total overhead cost per year is \$100,000
- Cost of overhead (O/H) = \$100,000/2,000 hrs = \$50/hour
- Activities required for each of products A and B are:- *Setup, Machining, Receiving, Packing, Engineering*

TCA in Company X

	Product A		Product B	
		Cost/unit		Cost/unit
Direct Labour	3 hours/unit		2 hours/unit	
Material used	5 lbs/unit		8 lbs/unit	
Labour cost @ $20/hour		$ 60		$ 40
Material cost @ $10/lb		$ 50		$ 80
O/H cost allocated @ $50/hour of labour		$150		$100
Total		**$260**		**$220**

ABC in Company X

Activity (Cost Driver)	Allocated O/H Cost ($)	Resource Driver	*Product A*	O/H Cost $ allocated	*Product B*	O/H Cost $ allocated
Set-Up	10,000	# of Setups	1	2,500	3	7,500
Machining	40,000	Machine hours	100	2,000	1,900	38,000
Receiving	10,000	# of receipts	1	2,000	4	8,000
Packing	10,000	# of deliveries	2	4,000	3	6,000
Engineering	30,000	# of engineering changes	4	12,000	6	18,000
Total	100,000			22,500		77,500
Activity Driver: annual demand units			100 units		500 units	
Overhead allocated			$22,500/100 units = $22.50/unit		$77,500/500 units = $155.00/unit	
Direct Labour Cost			$60.00/unit		$40.00/unit	
Direct Material Cost			$50.00/unit		$80.00/unit	
ABC cost per unit			**$132.50/unit**		**$275.00/unit**	

ABC in Company X with Resource Driver Changes

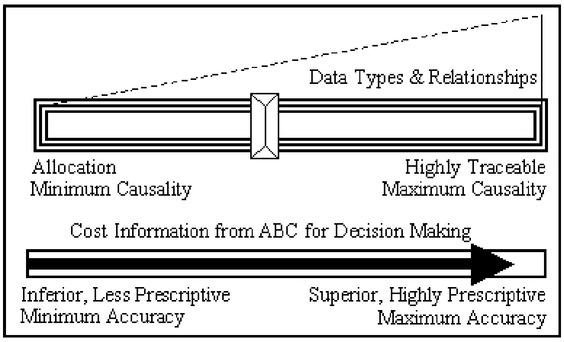
Activity (Cost Driver)	Allocated O/H Cost ($)	Resource Driver	*Product A*	O/H Cost $ allocated	*Product B*	O/H Cost $ allocated
Set-Up	10,000	*Set-up hours**	70	7,000	30	3,000
Machining	40,000	Machine hours	100	2,000	1,900	38,000
Receiving	10,000	# of receipts	1	2,000	4	8,000
Packing	10,000	# of deliveries	2	4,000	3	6,000
Engineering	30,000	*Engineering hours**	600	18,000	400	12,000
Total	100,000			33,000		67,000
Activity Driver: annual demand units			100 units		500 units	
Overhead allocated			$33,000/100 units = $33.00/unit		$67,000/500 units = $134.00/unit	
Direct Labour Cost			$60.00/unit		$40.00/unit	
Direct Material Cost			$50.00/unit		$80.00/unit	
ABC cost per unit			**$143.00/unit**		**$254.00/unit**	

***Note:-** The resource driver - # of Setups – of Table 2 is changed to Set-up hours in Table 3; and the resource driver - # of engineering changes – of Table 2 is changed to Engineering hours in Table 3. These resource driver changes in Table 3 provide better traceability and causal information linking resource consumption by activities that output Product A and Product B.

4 CASE STUDY CONCLUSIONS

1. Significant differences in cost per unit for Product A and Product B are seen by comparisons of Table 1 versus Table 2, and Table 1 versus Table 3. In short, significant differences in cost per unit for Product A and Product B have resulted by the application of Traditional Cost Accounting (TCA) for Table 1 versus Traditional Activity-Based Costing (ABC) for Tables 2 and 3. More importantly, the ABC results from Table 2 and Table 3 provide superior cost information for profit improvement relative to the cost information provided in Table 1.
2. On the other hand, by comparing Table 2 and Table 3, significant differences in cost per unit for Product A and Product B have resulted due to the *mere* changes in resource drivers of Table 2 to those of Table 3, notwithstanding the fact that ABC has been applied to both tables. More importantly, the ABC results of Table 3 are more accurate and superior for profit improvement relative to the ABC results of Table 2. The less accurate cost assignment by allocation in Table 2 due to minimal causal data, has shifted to the more accurate traceable cost assignment of Table 3 due to better traceability and causal data changes of Table 3. In short, the accuracy of cost assignment in ABC and the value of cost information for decision making varies according to the degree to which one can establish causal and traceable data types and relationships (refer Figure 1).

Decision Making with Cost Information from ABC



5 REQUIREMENTS FOR EISP

As illustrated in Figure 1, as data types and relationships represented by the volume control button, "slide" from being mere allocation with minimal causality towards being highly traceable with maximum causality, the decision making information from ABC correspondingly changes from being, inferior, less prescriptive with minimum accuracy, to becoming superior, highly prescriptive with maximum accuracy.

Owing to lack of overhead cost traceability and hence its accountability, companies attempting to implement ABC form overhead cost pools for allocation to activities. Too often, different types of costs are combined into one diffused overhead pool, so cost object costs are often grossly distorted due to allocation. Tracing enables one to assign costs based on specific data, whereas allocation from pools often involves indirect assignment of costs to activities.

In short, EISP must be based upon enterprise data types and relationships that have properties and/or attributes that are highly traceable and exhibit maximum causality for their existence. If such data types and relationships are deployed in EISP, our case study vividly illustrates that cost information generated from the application of ABC tends to be superior, highly prescriptive and maximally accurate.

6 SPECIFICATION FRAMEWORK FOR EISP

It is proposed that an ontology-based enterprise model should form the specification basis for EISP. First, by doing so, the design issues of enterprise modeling can be overcome. Secondly, enterprise-wide strategic intelligence is promoted. Thirdly, an ontology-based enterprise models can provide a superior generic modeling infrastructure towards enterprise profitability through the support of highly traceable, maximally causal data types and relationships in all enterprises.

According to Fox & Gruninger [1998]:-

"An *Enterprise Model* is a computational representation of the structure, activities, processes, information, resources, people, behaviour, goals and constraints of a business, government, or other enterprise. It can be both descriptive and definitional spanning what is and what should be. The role of an enterprise model is to achieve model-driven enterprise design, analysis and operation.

From a design perspective, an enterprise model should provide the language used to explicitly define an enterprise……

From an operational perspective, the enterprise model must be able to represent what is planned, what might happen, and what has happened. It must supply the information and knowledge necessary to support the operations of the enterprise, whether they be performed manually or by machine. It must be able to provide answers to questions commonly asked in the performance of tasks."

To represent and reason about costs using an enterprise model, the model should be descriptive, i.e., it should represent key entities, structures and concepts needed to describe the enterprise's activities, resources, products, information flows and costs.

The model should also be prescriptive. It should be possible to prescribe the costs of activities, resources and products of an enterprise using this model.

A number of issues exist concerning the design of enterprise models [Fox & Grüninger, 1998]. The issues are:-

1. Reusability: it is concerned with the large cost of building enterprise-wide data models. Is there such a thing as a generic, reusable enterprise model whose use will significantly reduce the cost of information system building?
2. The consistent usage of the model: given the set of possible applications of the model, can the model's contents be precisely and rigorously defined so that its use is consistent across the enterprise?
3. Accessibility: given the need for people and other agents to access information relevant to their role, can the model be defined so that it supports query processing so that answers to common queries in an agent's domain, e.g., costing and profitability, may be obtained.
4. Selectivity: how does one know which is the right Enterprise Model for one's application?

An *ontology* is a data model that "consists of a representational vocabulary with precise definitions of the meanings of the terms of this vocabulary plus a set of formal axioms that constrain interpretation and well-formed use of these terms" (Campbell & Shapiro, 1995).

The goal of ontology-based enterprise modeling is the implementation of an environment that supports the modeling and design of enterprises. To support this, ontological engineering deals with the design and evaluation of a shareable representation of knowledge that minimizes ambiguity and maximizes understanding and precision in communication in an enterprise. The product of ontological engineering is an ontology and/or micro-theory. An ontology is a formal description of enterprise objects, properties of objects, and relations among such objects. A micro-theory, however, is a formal knowledge required to solve a problem in a domain (e.g., costing, quality) or describes a subset of the domain in detail (e.g., ISO 9000 compliance as a subset of quality). A micro-theory is separate from, but constructed upon an ontology.

Vocabulary, definitions, and axioms that describe the enterprise are formally represented using ontologies, and prescriptions for achieving goals are formally defined using ontology representations. Tham [1999] formalizes enterprise activity-based costing, and prescribes to strategic cost management. Parts of these models can be shared and re-used by others with minimized interpretation ambiguity because they are modeled formally.

The business environment of an enterprise is defined by activities, resources, markets, customers, products, services, regulations and costs associated with the enterprise. *Strategic intelligence* is what a company needs to know of its business environment to enable it to gain insight into its present processes, anticipate and manage change for the future, design appropriate strategies that will create business value for customers, and improve profitability in current and new markets. Therefore, an ontology based enterprise model can provide an explicit knowledge representation infrastructure of shared understanding (Gruber, 1993) to promote strategic intelligence that guarantees profitability.

There is a distinction between a language and *knowledge representation*. A language is commonly used to refer to means of communication among people in the enterprise. Representation refers to the means of storing information (aka knowledge) in a computer (e.g. database). A representation is essentially a set of syntactic and semantic conventions that enables one to form a knowledge repository or database in a computer for usage by various agents in a distributed systems environment. The set of syntactic conventions specify the form of the notation used to express descriptions of the knowledge entities. The set of semantic conventions specify how expressions in the notation correspond to the entities described. With the proliferation of computer based distributed systems, enterprises can make significant gains towards data traceability and causality through the direct communication of various enterprise processes (aka agents) with one another. Consequently, the representation of knowledge becomes the language of communication for enterprises.

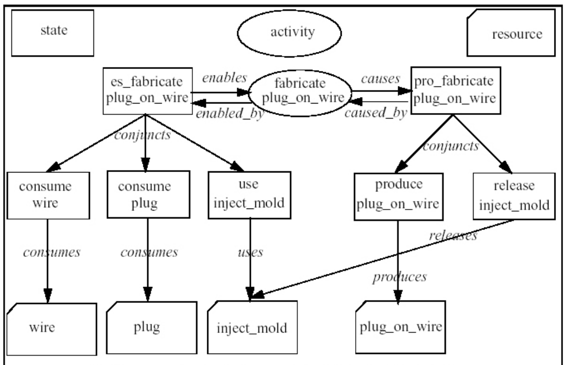
7 ENVELOPED ACTIVITY-BASED ENTERPRISE MODEL (EABEM) AND TEMPORAL-ABC

The motivation towards the research and development of EABEM and Temporal-ABC is based, first, upon the practical and implementation needs towards solving the fundamental macro level question in ABC as stated in Section 2 – "From where and how does one get the costs of resources for ABC?" Secondly, as demonstrated in the previous section, there is need to give every consideration to enterprise data, i.e., enterprise-wide information and knowledge, to be represented with maximum traceability, maximum causality, high consistency and minimal ambiguity for the eventual goal of obtaining highly accurate and prescriptive cost information to support decision making towards profitability.

Ontologies by design are constructed from existing ontologies. For example, Kim's [1999] and Tham's [1999] ontologies for quality and costs respectively are developed using ontologies of activity, state, causality, time, resource, and organizational structure that describe fundamental concepts about an enterprise. These are collectively called the TOVE Core Ontologies (Grüninger & Fox, 1995).

Enterprises are action oriented, and therefore, the ability to represent action lies at the heart of all enterprise models. In TOVE, action is represented by the combination of an activity and its corresponding enabling and caused states. An activity is the basic transformational action primitive with which processes and operations can be represented.

Activity-State Resource Cluster



** This example illustrates an Object-Oriented Model of Activity, States, Causality, Time, and Resources

An activity specifies a transformation of the world. Its status is reflected in an attribute called status. The domain of an activity's status is a set of linguistic constants:-

- Dormant – the activity is idle and has never been executing before.
- Executing – the activity is executing.
- Suspended – the activity was executing and has been forced to an idle state.
- ReExecuting – the activity is executing again.
- Completed – the activity has finished.

A state in TOVE represents what has to be true in the world for an activity to be performed. An enabling state defines what has to be true of the world in order for the activity to be performed. A caused state defines what will be true of the world once the activity has been completed. An activity along with its enabling and caused state is called an activity state cluster or simply activity cluster. The activity-state resource cluster (Fig. 2) is the nucleus in building EABEM.

States associate resources with activities through the four types of states which reflect the four ways in which a resource is related to an activity – *use, consume, release, produce*. The status of a state, and any activity, is dependent on the status of the resources that the activity uses or consumes. All states are assigned a status with respect to a point in time. There are four different status predicates:-

- Committed – a unit of the resource that the state consumes or uses has been reserved for consumption.
- Enabled – a unit of the resource that the state consumes or uses is being consumed.
- Disenabled – a unit of the resource that the state consumes or uses has become unavailable.
- Reenabled – a unit of the resource that the state consumes or uses is re-available.
- Completed – unit of the resource that the state consumes or uses has been consumed or used and is no longer needed.

EABEM represents the enterprise-wide infrastructure for representation of information and knowledge such that various domains of interests like cost management, performance measurement, quality, etc., can be supported in the enterprise. A formalized schema for EABEM may be represented as follows:-

- $E \equiv [\Sigma_{\text{internal resources}} \cap (\xi_{sig})] \cup [\Sigma_{\text{external resources}} \cap (\xi_{sig})] \cup [\Sigma_{\text{activities}} \cap (\eta_{sig})] \cup [\Sigma_{\text{frontier activities}}]$

where

- $[\Sigma_{\text{internal resources}} \cap (\xi_{sig})]$: the set of sentences defining significant internal enterprise resources,
- $[\Sigma_{\text{external resources}} \cap (\xi_{sig})]$: the set of sentences defining significant external resources (aka as frontier resources) to the enterprise,
- $[\Sigma_{\text{activities}} \cap (\eta_{sig})]$: the set of sentences defining significant activities of the enterprise,
- $[\Sigma_{\text{frontier activities}}]$: the set of sentences defining the enterprise frontier activities (aka as boundary activities that representationally envelope or surround the enterprise). Hence, the coining of the term Enveloped Activity Based Enterprise Model – EABEM.

To overcoming the shortcomings of current practices based upon traditional ABC, the Principle of Temporal-ABC states:-

- A cost object, i.e., a product or service, is the reason why activities are performed.
- The assignment of costs to activities is based upon their requirements of resources and the possible changing temporal states of those resources, thereby resulting in temporal costs for activities.
- The cost of a cost object is based upon the temporal costs of activities that produce it.

8 CONCLUDING REMARKS

This paper explains the nuances of traditional costing and traditional ABC methodologies and points to the inadequacies of these methodologies towards profitability. Applications of these methods to a case study, aptly demonstrates that companies can unwittingly stray away from the profitability path due to the inferior and incomplete knowledge about product and service costs produced by these methodologies. From a systems and information engineering perspective, the case study provides evidence for the requirements criteria of high traceability and maximum causality of data types and relationships for EISP. Finally, a specification framework for EISP is presented that is founded upon ontology based enterprise modeling, EABEM and the Principle of Temporal-ABC.

If profits are to be realized, companies urgently need to closely question and examine their current cost management practices towards profitability. The situation is further exacerbated as companies throw millions of dollars and countless human resource hours in the deployment of enterprise planning systems that incorporate the inadequate costing methodologies discussed in this paper.

In the hope that the terms and fundamental philosophies of the Sarbanes-Oxley Act are embraceable [Gartner, 2003], the following quote serves best as a practical and real motivation for adopting "change thinking" towards profitability:-

"Complying with the legal requirements of Sarbanes-Oxley is one thing; complying with the spirit of the Act is another. The fundamental message of the Act is that CFO's and boards need to know their businesses better. To comply with the Act, organizations will need to ensure that their senior finance managers really understand what drives their increasingly complex and diverse operations, and are constantly attuned to any changes that impact financial reporting and business performance." [Armstrong, 2003]

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