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Application of Computer-Assisted Techniques to Indirect Cost Identification and Reduction

abstract

This is a description of how two organizations, JPL and Bell Helicopter Textron, have utilized new techniques for manufacturing cost analysis. Both are computer-aided and offer new methodologies to engineers evaluating existing operations or designing new manufacturing processes. SAMIS, developed by JPL, is a ground-up look at new processes. It has value in evaluating new technology, evaluating prices of current and new products, and in the development of cellular manufacturing. Bell's Economic Assessment Model takes a top-down, functional view of costs throughout the company. It identifies cost drivers and helps prioritize projects to improve cost performance.

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Models
Cost Analysis
Economic Analysis
Simulation

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Reduction of cost in manufacturing continues to be a major challenge for managers and engineers. Recent acceleration of growth in the application of computer-aided techniques, in particular, has increased the challenge for economic assessment of the impact of modernization and cost reduction efforts. An accelerating trend has been the shift of total cost from "direct" cost to "indirect" cost. This is illustrated in Exhibit 1.

Unfortunately, the practice of cost accounting has not kept pace with the needs of engineers and managers in making economic assessments of modernization opportunities. Especially troublesome is the struggle that managers are now experiencing with developing concepts for the "integrated" factory. A substantial body of new knowledge and technology now exists, ready to go to work in their country's factories. However, the traditional engineering approach is inhibiting the application of these technologies.

This traditional approach generally looks at the lowest level of costs, often that of direct labor. Optimization occurs at the process level resulting in a string of optimal islands but a less than optimal whole. Another obstacle is the lack of or failure to communicate corporate strategy and the role of manufacturing in that strategy. Thus, the engineer's activities are relegated to the sole purpose of cost reduction with only coincidental application to the fulfillment of the organization's overall strategy.

What is needed are new links of communication and analytical tools that will accomplish four tasks. These are the following:

- Ensure that cost reduction efforts tackle the whole job, not just a part of it. This includes the burgeoning areas of capital, overhead, G&A and material costs.

- Improve interfunctional communications between engineers, senior management, and financial staff. This will probably be the language of numbers since all these groups will not be on an equal footing from a technology point of view. Meaningful numbers will be the catalyst to start the capital dollars flowing that will enable the engineer to do the difficult job of modernization better.

- Demonstrate what is possible from factory integration. The relationship between functions and different cost contributors is often hidden. Management should have a better view of what the cost and performance of the factory might be if started from the ground up. This model can serve as an ambitious target for improvement in current operations.

- Increase manufacturing's role in developing corporate strategy. Manufacturing improvement will be an increasingly important factor in strategy development. Manufacturing will cease to play only a passive role, and the sooner it can adapt to this more activist position, the better.

To deal with this situation, Jet Propulsion Laboratory and Bell Helicopter developed two distinct methodologies to serve their programs for development of new technology and cost performance improvement. This paper provides an overview of these two case studies.

THE SAMIS MODEL

JPL manages the Flat-Plate Solar Array Project (FSA) for the Department of Energy. This ambitious program has the goal of developing processes for manufacturing solar cells that will make these cells a competitive source of energy. JPL funds and manages research in a multitude of projects with individual contractors. To measure progress, JPL must assess whether the contractors' efforts are helping to reach the cost-reduction goal.

When it asked contractors to estimate the cost of their processes, JPL found many problems with the responses. First, assumptions differed on such factors as inflation rates, cost of materials, and the application of overhead. Second, many contractors would not include profit in their cost estimates. This omitted the necessary return on investment to account for the cost of capital.

A third problem dealt with the actual processes being developed. In many cases, it was difficult to determine what assumptions were made regarding availability of equipment, yields of processes, and assumptions regarding traditional indirect functions like rework, material handling, and so forth.

To remedy this situation, JPL developed SAMICS, the Solar Array Manufacturing Industry Costing Standards. From the SAMICS concepts came SAMIS, the Standard Assembly-Line Manufacturing Industry Simulation, which is a million dollar computer program for modeling any kind of manufacturing sequence.

The criteria for SAMIS development were several. The technique had to be accurate, consistent, and verifiable. This was because comparisons were to be made among contractors' processes, and management decisions regarding allocation of R&D and public dollars were at stake. SAMIS had to also perform as a technological scorecard. That is, it had to provide for direct comparisons among similar alternative processes. Thus, a great deal of detail was needed in terms of the process descriptions.

The resulting approach used a detailed description of each step of the manufacturing process as input. It included the characteristics of the equipment, the nature of the cycle of operation, and all direct requirements for each step of the process. This description also included assumptions regarding the quantity and quality of output. SAMIS had to also accommodate a wide range of scenarios for the industry. These included forecasts for differing sizes of plants and total aggregate demand for products in the industry.

SAMIS PRINCIPLES

Fundamentally, SAMIS expands the concept of direct cost. In conventional accounting, a process cost is equal to the product of direct costs times overhead. Overhead contains items such as depreciation, facilities cost, rework, setup, maintenance, and so forth. In using SAMIS, the analyst should attribute to a process all of the direct costs associated with it. This would include the capital cost as well as any other resource that is consumed because of the existence of the process. This is illustrated in Exhibit 2.

As expected, this has a dramatic impact on direct cost. Under conventional accounting, the total automation of a process that resulted in no direct labor would bear zero cost since all of its cost contributors would be carried in overhead. Under SAMIS the capital recovery cost, energy consumed, maintenance performed on equipment, and floor space would all be labeled as direct process costs.

After direct process costs are identified, SAMIS automatically adds indirect costs. The sequence of calculations is shown in Exhibit 3. These indirect costs are established by a matrix which is constructed to typify companies in the industry. In applying SAMIS, an individual company would construct a matrix that depicted its own style of operation. An example of a matrix factor would be supervision. Supervisory ratios could be provided for all of the direct components of work force like regular labor, maintenance, and quality.

After direct and indirect requirements are computed, the costs of operations are developed. These are derived from a Cost Account Catalog, which is a file containing prices for all factors of production. The file is updated periodically based on current prices.

The final step in the sequence is to develop a product price based on the financial objectives of the firm. The financial model includes assumptions about desired return on investment, debt equity ratio, and taxes. The output is a product price that would recover all costs of production. Output also includes financial statements for the factory and detailed descriptions of the cost for direct and indirect requirements that can be associated with each step of the process.

Exhibit 4 is an example of output from SAMIS. It shows that process costs do not necessarily follow the direct cost, reflecting variations in other factors that should be associated with the process that would not be under standard accounting systems.

The chief limitation of SAMIS is that it is applicable principally to production lines that are dedicated to a single product. Despite this limitation, it has valuable potential to anyone evaluating a new manufacturing venture or a substitute for an existing production line. It can help engineers set priorities for addressing cost reduction in production. By thoroughly documenting current levels of performance in each step of the process, cost drivers will be identified for subsequent attack on a priority basis.

SAMIS is also valuable for building a "composite production line" to determine the best achievable cost. Also, using different Cost Account Catalogs to reflect differing prices worldwide, a manager can develop a low cost strategy for locating a production facility.

The SAMIS methodology, or its equivalent, can play a significant role in a company's strategic planning. It allows the planner to construct, on paper, a vision of the factory of the future. Despite its limitations, the methodology can demonstrate the potential in terms of capacity, flexibility, and cost performance of new technologies integrated into a new factory.

Each key assumption that would affect cost must be documented in applying the methodology. This provides an audit trail that will serve as a checklist as the technical development and implementation of new processes strive to meet the objective. Where the inevitable shortfalls occur, or technical objectives are found to be too stringent, the speed of the computer can quickly update the decision maker regarding the impact.

SAMIS should greatly improve communications with management, will provide a basis for establishing a manufacturing strategy, and should demonstrate all of the impacts of an "integrated" factory. The strength provided by this "green field" approach that is performed without limitations can also be a weakness. Most managers must deal with the practicalities of evolving toward some ideal. They, therefore, need other instruments that can develop the program timetable for evolving to the ideal. This was the purpose of the Bell Helicopter Economic Assessment Model.

BELL HELICOPTER ECONOMIC ASSESSMENT MODEL

Bell Helicopter is an important defense contractor which sells current lines of helicopters to the Army and Navy and is designing new airframes under development contracts. It is also a participant in the Department of Defense Industrial Modernization Incentives Program (IMIP). Bell received a contract from the Army to conduct a top-down Phase I assessment of its operations. The purpose of this program was to develop projects for implementation to improve operating performance and prepare for new technologies.

Central to the IMIP concept is a business arrangement between the contractor and the government. This arrangement provides incentives to the contractor in the form of retained savings from cost-reduction efforts. Under normal practice, savings achieved by contractors may be called away by the government, and this can inhibit a contractor from making cost-effective investments.

In undertaking the Phase I, Bell realized that much of its cost is in indirect areas. It wanted projects that would address all factors of cost and not be limited to only direct labor actions. To accomplish this, Bell realized it needed a broader concept of cost than that derived from a conventional accounting model.

MODEL DESIGN CRITERIA

The model had to provide several needs for the Phase I IMIP project. First, it had to help identify the cost drivers in the Bell structure. Knowing these cost drivers would help set priorities for more intense study. The fruits of this study would be projects that would offer improvements in cost in the selected areas. The second criteria was the ability to track cost beyond the "highly measured" direct areas. This method had to be developed for assessing not only present but also future costs under varying market forecasts. And, to be thorough, the forecasting methodology had to be carried over into the indirect as well as the direct areas. Finally, when the government and the contractor sat down to develop a business arrangement, different scenarios had to be tested so that negotiations could proceed expeditiously.

MODEL STRUCTURE

The first principle applied in model development was to take a functional view of the firm. This implied that traditional cost center numbers had to be applied to company functions more amenable to common project programs. For example, a function like MOVE MATERIAL would contain costs from warehousing, transportation, and systems areas. The cost accounting system had these costs distributed among several departmental cost centers.

This goal was accomplished in the Corporate Cost Module as shown in Exhibit 5. In this module, current costs out of the accounting structure were adapted to a functional model of the firm. As we see later, this same functional cost structure was utilized for assessing the impact of projects on cost.

The second module was a Market Scenario Model. This model utilized the functional cost structure and forecasts of future activity to develop patterns for future cost. The forecast included direct labor hours in various programs, research and development contracts, IR&D, and spare parts. The Market Scenario Model translated these inputs into projections of costs and asset structure. Techniques such as regression were used to determine the fixed and variable cost relationships for different levels of business.

As the Phase I factory analysis developed project concepts, these were folded into a Project Economics Module. The Project Economics Module showed cash flows by category in all of the functional cost accounts that were part of the Corporate Cost Module. For example, if automation of a process is anticipated, then the engineer would develop an estimate of savings in direct labor or other areas and also would estimate the added cost associated with the automation, like maintenance. The Project Economics Model also included the development and capital investment costs associated with the project. The model contained a checklist to assure that the engineer considered all possible costs and benefits.

The next module is called the IMIP Discounted Cash Flow (DCF) Module. This model was developed by DoD and is provided for contractors assessing potential IMIP investments. Adaptations were made to suit the Bell situation. Using the DCF Model, the analyst could determine the sensitivity of project economics to various hurdle rates. They could also assess the sensitivity to negotiated rates of savings sharing with the government.

Upon completion of each individual project analysis, all of the projects can be totaled into the Integrated Project Module. This module in turn can be used to modify the Corporate Cost Module to show the collective impact from all the projects. The maintenance of the functional account structure developed in the beginning of the program provided the basis for interchangeability of information among the different modules.

USE OF THE MODELS

Both the Economic Assessment Model and SAMIS have roles to play in strategic planning. They offer distinctly different and complementary capabilities for application in a variety of environments. This is illustrated in Exhibit 6.

Exhibit 6 shows examples of four environments where innovative approaches to cost analysis can be applied. The first is an environment of rapid structural change, that is, where market and competitive conditions are changing. These external factors are forcing the organization to reevaluate its manufacturing capability from the point of view of location, number of products, and pricing. Within any particular plant, the structural change may be mandating more flexibility in manufacturing; and the company, consequently, is looking for approaches like cellular concepts.

Also a period of rapid structural change is a time when management must reevaluate all functions. This evaluation should underscore whether the charters and missions of segments of the organization should be reviewed or discontinued in light of the external changes.

Another environment that offers significant challenge is that of rapid technology change. Often, in this environment companies must make large investments to maintain competitiveness. They must seek funding for the new technologies from external sources, by raising new capital, or internally from current business. This environment also forces examination of a variety of alternatives in developing a manufacturing capability suited to the new technology.

Many companies are only undergoing evolutionary change. These companies are typically in mature markets with mature products. It is at this stage of their organizational life that they must emphasize better performance from their operations. They must also be wary of cross-subsidization of one product by another. This often results in overpricing one product or service while underpricing another. Both will have serious negative effects in a competitive market.

A final situation is that of the multiproduct government contractor. As in the Bell situation, these organizations may want to use the Economic Assessment Model as part of an incentive program. The SAMIS model could be a useful check to assure that different products are rationally priced. Like the commercial situation, the broad allocation policies used in assigning overhead to products can cause distortions and inaccuracy in assigning costs to specific products.

The Economic Assessment Model and SAMIS are complementary since they both emphasize different needs and provide different types of information. The EAM is a model of current operations as they exist. It provides current costs by functions within the organization. This organization will probably produce many different products, so the EAM is limited in that it cannot discriminate from one product to the other.

The SAMIS model, on the other hand, depicts a conceptual plant. This is an idealized structure that could exist, given the fulfillment of certain assumptions about manufacturing. Unlike the EAM, the SAMIS output is a price by product.

As shown in Exhibit 6, both models have their use in application in the four different environments described above. Where the corporate strategy calls for reduction of costs in current operations, the EAM can set priorities. It can also help evaluate projects directed at improving current operations through the use of the discounted cash flow model.

The SAMIS model provides a construct of operations that do not exist as separate entities. SAMIS can be applied for new products, for relocated facilities, and for evaluation of facilities or cells dedicated to particular products. It is also useful in testing whether the current methods of cost allocation are creating distortions in the prices charged to customers for specific products.

Where pricing distortions exist in private markets, the company can make the appropriate adjustments -- subject to the constraints of market acceptance. Where the distortions exist in government markets, the company can become aware of the losses incurred in one area and, perhaps, negotiate new allocations to eliminate these distortions. If this is not possible, the company can use the information in its bid and proposal strategies to increase the overall profitability of its business.

SUMMARY

The Economic Assessment Model provides a total view of the company and widens the viewpoint of the engineer. It forces attention away from the traditional "highly measured" areas of direct labor. In the initial construction of the functional model the engineer must make some allocations. However, the result is a fairer picture of actual cost drivers than that provided by traditional accounting.

The JPL SAMIS approach provides a valuable bottom-up construction of a factory around its processes. Bell's Economic Assessment Model, on the other hand, provides a top-down view of all costs usually with an eye toward overall cost reduction and restructuring of current operations. There will probably be creative new ways of combining the techniques for the purposes of product pricing, analyzing cost drivers, and prioritizing and evaluating development efforts.

New manufacturing technologies will demand corresponding improvements in the financial analysis processes. These are examples of how two organizations have met the challenge.

TYPICAL MANUFACTURING COMPANY COST STRUCTURE

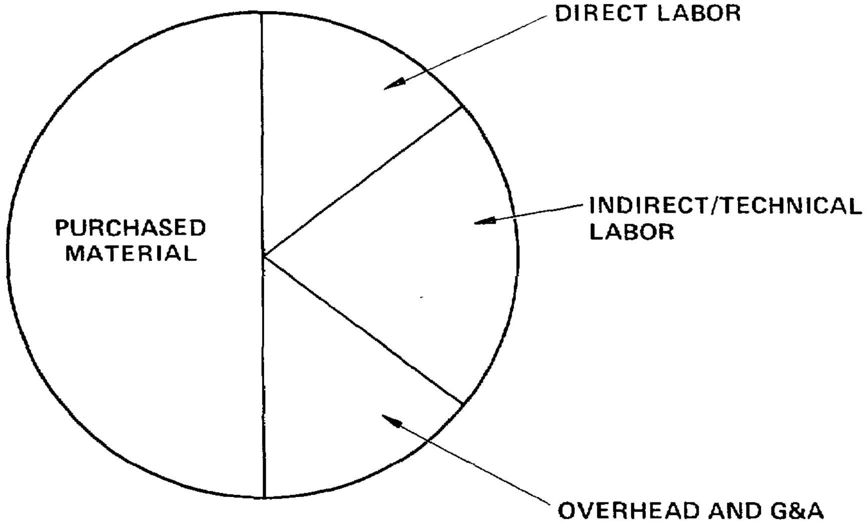
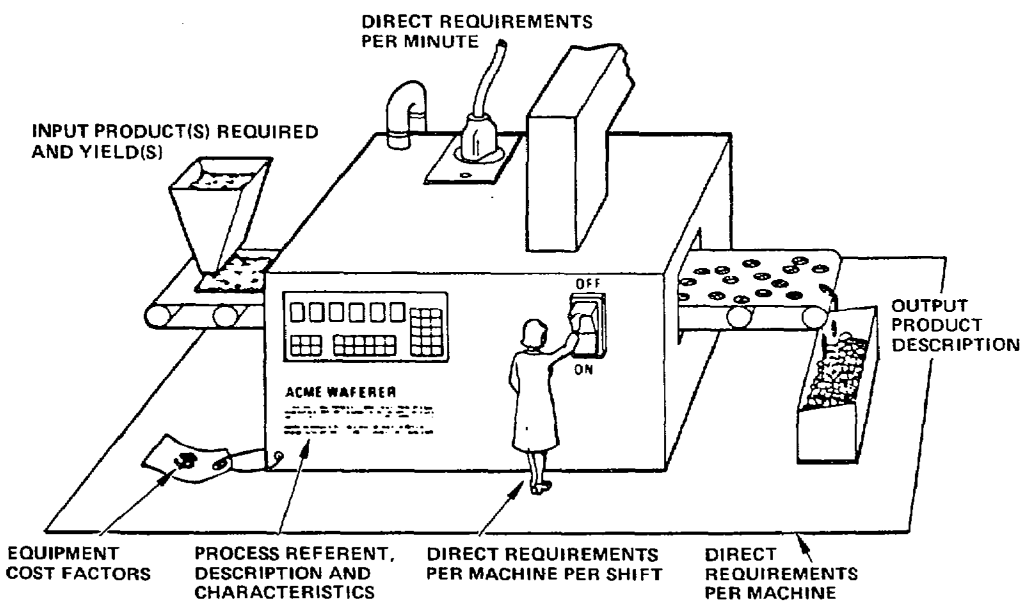


EXHIBIT 1

SAMIS EXPANDS THE CONCEPT OF "DIRECT"

CONVENTIONAL PROCESS COST = DIRECT LABOR x OVERHEAD



SAMIS PROCESS COST = EQUIPMENT + FACILITY + DIRECT LABOR + MATERIAL + UTILITY + INDIRECT LABOR

EXHIBIT 2

COMPONENTS OF SAMIS

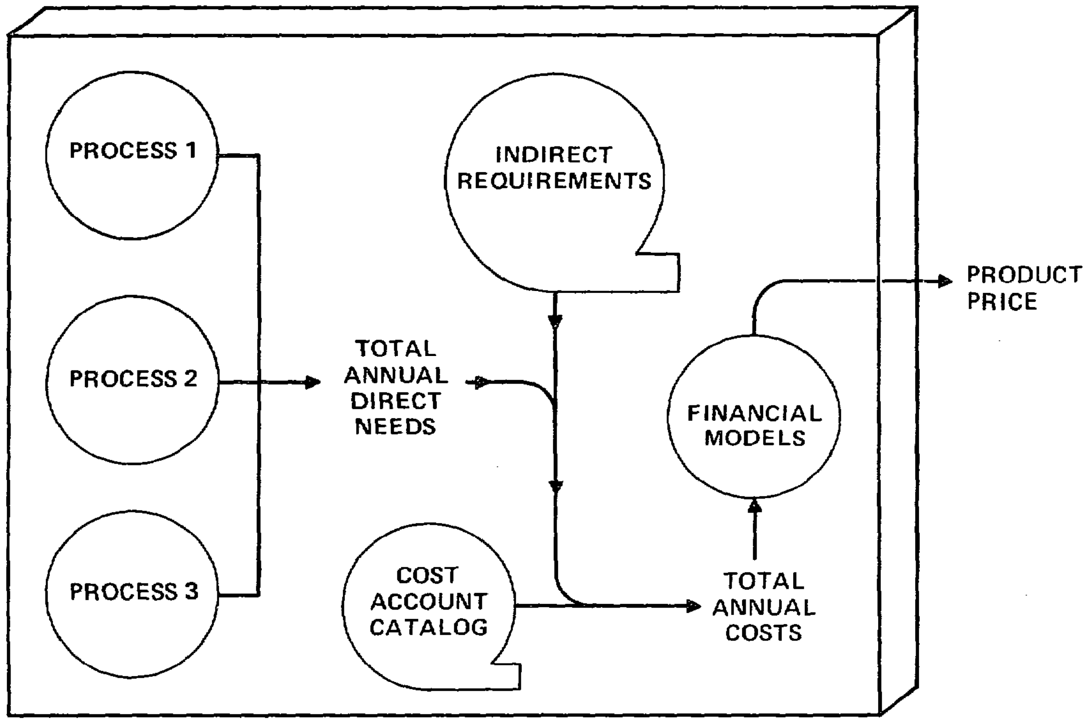


EXHIBIT 3

200 KW INVERTER ANALYSIS PROCESS COST SUMMARY

PROCESS STEP	DIRECT COST	LABOR %	MATERIAL %	OTHER %	% OF TOTAL
1. FANASSY	$ 19,775	1%	2%	0.5%	1.5%
2. LEGASSY	386,509	22%	31%	17.0%	28.0%
3. FILTASSY	206,800	10%	17%	3.0%	15.0%
4. EMIFTASSY	10,312	1%	1%	0.5%	1.0%
5. MODTEST	44,926	7%	2%	4.0%	3.5%
6. LGCASSY	249,337	17%	18%	11.0%	18.0%
7. CABASSY	378,277	27%	28%	19.0%	28.0%
8. FINTEST	56,224	14%	0%	7.0%	4.0%
9. PAINT	2,562	0.5%	0%	15.0%	0.0%
10. PACKING	14,179	0.5%	1%	23.0%	1.0%
TOTAL	$1,368,899	100.0%	100%	100.0%	100.0%

TOTAL LABOR	$ 412,689	(30%)
TOTAL MATERIAL	952,990	(70%)
TOTAL OTHER	3,223	(0%)
TOTAL DIRECT	$1,368,899	(100%)

EXHIBIT 4

ECONOMIC ASSESSMENT MODEL

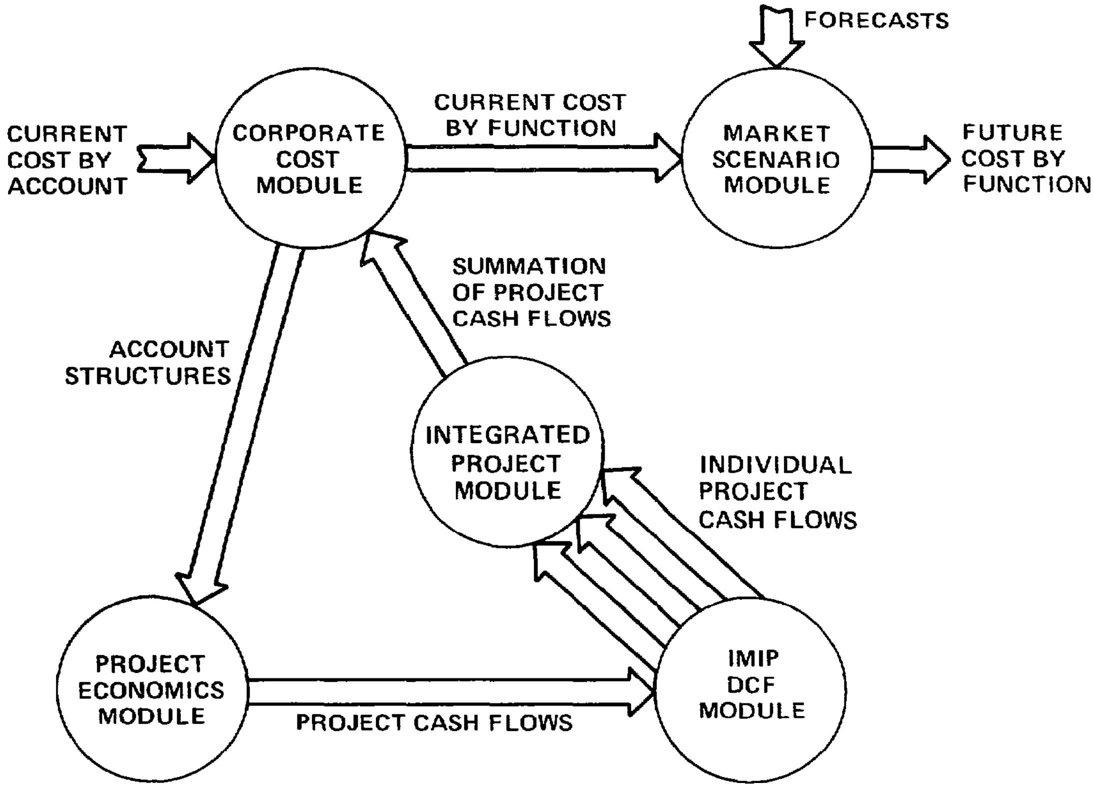


EXHIBIT 5

USE OF THE MODELS

	MODEL AND EMPHASIS	
	EAM	SAMIS
ENVIRONMENTAL CHALLENGE	CURRENT OPERATIONS CURRENT COSTS BY FUNCTION	CONCEPTUAL PLANT IDEALIZED COST BY PRODUCT
RAPID STRUCTURAL CHANGE – NEW MARKET, COMPETITIVE ENVIRONMENT	• ZERO BASE BUDGETING	• PLANT LOCATION • PRODUCT LINE EVALUATION • CELLULAR CONCEPTS
RAPID TECHNOLOGY CHANGE – LARGE INVESTMENTS NEEDED	• INCREASED FLOW OF $ TO SUPPORT PROGRAMS	• EVALUATION OF ALTERNATIVES
EVOLUTIONARY CHANGE – MATURE PRODUCTS AND MARKETS	• COST DRIVER ANALYSIS • PRIORITIES FOR TUNING OPERATIONS	• BETTER PRICING INFORMATION • FEASIBILITY OF INTEGRATION
MULTIPRODUCT GOVERNMENT CONTRACTOR	• IMIP INCENTIVE PROGRAM	• RATIONAL PRODUCT LINE PRICING

EXHIBIT 6