6

Cost-Based Decision Making

There are three important managerial uses of cost information. To:

1. Understand costs so as to determine whether to make or abandon a product and to influence the nature of customer relationships
2. Develop a cost basis for a price (as in cost-based transfer pricing or for a contract that calls for a cost-based price)
3. Identify opportunities for, or the need to, improve product or process design and process operation

This chapter considers the last use of cost information.

Exhibit 6-1 provides a useful way to think of the opportunities and perspectives that costs provide for product and process design and improvement and provides an outline for the discussion in this chapter. Exhibit 6-1 describes a time line from the initial planning for the product to its eventual removal from the market. There are three broad phases in a product's life cycle: the planning phase, the manufacturing phase, and the service and abandonment phase. **Life cycle costing** is used predominately in the planning phase. It attempts to estimate the product's cost over its lifetime. **Target costing** is used during the planning cycle and drives the process of choosing product and process designs that will result in a product that can be produced at a cost that will allow an acceptable level of profit, given the product's estimated market price, selling volume, and target functionality.[1] **Kaizen costing** focuses on identifying opportunities for cost improvement during the manufacturing cycle. Each costing method has a distinctive perspective and unique use, which we will now discuss.

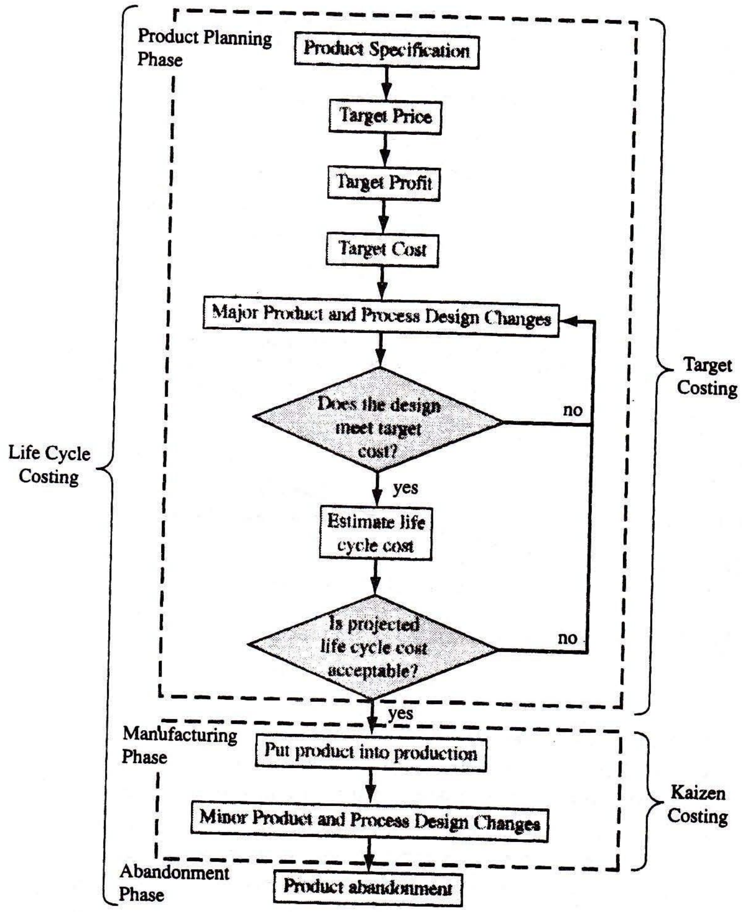

EXHIBIT 6-1 Costing Tools for Decision Making

TARGET COSTING

A widely accepted rule is that 80% of a product's costs are committed, or locked in, during the product design stage.[2] During this time, planners choose the product design and design the process that the organization will use to make the product. Although the pattern will vary among products, Exhibit 6-2 summarizes the typical pattern of cost commitment and cost incidence during a product's three phases.

As Exhibit 6-2 implies, effective cost control is exercised during the product's planning and design phase not when the product and process have already been designed and the product is being made. During the product manufacturing phase, most of the product costs have been committed and the focus is cost containment. This understanding of the pattern of costs has led to interest in controlling costs during the product's planning phase.

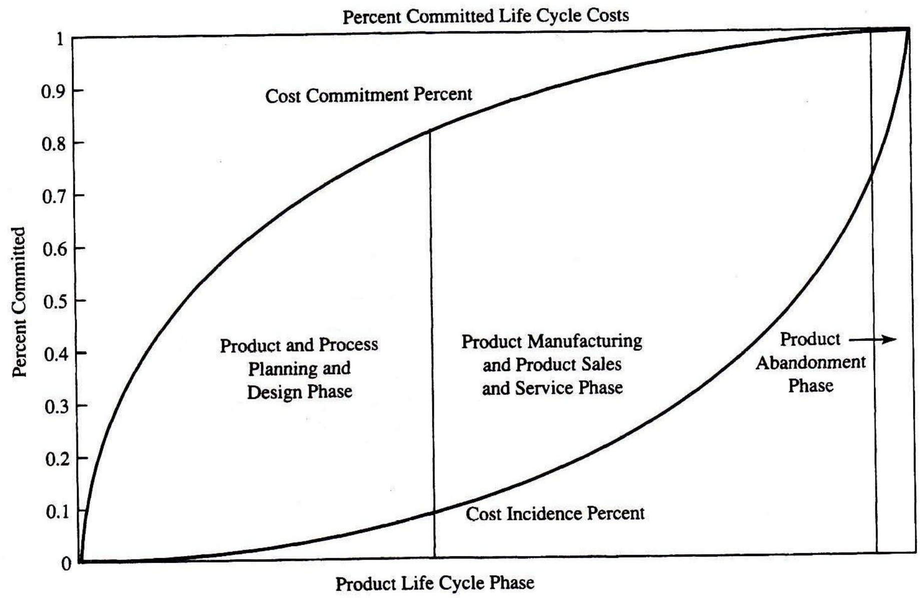

EXHIBIT 6-2 Cost Commitment versus Incidence

Target costing is a cost management tool that planners use during product and process design to drive improvement efforts aimed at reducing the product's future manufacturing costs. Above all, target costing is a tool that promotes and facilitates communication among the members of the cross-functional team that is responsible for product design. Target costing is customer-oriented; it begins with price, quality, and functionality requirements defined by customers. For this reason, observers call target costing price-led costing in contrast to conventional cost plus approaches to pricing, which they call cost-led pricing.

Customer Orientation

As suggested in Exhibit 6-1, target costing begins with an estimate of the product's price, which reflects the product's functions and attributes and competitive forces in the marketplace. One approach that planners have used to describe customer requirements is the notion of value, which is the ratio of functionality to the price paid by the customer. Organizations increase customer value by increasing the product's functionality while holding the price constant or by reducing the price while holding functionality constant.

Any given product may have many elements of functionality, with each function commanding an additional premium over the basic product price. The input to the target costing process is a market price-product functionality vector to which the product's planning process must conform. That is, the target price reflects a set of product functions that the product must deliver to the customer. There are two critical elements here. First, the customer, or more generally the market, defines the price that will be paid for the product and its designated functions. Second, to the extent that there is a market for the same product with different functions, for example an automobile with different options, the organization can choose which product functions to supply, but the market or consumer will choose a price that reflects the set of product functions supplied.

The Target Costing Process

Once the product price-functionality-quality targets have been set, planners then subtract a target profit from the target selling price. This target profit is the contribution that the product is expected to make toward the organization's business-sustaining costs. The residual is the target cost, which is the focus of, and the driving force behind, the product and process design efforts. As shown in Exhibit 6-1, the target costing process is iterative and continues until the design team finds a product design with a projected cost that meets the target cost.

A major strength of target costing is that it is embedded in a team environment. The team members include representatives from design, process engineering, purchasing, manufacturing, and marketing—a cross-functional process called **concurrent design**. With concurrent design all the members of the design team are focused on the same objective: to deliver a product with the target functionality, quality, and price to a specific market segment. In this environment, there is no room for individual groups to specify product features that reflect a functional fixation. For example, design engineers are notorious for designing into products features that customers do not value but that increase cost.[3] Customers will not pay for functions they do not value. Therefore an important consideration during the product design process is to eliminate product functions or features that add cost but provide no market price increment because they provide no value to the customer.

Another strength is that target costing is deployed at a time, the product and process design phase, when design choices can have a maximum impact on a product's cost. For example, without the discipline of a team approach to product design, an engineering group might design a production process that uses the latest production technology without regard for its effects on cost or manufacturability—which is what happened to General Motors in the 1980s when it built its automated guided vehicle assembly plants. Operating on its own, a marketing group might specify many product features that customers would like to have but do not consider essential in the product and therefore would not be willing to pay to have included in the product design.

Some organizations, such as Chrysler, include representatives from their suppliers on the design team. Chrysler involves its suppliers through its **SCORE** (Supplier Cost Reduction Effort) program.[4] This program includes suppliers as active members of the product design teams to elicit their expertise. This approach requires a sharing of ideas and information—a relationship requiring trust that, in turn, takes time to develop.

The paybacks for suppliers are long-term contracts, a negotiated return on the investment they make in product design and manufacturing, and participation in the cost savings that they generate. The goal is to reduce product costs but not by squeezing the suppliers. Rather the approach is to use lower-cost commodity components rather than custom-designed components and to reduce production costs by implementing process improvements. For example, Magna, a Chrysler supplier, recommended an exterior molding that cost less while offering the same functionality as what Chrysler was using.[5] Owens Corning described one of the suggestions that it made to Ford Motor Company:

> In the award-winning Ford Taurus radiator support, Owens Corning glass fibers enabled a composite material to replace metal, yet support the weight of several radiator components. The design flexibility and structural integrity available with composites enabled Ford to consolidate what formerly required 23 separate parts into a two-piece modular assembly. (Owens Corning, 1996 Annual Report, p. 6)

This model of suppliers' reducing costs by designing components that provide the same functionality at lower cost or by improving existing processes is the model suggested by the Japanese *keiretsu* and South Korean *chaebols*, which are affiliations of companies interrelated by supplier-purchaser relationships. Although this approach seems promising and interesting, there is some evidence that it does not always work. Recently, several large and important Japanese keiretsu were disbanded because evidence suggested that the protected suppliers had become inefficient and noncompetitive. Chrysler is trying to avoid this situation through provisions that allow it to drop poorly performing suppliers when performance is based on cost savings resulting either from design proposals or from manufacturing process improvements, quality, and on-time delivery.

Suppliers often can offer suggestions, such as modest design changes, so that a product design will include a standard component or part, rather than a custom-designed part, that will reduce the product's target cost and increase its quality.[6] Alternatively, suppliers can offer their expertise when new components or parts are required so that, for a given level of functionality, the part can be supplied at the lowest cost.[7]

A major strength of involving different functional areas concurrently in the product and process design is that it reduces product development time and cost by reducing required design changes. A second, and related strength, is that each subgroup within the team (e.g., purchasing, design, engineering) is assigned cost reduction targets that it is expected to meet in order to achieve the team's overall target cost objective. This approach has the effect of assigning individual responsibilities but within an overall structure of group objectives relating to product quality, functionality, and price.

The concept of target costing is simple to state and hard to accomplish. The idea is that the team will continue its product and process design efforts until it finds designs that yield an expected cost that is equal to, or below, the target cost. Design teams are not allowed to reduce planned costs by eliminating desirable product functions or features. Design teams reduce costs by improving product or process design to deliver a product while still delivering a product that meets the target level of functionality.

Recall that the design team is working toward a target cost that reflects a product's set of functions. Occasionally design teams encounter situations in which the cost of adding a function exceeds the price increment that the customer is willing to pay for that function. At this point, the design team must decide whether each function must cover its incremental costs or whether the excess of customer value over cost for some functions will subsidize the excess of cost over customer value for other functions.[8] In general, this choice will reflect strategic and product evolution considerations.

The target costing idea reflects the reality that most product and process design decisions are not the lowest-cost designs but rather designs that the organization has decided it can live with. This is the notion of satisficing: We use solutions that are good enough, not necessarily the best solutions. Target costing takes the organization beyond the effort levels usually chosen in satisficing operations and drives the planning activity toward the target cost.

Target costing places huge pressures on the design team. The design team has a common objective: to meet target cost. There is no possibility of renegotiation in target costing; the product will not be launched unless the team meets the target cost, which ultimately reflects what the customer demands and what the suppliers of capital expect as a reasonable return on their investment. Therefore, there is pressure on design teams to develop and use tools that can help them reach their target cost objectives. The major tools planners use in target costing are tear-down analysis, value engineering, and reengineering.

Target Costing in Action: Toyota Motors[9]

Toyota Motors seems to have invented the process of target costing during the 1960s. At Toyota, the target costing process begins when the marketing group specifies the target price. The market value of additional functions added to existing vehicles determines the increment of the price of the new model over the existing model. Planners then multiply this price by the estimated production volume over the product's life cycle to determine the total product revenue.

The next step is to estimate the costs of the new product. These costs are estimated by adding to the cost base of the existing product the incremental costs of the design changes associated with the new product. The design team then compares revenues and costs to compute an estimated margin. A margin that fails to achieve the target return on costs needed to provide an appropriate return on investment triggers a redesign process.

This redesign process begins by computing the required cost reduction. The leader of the design team then distributes this target cost reduction among the members of the design team.[10] For example, the assembly division may have estimated an increase in assembly costs on the basis of an increase in the number of parts in the new vehicle. The assembly division would be asked to identify ways that the assembly process could be redesigned so that the expected cost increment would be reduced. Another possibility would be for the assembly group to negotiate with the design engineers to reduce the number of parts by increasing the number of preassembled modules or components used in the vehicle. This is where the insights provided by people experienced in making the product, working with other members of the design team, can result in considerable cost savings.[11] This process of finding improvements in existing production practices or in altering the design of the product so as to deliver the same functionality at a lower cost continues until the design team achieves its target cost.

Tear-Down Analysis

Tear-down analysis, or reverse engineering, is a process of evaluating a competitor's product to identify opportunities for product improvement. In tear-down analysis, the competitor's product is taken apart piece by piece to identify the product's functionality and design and to make inferences about the process that made the product. Tear-down analysis provides insights into the cost of the product and suggests the relative advantages or disadvantages of the competitor's approach to product design. The major element of tear-down analysis is **benchmarking**, which involves comparing the tentative product design with the designs of competitors.

Quality Function Deployment

Quality function deployment (QFD) is a management tool originally developed during the 1970s in Japan's Kobe shipyards. Quality function deployment provides a structure to identify customer requirements, a key input into the target costing process. Organizations use QFD to identify what customers want from a product before the product design is undertaken. The process then compares what the customer wants with how the design team proposes to satisfy those requirements. As such, QFD supports the process of value engineering, a critical element in the target costing process.

Value Engineering

Value engineering, also known as value analysis, is a systematic, usually team-based, approach to evaluating a product's design in order to identify alternatives that will improve the product's value—defined as the ratio of functionality to cost. Therefore, there are two ways to improve value: Hold functionality constant and reduce cost, or hold cost constant and increase functionality. Value engineering looks at all of the product's elements, including the raw materials, the manufacturing process, the type of labor and equipment used, and the balance between purchased and self-manufactured components.

Value engineering achieves its assigned target cost in two ways: (1) by identifying improved product designs (or even new products that may meet functionality in different ways) that reduce component and manufacturing cost while not sacrificing functionality[12] and (2) by eliminating unnecessary functions that increase the product's cost and complexity.[13]

The process of value engineering begins with a detailed specification of the product's functions, an activity often called **functional analysis**.[14] This is the heart of the value engineering approach and results in a detailed specification, usually in the form of a diagram called a function analysis systems technique (**FAST**) diagram, that specifies the product's major functions. By focusing on the product's functions, the design team will often consider components that perform the same function in other products, thereby increasing the possibility of using standard components, which often leads to increased quality and lower costs. At the same time, developing a specific statement of product functions allows the design team to compare the cost of the functions of the product it is building with what customers are willing to pay for each function.

The design team then considers how existing products achieve those functions and then evaluates new ways of achieving those functions and the cost of each of the alternatives. The alternatives are then rated, and, if possible, the best elements are taken from each of the alternatives to develop the proposed product design.

Some companies belonging to the Siemens group have carried functional analysis one level further. These companies use functional analysis to specify the functions of each of a product's components. Then, planners identify what customers are willing to pay for each function and what each function costs. Because this process is driven by values that customers place on functions, of particular interest are situations in which the cost of a component's function is higher than the value placed on that function by customers. This process often identifies component functions that are not wanted or valued by customers and are there solely to serve engineering objectives.

Reengineering

The tear-down and value-engineering approaches focus mainly on the product design. Another critical element in determining the cost of a product is the process that the organization uses to make the product. In fact, the target costing team will consider both product and process design simultaneously since the product's cost and quality will be jointly affected by the product and process design. Reengineering is the activity of redesigning a planned or existing process, and it is driven by the desire to improve a product's cost and quality attributes.[15]

KAIZEN COSTING

Once planners have fixed and implemented the product and process designs, interest turns to operating the process in the most efficient way—an activity driven by **kaizen costing.**[16] Kaizen costing focuses the organization's attention on things that managers or operators of an existing system can do to reduce costs. Therefore, unlike target costing, which planners use before the product is in production, operations personnel use kaizen costing when the product is in production. However, target and kaizen costing are similar in that targets drive them. Whereas target costing is driven by customer considerations, kaizen costing is driven by periodic profitability targets set internally by senior management.

The focus of the cost reduction efforts driven by kaizen costing is incremental improvements to the current production process or product design. These improvements take the form of developing improved setup processes, improving machine performance to reduce waste, and increasing employee training and motivation to encourage employees to identify and implement the incremental daily changes that can improve cost and quality performance. In short, the focus in kaizen costing is the process and not the product itself.

Organizations attack continuous improvement in different ways, and the kaizen costing system will reflect the cost reduction strategy. For example, Olympus Optical Company implemented a kaizen costing system with four components: production costs, costs of defects, capacity use costs, and overhead expenses. Each subsystem gathered and reported costs that directed attention to areas for improvement.[17]

Some observers have criticized both target and kaizen costing on the grounds that they often place huge stress on employees. Some organizations have responded to this charge and to the effect of using target and kaizen costing techniques by lowering their performance expectations. However, by their nature, which focuses on motivating intense effort at reducing costs, these measures are stressful.

Operational **activity-based management** drives the process of reengineering. Analysts map out the steps or activities in an existing or proposed process—an activity called **process mapping**, or **flowcharting**. Planners then look for opportunities to reduce cost by eliminating factors that cause delay or waste in the planned process design. Activities that consume resources without adding functionality to the product that the *customer* values are called nonvalue-added activities. Nonvalue-added activities reflect things that the organization does because of poor design or poor planning rather than what is inherently required to make the product. Moving, storing, and inspecting are all activities that cause delay or waste in the manufacturing process while consuming resources. A product or process redesign that eliminates the need for non-value-added activities will reduce costs and cycle time and often will increase product quality. The steps in operational activity-based management include:

1. Chart the process to identify each activity.
2. Identify the cost of each activity.
3. Identify opportunities for improvement (reengineering to eliminate the need for non-value-added activities and continuous improvement to improve the performance of value-added activities).
4. Set priorities for improvement. (Usually, improvement efforts are ordered by value added; that is, they attack the non-value-added activity with the greatest difference between cost added and cost to eliminate or the value-added activity that has the highest cost.)
5. Provide the financial justification (business plan) for the reengineering efforts.
6. Identify what needs to be done to eliminate or otherwise reduce the activity's cost.
7. Make the required changes.
8. Track the benefits to compare them with the costs.

TARGET COSTING: A COMPREHENSIVE EXAMPLE

The Power Division supplies engines to the seven assembly divisions at Giant Motors, which, over its lifetime of 80 years, evolved from an automobile assembler that purchased all its components to a fully integrated automobile manufacturer. Reflecting its history of evolution through buying existing components manufacturers, Giant Motors had always been operated on a profit center basis in order to compute divisional profits that were intended to approximate what the individual divisions would report as independent operating units.

Recently, the assembly division managers had expressed dissatisfaction with the current arrangement. They argued that the internal component suppliers, who had a protected status, had become lazy and inefficient. The assembly division managers argued that they should be allowed to source their components externally.

After many years of disputes between management and the board of directors and the union, Giant Motors decided that, for any new engines, it would immediately allow the assembly division managers to source components from whatever supplier they preferred. External suppliers were given the blueprints for existing engines and told that they could compete to supply existing engines starting in two years. The managers of the component divisions were put on notice that any division not showing the potential for adequate profitability would be liquidated.

It was with this in mind that Roberta Ward, the manager of the engine division, ordered a review of Engine Division's operations. A study group, comprising division employees and a consultant, prepared a report that suggested that the Engine Division's costs were about 25% higher than the costs of organizations producing comparable engines. With this information, Ward immediately instructed her senior managers to implement a process of target costing that she believed would focus the division on cost reduction efforts. Ward's objective was to better any market price offered by any competitor.

A study and interviews with customers, including automobile assembly divisions inside and outside the company, concluded that there were four important engine requirements: power, fuel consumption, weight, and noise level. Costs increased with designs that increased engine power and quietness, and, in general, costs decreased as fuel consumption and weight increased. In addition, there were complex interactions between the four engine characteristics.

Based on a study of the existing cost structure, Ward and her staff decided that the division would reduce product line complexity and therefore costs by offering three new engines that were adaptations of existing engines. Each engine offered a unique mix of the power, fuel consumption, weight, and quietness features. These basic engines could be modified to meet the demands of individual customers. The following table provides the details for each of the three engines.[18]

	ENGINE 1	ENGINE 2	ENGINE 3
Projected lifetime volume	850,000	2,200,000	1,500,000
Target average selling price	$7,500	$4,500	$6,000
Target average margin	$1,100	$ 800	$1,000
Target cost	$6,400	$3,700	$5,000
Raw materials cost	$2,500	$1,800	$2,300
Purchased components	2,200	1,400	1,200
Indirect costs	$3,317	$1,649	$2,699
Projected cost	$8,017	$4,849	$6,199

The excess of projected cost over the target cost motivated an intense target costing exercise. The first step of this target costing exercise was to identify the nature of the indirect costs for each engine. An analysis provided the indirect cost details reported in the following tables.

Unit-Related Indirect Costs

			DRIVER UNITS		
COST ITEM	DRIVER	DRIVER COST	ENGINE 1	ENGINE 2	ENGINE 3
Assembly	Assembly hours	$35	7	3	5
Quality assurance	Inspection hours	$42	2	1	2
Rework	Labor hours	$35	3	1	3
Materials handling	Helper hours	$28	5	2	4

Batch-Related Indirect Costs

			DRIVER UNITS		
COST ITEM	DRIVER	DRIVER COST	ENGINE 1	ENGINE 2	ENGINE 3
Moving	Number of moves	$ 50	7	5	4
Setup	Setup hours	$250	8	4	7

Product-Related Indirect Costs

	ENGINE 1		ENGINE 2		ENGINE 3	
COST ITEM	TOTAL COST	COST/ UNIT	TOTAL COST	COST/ UNIT	TOTAL COST	COST/ UNIT
Engineering	$80 million	$94	$45 million	$20	$55 million	$37
Supervisory	$ 8 million	$ 9	$ 8 million	$ 4	$ 8 million	$ 5

Facility-Sustaining Indirect Costs

			DRIVER UNITS		
COST ITEM	DRIVER	DRIVER COST	ENGINE 1	ENGINE 2	ENGINE 3
General administrative	Labor hours	$ 18	17	7	14
General overhead	Materials costs	$0.02	$2,500	$1,800	$2,300

The cost per unit for product-related costs was computed by dividing total budgeted costs by the projected volume of sales over the product's life. The driver cost for facility-sustaining costs was estimated by dividing Giant Motors' total cost deemed to be capacity by the estimated practical capacity, stated in cost driver units. The implication of this calculation was that as volume changes, in the long run, capacity, and therefore these facility-sustaining costs, will adjust accordingly.

The cost estimates produced the following unit budget calculations.[19]

	ENGINE 1	ENGINE 2	ENGINE 3
Lifetime volume	850,000	2,200,000	1,500,000
Price	$7,500	$4,500	$6,000
Materials Cost			
Raw materials cost	2,500	1,800	2,300
Components cost	2,200	1,400	1,200
Unit-Related Costs			
Assembly	245	105	175
Quality assurance	84	42	84
Rework	105	35	105
Materials handling	140	56	112
Batch-Related Costs			
Moving	350	250	200
Setup	2,000	1,000	1,750
Product-Related Costs			
Engineering	94	20	37
Supervisory	9	4	5

continued

	ENGINE 1	ENGINE 2	ENGINE 3
Facility-Sustaining Costs			
General administrative	306	126	252
General overhead	50	36	46
Total projected costs	$8,017	$4,849	$6,199
Projected profit	−517	−349	−199
Target profit	1,100	800	1,000
Excess of projected profit over target	−$1,617	−$1,149	−$1,199

Value Engineering

Suppose, in response to the need to reduce projected costs, that the Engine Division puts together a project team to undertake a target costing exercise relating to the three engines. As a first step, the team undertakes a value-engineering exercise. The team purchases engines from competitors and dismantles the engines to develop alternative engine design ideas. In addition, the team works with design engineers to identify new designs that will accomplish the same functions with a lower cost and to eliminate unneeded functions. The value-engineering activity results in the changes shown in the following table.

CHANGED ITEM	ENGINE 1	ENGINE 2	ENGINE 3
Raw materials costs	$2,400	$1,600	$2,200
Purchased components costs	$2,100	$1,300	$1,000
Assembly hours	6	2	4
Rework hours	2	No change	2

These changes result in the following cost projections.

	ENGINE 1	ENGINE 2	ENGINE 3
Lifetime volume	850,000	2,200,000	1,500,000
Price	$7,500	$4,500	$6,000
Materials Cost			
Raw materials cost	2,400	1,600	2,200
Components cost	2,100	1,300	1,000
Unit-Related Costs			
Assembly	210	70	140
Quality assurance	84	42	84
Rework	70	35	70
Materials handling	140	56	112

continued

	ENGINE 1	ENGINE 2	ENGINE 3
Batch-Related Costs			
Moving	350	250	200
Setup	2,000	1,000	1,750
Product-Related Costs			
Engineering	94	20	37
Supervisory	9	4	5
Facility-Sustaining Costs			
General administrative	270	108	216
General overhead	48	32	44
Total projected costs	$7,709	$4,492	$5,791
Projected profit	−209	8	209
Target profit	1,100	800	1,000
Excess of projected profit over target	−$1,309	−$792	−$791

Functional Analysis

Next, the design team evaluates the power, fuel consumption, weight, and quietness levels for each of the three engines. The team interviews customers to identify situations in which a change in any of these elements, up or down, will increase (or decrease) costs less (or more) than the corresponding increase (decrease) in the price that the customer is willing to pay. Suppose that this process results in the following changes in each of these functions for the three engines.

Based on the function changes, the prices of engine 1, 2, and 3 become $7,200, $4,800, and $6,300, respectively; the raw materials costs become $2,200, $1,700, and $2,400; the assembly hours become 4, 3, and 5; the materials handling hours become 5, 3, and 4; and the engineering costs become $70,000,000, $50,000,000, and $62,000,000. These changes result in the following cost projections:

	ENGINE 1	ENGINE 2	ENGINE 3
Lifetime volume	850,000	2,200,000	1,500,000
Price	$7,200	$4,800	$6,300
Materials Cost			
Raw materials cost	2,200	1,700	2,400
Components cost	2,100	1,300	1,000
Unit-Related Costs			
Assembly	140	105	175
Quality assurance	84	42	84
Rework	70	35	70
Materials handling	140	84	112
Batch-Related Costs			
Moving	350	250	200
Setup	2,000	1,000	1,750
Product-Related Costs			
Engineering	82	23	41
Supervisory	9	4	5

continued

	ENGINE 1	ENGINE 2	ENGINE 3
Facility-Sustaining Costs			
General administrative	234	144	234
General overhead	44	34	48
Total projected costs	$7,387	$4,695	$6,053
Projected profit	−187	105	247
Target profit	1,100	800	1,000
Excess of projected profit over target	−$1,287	−$695	−$753

Reengineering

With these changes in mind, the design team proceeded to the process design, which involved considering changes to the current process the Engine Division was using to make motors. This process was the basis for the cost projections for the new motors. The design team focused specifically on the production process and on identifying new ways to design the sequencing and assembly of engines. In conjunction with suppliers, the team developed a just-in-time manufacturing process and reorganized the production lines from a batch-oriented system that involved moving assembly components in different parts of the plant to a continuous flow system that used manufacturing cells. These changes were directed particularly at eliminating non-value-added activities in the assembly process but also considered efficiencies in value-added activities. These process design changes resulted in the following activity changes. For engines 1, 2, and 3, respectively:

1. Assembly hours became 3, 2, and 4.
2. Inspection hours became 1, 1, and 2.
3. Rework hours became 1, 1, and 1.
4. Materials handling hours became 3, 2, and 2.
5. The number of moves became 4, 2, and 2.
6. Setup hours became 4, 2, and 5.
7. Engineering costs, which included the cost of process redesign, became $115,000,000, $80,000,000, and $95,000,000.

These changes resulted in the following cost projections:

	ENGINE 1	ENGINE 2	ENGINE 3
Lifetime volume	850,000	2,200,000	1,500,000
Price	$7,200	$4,800	$6,300
Materials Cost			
Raw materials cost	2,200	1,700	2,400
Components cost	2,100	1,300	1,000
Unit-Related Costs			
Assembly	105	70	140
Quality assurance	42	42	84
Rework	35	35	35
Materials handling	84	56	56

continued

	ENGINE 1	ENGINE 2	ENGINE 3
Batch-Related Costs			
Moving	200	100	100
Setup	1,000	500	1,250
Product-Related Costs			
Engineering	135	36	63
Supervisory	9	4	5
Facility-Sustaining Costs			
General administrative	144	108	162
General overhead	44	34	48
Total projected costs	$6,074	$3,960	$5,277
Projected profit	1,126	840	1,023
Target profit	1,100	800	1,000
Excess of projected profit over target	$26	$40	$23

At this point, the process concluded because the projected cost was less than the target cost.

LIFE CYCLE COSTING

Life cycle costing is the process of estimating and accumulating costs over a product's entire life. Life cycle costing is particularly important in environments in which there are large planning and development costs (for example, developing a new jetliner) or large product abandonment costs (for example, decommissioning a nuclear generating facility).

There are three broad purposes of life cycle costing. First, life cycle costing helps to develop a sense of the total costs associated with a product in order to identify whether the profits earned during the active, manufacturing, phase will cover the costs in the development and decommissioning phases. Life cycle costing often will identify products that are no longer profitable when their decommissioning costs are factored into the product evaluation process. Second, because of its comprehensive consideration of costs, life cycle costing will identify a product's environmental cost consequences and will spur action to reduce or eliminate those costs. Third, life cycle costing helps to identify the planning and decommissioning costs during the product and process design phase in order to control and manage costs in that phase. For example, several design or process alternatives may promise the same product cost for a given level of product quality and functionality. However, one of the product or process designs may offer clear advantages when the costs of development and decommissioning are considered. In general, life cycle costing provides a comprehensive accounting of a product's costs, both manufacturing and environmental, from cradle to grave to help decision makers understand the cost consequences of making that product and to identify areas in which cost reduction efforts are both desirable and effective.

OTHER COSTING TOOLS

Quality Cost

Over the years, organizations have developed many approaches to monitor and control the cost of quality. One of the most popular recognizes four types of quality costs:

1. The costs of *preventing* quality problems. Examples include the cost of designing improved processes that reduce quality failures, employee training, and supplier training.
2. The costs of *finding* quality problems. Examples include the cost of the equipment and personnel who perform quality checks on work in process.
3. The costs of *fixing* quality problems that are found when the product is still in the manufacturer's hands. Examples are the cost, both out of pocket and opportunity, of personnel, materials, and machine time that are used to rework the product into a saleable condition.
4. The costs of *fixing* quality problems that are found when the product is in the hands of the consumer. Examples are warranty-related costs, the profits on sales lost when the organization's image is damaged by quality problems, and the costs of lawsuits prompted by product failures.

The idea in quality costing is to manage the total cost of quality, which is usually expressed as a percentage of sales, in order to provide a shifting standard as sales levels rise or fall. The strategy is to invest in preventing and finding quality problems as long as the cost incurred is less than the costs of fixing quality problems that would otherwise occur.

Taguchi Cost

A variation of quality costing is Taguchi cost, which was proposed by a Japanese academic. Conventional approaches to computing quality cost begin by classifying output as conforming or nonconforming. Conforming output is deemed to create no quality cost, whereas all nonconforming output is deemed to create equal quality cost.[20]

Taguchi's observation was that output failing to meet the target value of the characteristic creates quality losses and that quality losses increase quadratically with the deviation from the target characteristic. That is, if a machine is supposed to mill bolts to 2 centimeters, a machine that consistently mills bolts to 1.8 centimeters with virtually no variance will create fewer quality problems than a machine that produces bolts with an average of 2.0 centimeters but with a variance of 4 millimeters.

Taguchi proposed three types of quality loss functions:

1. When any deviations from the target are undesirable, the quality loss function can be written as

$$L(y) = k(y - T)^2$$

Where k is a parameter that reflects customer and process characteristics, y is the actual value of the output characteristic, and T is the target value.

2. When the objective is to make the process characteristic as small as possible, as in the case of contaminants in a piece of steel, the loss function can be written as

$$L(y) = k(y)^2$$

3. When the objective is to make the process characteristic as large as possible, as in the case of the reliability of a safety device, the loss function can be written as

$$L(y) = k(1/y)^2$$

The basis for Taguchi's hypothesis was observations of manufacturing environments. Therefore, Taguchi costing aims at one of three possible goals:

1. Reduce the variability of a process by identifying the factors that create variability in the process
2. Adjust the process mean so that it moves closer to the desired target
3. Reduce the variability and adjust the process mean toward its target

ENVIRONMENTAL, SALVAGE, AND DISPOSAL COSTS

Organizations have experienced a rapid rise in environmental costs. It is normal for organizations in the chemical industry to spend in excess of $1 billion annually on environmental costs. The sheer magnitude of these expenditures has forced organizations to think systematically about controlling these costs. Emphasis has changed from accepting environmental costs as an inevitable part of doing business to a business-related cost that, with appropriate management, can be reduced. As part of this process of managing environmental costs, organizations are beginning to develop detailed cost records that attribute environmental costs to activities and ultimately to products in order to identify the processes and products that create these environmental costs. Armed with this knowledge, organizations are taking steps to reduce or eliminate the drivers of environmental costs. Many organizations base part of incentive compensation on steps employees have taken to reduce environmental costs. For example, they may provide for bonuses based on measures of environmental performance that include elements such as the level of waste discharged.

Organizations face environmentally related costs during and after the product manufacturing phase. The cost of waste disposal is the most common environmental cost organizations incur during a product's manufacturing stage. Many organizations face significant costs in winding up projects or products. These costs are part of the product's life cycle, or cradle-to-grave, costs. There are two components of these winding-up costs: costs related to shutting down or decommissioning the manufacturing facility[21] (for example, shutting down a mine or a nuclear reactor) and the costs of disposing of products, which have come to be called take-back costs.[22] The effects of recognizing and accounting for environmental costs are to:

1. Provide an accurate picture of product profitability (currently most organizations simply charge these costs to corporate overhead thus obscuring both the nature and source of these costs)
2. Focus attention on developing products that have lower decommissioning and take-back costs (by identifying the magnitude of these costs)
3. Increase efforts to recycle or otherwise remanufacture existing product waste

CONCLUSION

Costs play many roles in organizations, but the most important is to inform and guide product-related decision making. Life cycle costing is an approach to costing that attempts to determine a product's cost over its entire life cycle including the design stage (the domain of target costing), the manufacturing stage (the domain of kaizen costing), and the postmanufacturing stage (the domain of take-back costing and costing systems that compute the cost of decommissioning manufacturing systems).

Target costing is a tool that organizations use to focus attention on, and to manage the process of, product and process design. Because most of the opportunities to improve cost performance are at the design stage, target costing is a particularly important tool in the organization's attempt to improve its profitability. The objective of target costing is to achieve a product and process design that allows the company to meet a profit target at a price customers are willing to pay.

Kaizen costing focuses on improving an existing process. The role of kaizen costing is to direct the continuous improvement of process cost performance.

Finally, organizations are developing costing systems to identify the costs of decommissioning production systems and recovering their products from customers.

The importance of target costing is that it provides a management tool that coordinates and focuses attention on the process of cost reduction. The importance of kaizen costing is that it focuses attention on the activity of improving the efficiency of existing production systems. Finally, the importance of emerging systems designed to compute product abandonment costs are that the costs that are identified will spur management efforts to design products with lower abandonment costs and also to manage the abandonment process more efficiently.

ENDNOTES

1. Although organizations have used target costing in some form since at least the early 1960s, the period since 1990 has seen an explosion in the articles and texts on target costing. Readers interested in a detailed treatment that includes design and implementation issues should consult S. L. Ansari, J. E. Bell, Irwin Professional Publishing, and CAM-I Target Cost Core Group, *Target Costing: The Next Frontier in Strategic Cost Management* (Burr Ridge, IL: Irwin Professional Publishing, 1997), Chapter 11 of the CAM-I book provides a detailed and interesting illustration of target costing in a hypothetical firm. Another useful reference is R. Cooper and R. Slagmulder, *Confrontational Cost Management, Volume 1: Target Costing and Value Engineering* (Portland, OR: Productivity Press, 1997).
2. See, for example, CAM-I/CMS, *Cost Management for Today's Advanced Manufacturing Systems* (Arlington, TX: CAM-I/CMS, 1991).
3. Historically, Hewlett-Packard frequently designed features into its printers that reflected engineering considerations that customers did not value. When Hewlett-Packard began to design printers that reflected customer requirements, printer costs declined dramatically as features the customers found irrelevant were designed out of the printers. Mercedes Benz automobiles are another example of a product that many automobile industry observers claim are overengineered. Organizations that can set a market price based on realized cost plus a markup, the antihesis of target costing, are becoming rare with the advent of global competition.
4. For a description of Chrysler's SCORE program see J. H. Dyer, "How Chrysler Created an American Keiretsu," *Harvard Business Review* (July–August 1996), p. 42.
5. This example reflects what happens when designers operate without knowledge of what customers value or what product functions cost. For example, the supplier of carpets that Ford uses in its car trucks pointed out that the proliferation of carpet types and colors was creating additional costs without providing a product funtionality that customers wanted or valued. By moving to a single carpet type and color, Ford was promised a savings on carpet materials of more than 5%. Because the cost of purchased components amounts to about 80% of the cost of the automobile, effective supplier relationships are critical for automobile assemblers. The

critical nature of supplier relationships may explain why competitive bids are not used for most parts sourcing in the automobile assembly industry.

6. This perspective is illustrated in the following observation. "Instead of having company engineers provide potential suppliers with detailed designs for a piece of equipment, most steelmakers today issue functional specifications. The functional specs define the equipment needs in terms of the steelmaker's business objectives. . . . Equipment suppliers can propose several ways to meet the goal. This reduces engineering costs and lets the steelmaker take full advantage of the suppliers' expertise." J. Schriefer, "Completing Mill-Construction Projects Faster and Smarter," *Iron Age New Steel* 12, no. 7 (July 1996), pp. 46–52. The idea is to make parts more manufacturable, with higher quality and lower costs, by involving the supplier in part design.
7. For an interesting and detailed description of this process at Komatsu, see R. Cooper and W. B. Chew, "Control Tomorrow's Cost through Today's Design," *Harvard Business Review* (January–February 1996), p. 88.
8. For example, in the early 1990s the General Electric jet engine division fell on hard times as the military and commercial airlines cut back on purchases. General Electric realized that it had to reduce its costs to become more competitive. The organization moved from cost-plus pricing to target costing based on market requirements. In this process, engine customers advised General Electric that an expensive valve used to reduce the fuel consumption of one of its engines was useful but its costs outweighed its benefits. Based on this customer feedback, General Electric eliminated this part from the engine, thereby reducing its costs and increasing its ability to meet the market price.
9. The summary provided in the section is based on T. Tanaka, "Target Costing at Toyota," *Journal of Cost Management* (Spring 1993), pp. 4–11. Readers interested in descriptions of the nature and evolution of target costing can consult Y. Kato, G. Boer, and C. W. Chow, "Target Costing: An Integrative Management Process," *Journal of Cost Management* (Spring 1995), pp. 39–51, or J. Fisher, "Implementing Target Costing," *Journal of Cost Management* (Summer 1995), pp. 50–59.
10. An alternative approach is to focus on product components and to assign the target cost to individual product components on the basis of functionality and the perceived opportunity for improvement. For example, in designing its brakes, ITT Automotive assigns the total target cost for a brake system first to assemblies, then to subassemblies, and ultimately to individual components. A cross-functional team undertakes the process of meeting the assigned target cost. For details on the ITT Automotive approach see G. Schmelze, R. Geier, and T. E. Buttross, "Target Costing at ITT Automotive," *Management Accounting (USA)* (December 1996), p. 26.
11. There are many examples of these types of cost savings. For example, a factory worker on a General Motors design team pointed out that a tiny change in the design of a body panel would reduce the number of stampings needed to shape that panel from seven to five, resulting in a significant cost savings. A factory worker on a Ford design team pointed out that increasing the size of the access opening in a door would significantly reduce the time to install the lock and window hardware and would improve the quality of the work.
12. For example, a manufacturer of food-processing equipment found that it could replace a steel drive shaft with a plastic composite to reduce costs. In turn, this substitution allowed the manufacturer to use a smaller motor in the equipment, further reducing costs. These changes increased functionality to the customer in three ways: the product was lighter, it was more durable, and it consumed less electricity. In this case, value engineering increased functionality while reducing costs.
13. For example, in 1996, after experimenting for several years with a higher grade of dual-coated steel, Toyota switched back to conventional galvanized steel. This was an example of an overengineered product. That is, the functionality was beyond what the customers wanted. Therefore, the customers were unwilling to pay for this feature—meaning that this feature represented a non-value-added cost that could be eliminated without affecting product sales. Earlier, reflecting similar considerations, Toyota announced that it was suspending the practice of painting car parts that were not visible to the customer.

14. Interestingly, the management literature seems to have borrowed this term from the sciences, both physical and behavioral, where it has long been used to describe the contributions of individual factors in multifaceted behavior.
15. The product's design determines its functionality.
16. Japanese manufacturers originally developed kaizen costing. *Kaizen* is the Japanese word for small, continuous, and incremental improvements. Therefore, kaizen costing refers to applying kaizen to cost reduction.
17. For an interesting and detailed description of Olympus Optical Company's approach to costing, see Olympus Optical Company, Ltd. (A), Case Number 9-195-072, Harvard Business School Publishing, Boston.
18. The interested reader can follow along this discussion using the Excel spreadsheet **ch6ex.xls**.
19. The details underlying these, and subsequent cancellations can be found in the Excel worksheet **amach6(a).xls** through **amach6(d).xls**. These have been made available to your instructor.
20. For example, the relevance of measures such as parts per million defects and percent conforming are based on the implicit assumptions that output can be classified as conforming or nonconforming and that every element in each set creates an equal amount of quality cost. Gen'ichi Taguchi (*Taguchi Methods, Research and Development*, American Supplier Institute, 1992, Dearborn, Michigan.)
21. For a discussion of some of the issues related to developing costing systems to compute shutdown costs, see J. G. Kreuze and G. E. Newell, "ABC and Life-Cycle Costing for Environmental Expenditures," *Management Accounting (USA)* (February 1994), p. 38.
22. For an interesting summary of some of the legislation that regulates product take-back see M. J. Epstein, "Accounting for Product Take-back: Accounting for Future Disposal Cost of Products," *Management Accounting (USA)* (August 1996), p. 29.

PROBLEMS

6-1 Cost Commitment

Using published sources, identify the process of cost commitment during various phases of some product's life cycle. Try to find several examples so that you can contrast the rate of cost commitment for different products.

6-2 Functional Analysis

Consider the task of designing an automobile. Identify what you think are the major functions of an automobile and the key components that supply those functions. How might this information be used in a target costing exercise? What is the role of management accounting in this process?

6-3 Reengineering

Using published sources find an example of reengineering. Identify, if you can, what motivated or promoted the reengineering process, the objectives of reengineering, and how the organization decided whether the process was successful. What was the role of management accounting in the example that you found?

6-4 *Kaizen Costing*

Many observers of contemporary management practice have criticized Kaizen costing because of the intense pressures that it places on organization members. Give an example that you have seen or read about that illustrates the type of continuous improvement activity sought by kaizen costing. Do you believe that there is any way of mediating this pressure, or is it an inevitable part of the kaizen costing process?

6-5 *Activity Management*

Consider the process of finding and purchasing a list of grocery items in a grocery store. What activities involve moving, storing, and inspecting? How might the process be changed so that the cycle time, that is the time you spend in the store, is reduced?

6-6 *Activity Management*

Is reducing cycle time always important? Why is reducing cycle time likely to be more important in a fast-food restaurant than in a five-star restaurant?

6-7 *Quality Cost*

By consulting published sources, see if you can develop evidence to support the hypothesis that money spent on preventing, finding, and fixing quality problems before the product reaches the customer outweighs the cost of fixing quality problems once the product is in the customer's hands.

6-8 *Quality Cost*

Can you think of products for which it would be less expensive to forgo prevention and inspection costs and to just fix a quality problem when the customer reports it? Can you think of a general rule for making such prevention/repair decisions?

6-9 *Take-back Costs*

Identify three products for which the take-back costs are high and three products for which the take-back costs are low. Why is it important to identify take-back costs? Find a published example of a situation in which an organization was motivated to change its behavior when it understood the magnitude of one of its product's take-back costs.

6-10 *Life Cycle Costs*

Construct a credible example in which an organization that, in considering a product's life cycle costs, might make a decision not to make the product but that, in the same circumstances, if considering only costs during the product's manufacturing stage it might produce the product. Can you find a published example of a product that would clearly not have been made if the organization had computed the product's life cycle costs?

6-11 *Life Cycle Costs*

Most organizations do not compute the life cycle costs of their products. Why do you think they do not?

6-12 *Target Costing*

The Smiths Falls Time Company (SFTC) assembles sports watches. The watches consist of three main components: the quartz mechanism, the case, and the strap. SFTC sources the components from suppliers and assembles the watches in its factory.

Extensive customer surveys have established that there are three functions for the watches in the niche that SFTC has chosen: time, water resistance, and style. Time is provided by the quartz mechanism; water resistance and style are provided by the case and strap. Replaceable batteries power all the watches. However, once the case is opened to replace the battery, the waterproof nature of the watch is usually lost.

Market surveys have established three price points for three new watches that SFTC now has in the design stage: (1) $30 for a basic watch, (2) $50 for a basic chronograph, and (3) $120 for a multifunction watch.

SFTC has determined, given its facility-sustaining costs and its cost of capital, that the three watches must provide a margin of $4, $8, and $15 to be acceptable.

Based on initial specifications, the supplier of the quartz mechanisms has quoted prices of $8, $15, and $40 for the three watches. Because these mechanisms use standard components and well-understood technology, planners at SFTC consider these costs to be about as low as they can be with very little variation due either to functionality or to cost efficiencies among suppliers. The implication is that any needed target cost reductions will not be wrung out of the quartz mechanism component of the watch.

There are many sources for the watch straps, and prices vary widely based on functionality, which includes appearance, composition, and wearability. Suppliers quoted price ranges for the three watches as follows: $2–$7, $6–$9, and $20–$30. For any given level of functionality chosen, there is very little price variation among suppliers because the watch straps are virtually commodity products and are produced very cost-effectively.

The case provides two critical functions—style and water resistance. And, given the commodity nature of the quartz mechanism, it is the distinguishing feature of the watch. All cases have to be guaranteed to a depth of 50 meters minimum, and customer focus groups indicate that customers find a guaranteed depth of 100 meters desirable. Depending on style and degree of water resistance, suppliers quoted the following price ranges for the watch cases: $5–$15, $10–$25, and $20–35. Both style and water resistance increased in the product price.

Conversations with factory personnel indicated that the estimated costs of assembling, packaging, and shipping each watch were about $5, $7, and $15.

Discussions with the primary supplier of the watch cases have yielded the following facts. For an investment estimated at about $5,000,000, SFTC could provide management advice to one of its case suppliers. This advice would be related to developing better manufacturing methods. These improved methods would likely reduce the cost of each case supplied by about 25%.

Required

(1) Compute the cost ranges for the three watches.
(2) Identify how you would choose the specific strap and case for each watch.
(3) What role does management accounting have in the decisions you made in Part 2?
(4) How would you decide whether to make the investment to improve the efficiency of the case supplier?
(5) Factory personnel indicate that for an investment of about $10,000,000 the existing factory layout could be altered to accommodate more-efficient production. The result would be to reduce assembly, packaging, and shipping costs by about $2 per unit. How would you decide whether to make this investment?

6-13 Reengineering

Southhampton Fabricating makes steel storage boxes. The steel storage boxes have a standard design but are made in different sizes to accommodate customer requirements.

The factory is laid out on a functional basis. Sheet steel is stored at one end of the factory near the loading dock where it is received. Production is triggered when inventory of a particular product reaches a reorder point. Production is in batches that vary from 40 to 200 boxes and depends on the individual product's demand, carrying costs, and setup costs.

When a production order is issued, workers are directed to withdraw an indicated amount of sheet steel from inventory. The steel is moved to the area of the factory where it is cut into the required pieces. The pieces are then moved to the area of the factory where stamping and shaping machines are kept. The machines are then set up for the particular box being made.

When the stamping and shaping work is completed, the work in process is moved to the assembly area, where the pieces are welded into the finished storage boxes and all the work is inspected. The storage boxes are then moved to a storage area where they are held until they are shipped to customers. Therefore, the existing production process requires one major setup for each batch and four moves.

In response to falling profits, senior management undertook a costing analysis of the various factory activities. This costing analysis revealed that, on average, the cost of moving a batch of production was approximately $300, and the cost of setting up the stamping and shaping machines for each batch was $200. An activity analysis revealed that the company processed about 4000 batches of storage boxes each year.

An engineering study suggested that the factory could be reorganized into a cell format with five cells that would specialize in making boxes of various sizes. This reorganization would cost about $20,000,000 and would reduce the number of moves per batch from five to two, and the average number of setups for every five batches would fall from three to one.

Should this process reengineering be undertaken? Make any assumption you feel is necessary to answer this question, but make your assumptions clear in your solution.

6-14 Target Costing and Functional Analysis

Many people have complained that modern computer suites offer programs with many features that users find not only confusing but also useless. (For example, consider how many of the features of your word processor that you use, let alone understand.) How might target costing and functional analysis be applied to software design in order to provide customers with software that has both a target cost and target functionality?

6-15 *Activity Management*

The Paris Bank specializes in loans for automobiles. The automobile loan process is organized as follows. The bank has arrangements with more than 500 automobile dealers to be the preferred supplier of loans. The referring dealership receives a fee of 0.5% of every loan that is written by the Paris Bank.

The business manager of the dealership completes a form with the customer that is required by the bank. The form is then mailed to the bank's main office, where the information on the form is entered into a computer file. Cursory credit checks are then run to identify whether the customer is a potential credit risk. If nothing is found, an interview is scheduled with the customer at a branch that is convenient for the customer. During the interview, a bank representative verifies the information and obtains a signature. The completed form is then forwarded to the bank's main credit office for approval. This process usually takes three to five working days.

The Paris Bank is concerned that it is losing customers to other financial institutions. Evidence suggests that the fastest time for loan approval is two days. Estimates by bank personnel suggest that the cost of the delay in approving a loan *beyond two days* is

$$\text{Cost} = \$30{,}000{,}000^{(\sqrt{\text{days delay}} - 2)}$$

Automobile dealers are also complaining that 10% of the customers balk; that is, they withdraw their offer of purchase during the time that they are waiting for approval. The present value of the lost profits from a lost customer amounts to about $3,000 to both the bank and the dealership.

What would you suggest in this case? Make any assumptions concerning the cost of making improvements, the number of customers, or any other relevant matter that you feel are necessary to answer this question.

6-16 *Life Cycle Costing*

St. Agatha Company manufactures laser printers. Government agencies have advised the company that for all new products it will have to provide for recycling of used toner cartridges.

A study has determined that St. Agatha Company has three options. It can design a printer with cartridges that the customer refills with toner, eliminating the need to recycle the cartridges. It can design cartridges that it will recover and refill with toner. Or it can design cartridges that it will recover, crush, and sell the resulting plastic as scrap.

Planners at St. Agatha are considering the design of a cartridge for a new printer. The company expects that customers will use about 600,000 cartridges a year during the five-year manufacturing life of the new printer. After that, the company expects that cartridge use will fall at the rate of 200,000 per year. The cost of making a cartridge is $60. Assume that the company's before tax cost of capital is 12%.

Marketing staff estimates that printer sales will suffer if it offers a cartridge that customers have to refill. Therefore they plan to cut the printer prices to maintain volume. The net effect on profits is expected to be about $6,000,000 per year during the five-year manufacturing life of the printer. Under this alternative, the company would price the replacement toner to break even and would make 250,000 cartridges in each of the five-year manufacturing life of the new printer with the balance of use in the first five years and the last two years accounted for by refills.

The marketing staff has estimated that for every 100 cartridges used, only 80 will be returned. Returns are made in the year that the cartridge is used. The company is expected to pay a $15.00 landfill fee at the end of the product's lifetime for every cartridge disposed of.

The cost to clean and refill a cartridge is $20. Under this alternative, the company would make 500,000 cartridges in each of the first two years and rely on recovered cartridges after that.

If the company chooses the crushing alternative, it must purchase a plastic recovery machine at the start of the project. The cost of the machine is $5,000,000 and it would be useless when the product is abandoned. The recycled plastics and other materials can be sold to yield $38.00.

Ignore the effects of taxes in answering this question.

If the company's objective is to minimize the take-back cost, which alternative should it pursue: (1) make a cartridge that customers can refill, (2) make a cartridge that is recycled, or (3) make a cartridge that is recovered, crushed, and remanufactured?

■ CASES

PIEDMONT EXPRESS FORMS: PROCESS ANALYSIS FOR STRATEGIC DECISION MAKING[1]

Part A—Introduction

Henry faces a tough decision. Although the forms business is undergoing structural changes, his business is growing, so his organization needs to change and grow. However, there is no space for expanding in the building rented by his company. He and his partner are planning to build a warehouse and office complex to house the company to meet its space needs well into the future, but they are not sure how big a facility to build. To address this issue, Henry needs to make an analysis of his firm's existing operations, and in light of the industry's change, make a decision on how much emphasis to put on the various aspects of his business.

Company Profile Piedmont Express Forms, Inc. (PEF) was started in 1983 by Henry Johns

Paul E. Juras, Paul A. Dierks, and Henry Johns. Reprinted with permission from AICPA Case Development Program, Case No. 94-09.

[1]This problem illustrates the use of process mapping to support reengineering. You should begin this exercise by reading M. Morrow and M. Hazell, "Activity Mapping for Business Process Redesign," *Management Accounting (U.K.)* (February 1992), pp. 36–38.

and Larry Atkins. There are now nine employees generating revenues of approximately $2,000,000 per year. The company occupies about 1,500 square feet of office space and 3,500 square feet of warehouse space in Greensboro, North Carolina.

PEF is a distributor organization providing business forms in both national and local markets. The firm also provides other products and services to businesses, including printed products, plastic cards, data collection and bar coding devices for information transfer, consulting work in the form of systems analysis for work simplification, and advertising specialties (promotional products or "give aways"). The latter is expected to be at least 10% of the company's revenue in the current year.

For clients in its local market, consisting of the counties surrounding Greensboro, N.C. (referred to as the Piedmont Triad Area), PEF specializes in providing forms management and inventory control for clients with large forms budgets. Within this market PEF offers three levels of service:

Level 1. Clients with no warehousing needs for forms are serviced by having a sales representative go by on a regular basis to take orders, offer solutions to problems, etc. Any goods purchased are shipped directly to the client by the supplier and billed at the time of shipment. No warehouse or delivery service is provided.

Level 2. For clients using large volumes of forms, but with inadequate storage space, PEF performs the services outlined in level 1, plus receiving and storing goods in their warehouse for later distribution, usually on a just-in-time basis. The goods are billed in full when they arrive at PEF's warehouse.

This level of service requires much more activity. The warehouse must receive and store goods, generate picking tickets, pick the items, and deliver them, while accounting must process the release, adjust inventory, and process an invoice for a small amount of freight.

Level 3. Identical to level 2, except that a custom product is stored, and billings for the goods aren't made until the goods are delivered to a client.

PEF currently averages between 120 and 150 deliveries each month to Level 2 and Level 3 firms.

In their national market, PEF has formed strategic alliances with software vendors around the country to provide the necessary forms for purchasers of the software. PEF guarantees the compatibility of their forms with the software system. This market represents about 15% of PEF's business and serves 210 clients in 30 states. While the national market represents nearly 50% of the customer base and less than 20% of revenue, Henry believes that once such a client is obtained, only 10 to 15 minutes of staff time per order is needed and little, if any, warehouse support is required of these customers. PEF's average gross margin on it's national customers is 38%.

Although he takes pride in keeping up with the changes in the forms industry, Henry Johns feels that the main focus of his business is to help capture and manage the movement of information through an organization, whether or not it requires a paper form. The services that help meet customer needs include ordering, warehousing and distribution, the redesign of business forms to make them more useful, and gathering and distributing management information relating to the use of these products. Form usage information includes showing past usage and stock-outs by end users, past ordering behavior, the possibility of combining orders based on expected usage to save on order processing and delivery costs, and information on what has been shipped where and when. For example, an insurance client may want to know how many insurance application forms were used each month nationwide for a two year period. PEF could provide this information in seconds, whereas the client might take days to gather the same information.

Henry is aware that his firm must offer a variety of products and services, it must be service oriented, and be ready to adopt or adapt to the latest trend. His firm has responded to these pressures through diversification into such areas as bar coding services and a newly formed imaging division. However, Henry feels that forms, as his "base business," provide an entree to new clients who will use the variety of other products and services PEF offers. Thus, forms will always be a product line of PEF, and the only issue is how big the local segments of PEF's business will be—and how much warehouse space is needed.

PEF's managers understand that different activities are required to support each service or product offered, and a different markup is used for each service level. However, since management doesn't know the costs of providing the support required, they: (a) don't know how much net profit is generated from each level of service; and (b) have no way of knowing whether or not any given client is profitable.

More importantly, as PEF looks to the future, it becomes difficult to target any specific type of client (i.e., national or local) since they don't know which type is the most profitable to serve. At the local level, they prefer serving at Levels 2 and 3 because gross profits are higher and there are fewer competitors, but they think the support required at those levels absorbs much of the gross profit. Thus, they are unsure over how aggressively they should pursue this segment of the business, or, to focus their efforts on the national market. This decision impacts their long run plan to build an office and warehouse facility, and, if they build, what warehouse capacity to provide.

Financial Information Table 1 presents PEF's Sales, Cost of Sales, and Profits for 1993. Table 2 shows the sales and gross profits for the largest local customers not requiring warehousing and the largest local customers needing warehousing.

A quick computation of the costs and revenues involved in the delivery of goods, in-

TABLE 1

Sales		
Sales—Custom		$1,519,433
Sales—Stock		225,785
Sales—Other		236,247
Sales—Forms Design		13,333
Freight Out		96,550
Freight Out-Forms Express		7,271
	Total Sales	$2,098,619
Cost of Sales		
Cost of Sales—Custom		$ 947,158
Cost of Sales—Stock		164,433
Cost of Sales—Other		162,371
Forms Design Cost		22,256
Freight In		110,046
	Total Cost of Sales	$1,406,264
	Gross Profits	$ 692,355
	Selling, General, and Administrative	586,355
	Pretax Profit	$ 106,000

TABLE 2

LOCAL NO WAREHOUSING			LOCAL WITH WAREHOUSING		
CLIENT	TOTAL SALES	GROSS PROFITS	CLIENT	TOTAL SALES	GROSS PROFITS
1	$ 99,599	$ 31,839	1	$ 147,789	$ 50,302
2	87,220	14,109	2	33,079	8,644
3	30,825	11,006	3	181,545	56,341
4	23,660	7,992	4	210,300	46,986
5	20,702	7,413	5	66,739	22,091
6	28,945	9,920	6	21,413	7,819
7	19,055	6,922	7	24,472	10,530
8	124,468	24,521	8	209,580	93,392
			9	71,679	28,147
			10	76,617	25,432
			11	22,437	5,919
Totals	$434,474	$113,722		$1,065,650	$355,603

cluding running "Forms Express" is given in Table 3. Some clients will not accept separate billing for "Forms Express" or delivery services so the delivery charge is built into the selling price for these customers.

TABLE 3

Expenses	
Local delivery expense	$ 215.23
Gas expense	1,200.00
Van maintenance	1,181.46
General warehouse	873.99
Compensation warehouse	20,679.00
Insurance—medical warehouse	1,375.23
Insurance—disability warehouse	388.08
Insurance—van warehouse	432.84
Temporary help warehouse	1,331.03
Workman's compensation warehouse	875.00
FICA warehouse	1,551.00
Rent	$ 8,250.00
Subtotal	$ 38,352.86
Freight-in	110,046.00
Total delivery costs	$148,398.86
Revenues	
Freight-out revenue	$ 96,550.00
Forms Express revenue	7,271.00
Subtotal	$103,821.00
Reclassify sales as delivery revenue	$ 5,000.00
Total delivery revenue	$108,821.00

Part A—Questions

(1) Using only the information in Part A, prepare a brief report giving Henry Johns your assessment of the situation at PEF in light of the decision(s) they face (e.g., whether to build a warehouse) and the available data. Your report should address PEF's overall profitability, and the profitability of its various markets and customers. How would you advise Henry at this point concerning the two local markets and the construction of a warehouse? (Refer to this report as the Preliminary Analysis.)

(2) Read the Overview of the Forms Industry in the Appendix. In light of this overview and the preliminary analysis of PEF's financial data, how would you advise Henry Johns?

(3) Henry Johns heard about activity-based costing at a professional meeting and wonders if it could be used at PEF. Describe activity-based costing, explain "how it works," and point out how it might be useful to PEF in their current situation. How would you go about applying activity-based costing at PEF? What additional information would you want from PEF to apply it to their operations? How would you go about acquiring this information?

Appendix to Part A: Overview of the Forms Industry

The forms industry is a mature, $8 billion industry, but it is declining even as new players enter. It's an industry that doesn't have to build a need for the products it provides, since the need for forms to operate a business already exists—and will probably continue to exist. But, the industry is facing a smaller market as technology and hardware make it possible for end users to design and print their own forms.

Customers are also reducing the number of vendors they buy from. Suppliers that cannot "do it all" are likely to lose out to those that can. Being a full service supplier (warehousing, distribution, consulting, information support) is becoming more important.

Profits have been reduced and competition has increased significantly. Clients have always wanted price, service and quality, but today they'll switch suppliers as soon as something goes wrong, or for the difference of "a few dollars." Also, the line between distributor and manufacturer has begun to blur. Many distributors now have print shops and manufacturers are selling directly to customers. Mergers and acquisitions have been, and will continue to be, a means of survival. But some owners, who are too close to retirement to start over, are likely to sell out. Others will stay in the business through mergers.

The key word for the industry is "change." In order to survive, distributors must add services, expand product lines or diversity to add value and maintain margins. However, diversification means that traditional forms products are a smaller percentage of sales.

The industry SIC code (2761) description of the industry is "Manifold Business Forms." In an earlier time this may have appropriately described the central focus of designing, printing and distributing continuous, multi-copy, fan-fold, and custom business forms. However, today it is far too succinct a label for an industry whose members refer to themselves as either distributors, manufacturers, "forms professionals," or "customer service professionals"—the strength of this trend is seen by the latter group's formation of a new association: Society for Service Professionals in Printing (SSPP).

The degree of industry diversification is found in the product and service ads regularly appearing in *FORM* magazine, the official publication of NBFA, the Association for Independent Marketers of Business Printing and Information Management Services. Segments of the industry include:

Forms—pre-printed, custom continuous, instantaneous (computer generated and forms composition software), tax forms, "smart cards" (contain microprocessors), stock mailers, guest checks

Printers—of forms, checks, stationery, announcements

Graphics services

Office stationery supplies, like "plain" envelopes, peel apart envelopes, paper stock (cutsheet), rubber stamps, cash register rolls

Labels and tags

Direct mail servicing

Bar coding scanners and supplies

Plastic cards (for credit cards, ATM cards, etc.)

Among the more popular products that firms in the forms industry have added are advertising specialties—promotional products or "give aways." Ad specialties have had a strong growth pattern for several years. In 1990, sales of ad specialty items were more than $5 billion, which was an 11.9% increase from the prior year. The following year saw a 2.9% increase.

Forms firms are also placing increased emphasis on security documents to reduce the chance of forgery by using specialty papers and adding foil stamping, embossing, diffractional holographic foils, and artificial watermarks.

Greater use of computers and laser printers in firms of all sizes provides new opportunities to the forms industry for supplying equipment, supplies and services. Laser printers and computer generated forms software make it possible to create electronic templates for data entry, and the completed form can be saved and printed on demand. Instead of stocking preprinted multilayer forms, low cost and high speed laser printers make it faster and cheaper to print multiple copies of the same form.

A natural extension of an industry built on printing and distribution forms, is document imaging. Bulky paper forms are converted to electronic format for storage and processing by an expanding service labeled as "document imaging."

Also, the simplicity of form creation often results in non-standard forms, which open opportunities for forms and work process consulting.

However, it is service that tends to set companies apart from their competition: "It's the little extras that count the most." The most important service a distributor offers is information about new products and technologies: "Distributors must become more knowledgeable and help customers find new solutions to their problems."

The forms industry has matured and forms have become commodity items. To survive in a mature marketplace, firms must expand product lines, add services, offer new value-added products, and become full service vendors capable of providing just about any printed item or related service, including distribution. The survivors will be those who proactively exploit the changes in the industry, not those merely reacting to them. Some forms distributors and manufacturers may not survive the changes.

Despite the implications of the changes occurring in the forms industry, Henry Johns

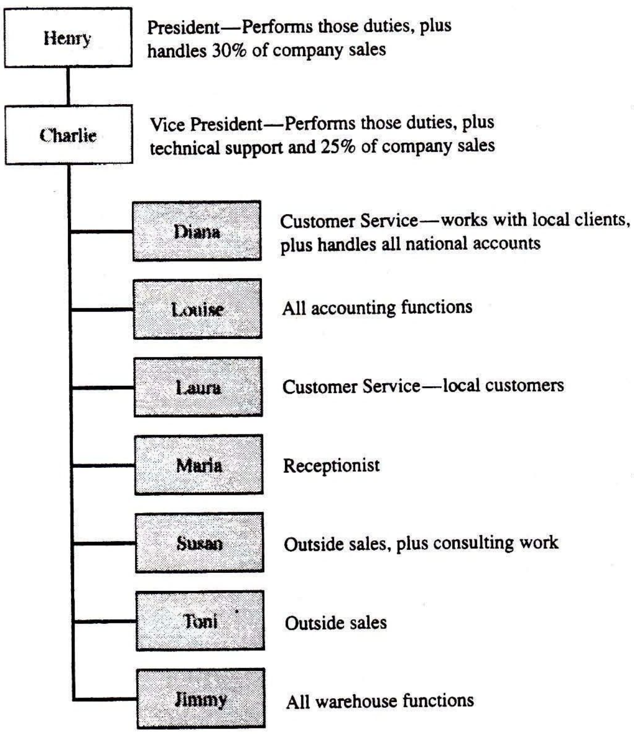

EXHIBIT 1 Organizational Chart

EXHIBIT 2 Business Process Outline

DESCRIPTION OF ACTIVITY	IDENTIFY PERSON WHO PERFORMS THE ACTIVITY		
	NATIONAL MARKET	LOCAL—DIRECT SHIPMENT	LOCAL—VIA PEF WAREHOUSE
1. Solicit new client(s)	Inside sales	Sales rep.	None
2. Solicit business from a client		Sales rep.	None
3. Client requests a quote	Inside sales	Sales rep.	None
4. Follow up quote with a client contact	Inside sales	Sales rep.	None
5. Contact plants to determine cost (bid)	Inside sales	Customer service	None
6. Wait for arrival of bids	Inside sales	Customer service	None
7. Select quote to give to client	Inside sales	Sales rep.	None
8. Give quote to client	Inside sales	Sales rep./cust. serv.	None
9. Client places order			None
10. Write up order	Inside sales	Sales rep./cust. serv.	None
11. Do forms composition	Inside sales	Sales rep./cust. serv.	None
12. Key order into computer	Inside sales	Sales rep./cust. serv.	None
13. Proof obtained	Inside sales	Sales rep./cust. serv.	None
14. Send proof to client	Inside sales	Sales rep./cust. serv.	None
15. Wait for proof from client	Inside sales	Sales rep./cust. serv.	None
16. Proof approved by client	Inside sales	Sales rep./cust. serv.	None
17. Order printed out of computer	Inside sales	Customer service	None
18. Order sent to plant	Inside sales	Customer service	None
19. Wait for acknowledgment of order		Customer service	None
20. Verify acknowledgment	Customer service	Customer service	None
21. Contact plant if problem exists	Inside sales	Sales rep./cust. serv.	None
22. File acknowledgment	Customer service	Customer service	None
23. Plant ships order and invoices IBP	Plant	Plant	None
24. Key accounts payable into computer	Accounting	Accounting	None
25. Invoice the client	Accounting	Accounting	None
26. Assemble order and file it	Admin. assist	Admin. assist	None
27. Pay invoice to plant	Accounting	Accounting	None
28. Receive client's payment	Accounting	Accounting	None
29. Shipment arrives at warehouse (re: 24)	Warehouse	None	None
30. Check shipment for damage	Warehouse	None	None
31. Mark quantities on shipping papers	Warehouse	None	None
32. If not damaged, put stock away	Warehouse	None	None
33. Send shipping papers to accounting	Warehouse	None	None
34. Write up a release	Inside sales	None	Customer service
35. Enter release into the computer	Inside sales	None	Customer service
36. Picking ticket printed by computer	Inside sales	None	Customer service
37. Picking ticket forwarded to warehouse	Inside sales	None	Warehouse
38. Warehouse pulls product	Warehouse	None	Warehouse
39. Warehouse ships or delivers order	Warehouse	None	Warehouse

continued

DESCRIPTION OF ACTIVITY	IDENTIFY PERSON WHO PERFORMS THE ACTIVITY: NATIONAL MARKET	LOCAL—DIRECT SHIPMENT	LOCAL—VIA PEF WAREHOUSE
40. Warehouse files papers and forwards to acct	Warehouse	None	Warehouse
41. Accounting completes the release	Accounting	None	Accounting
42. Paperwork is filed away	Admin. assist	None	Admin. assist.
43. Invoice the client, if appropriate	Accounting	None	Warehouse

is confident of the continued existence of the forms business, and its profitability. He once stated, "A forms professional could move to Los Angeles tomorrow, open a forms business, and survive."

Part B

The Preliminary Analysis confirmed Henry's belief that forms firms must offer a variety of products and services, be service-oriented, and be ready to adopt, or adapt to, the latest "trend." Thus, he must closely manage his current range of activities, but he must also be vigilant in finding and evaluating other forms-related business lines that can "turn a profit." More specifically, the analysis didn't provide a great deal of insight into the fundamental problem he faced: how much emphasis to put on the local markets, especially those that use warehouse space, in order to decide whether or not to build a new warehouse facility.

The preliminary analysis provided mainly firmwide, general information. What is needed is detailed information, including work done to run the warehouse (picking, loading and delivering orders by market and client category), and a breakdown of administrative costs, especially those that relate to sales and customer support for the local markets. To address this issue, Henry needs to analyze his firm's sales, administrative and support operations. A more sophisticated analysis is necessary, and process analysis is the logical step to take.

As the initial step in this analysis, Henry prepared the organizational chart in Exhibit 1 and the description of how PEF goes about doing its work, which appears in Exhibit 2.

Part B—Questions

(1) Henry was unsure of what process analysis was and what kind of work it entailed. Describe process analysis, including the steps involved and its benefits to an organization.

(2) Using the Business Process Outline provided in Exhibit 2, draw a process flowchart.

(3) (a) Prepare a memo to PEF management evaluating the information added as the result of completing the process flowchart in Question B2. (b) Point out what additional steps would be needed to use activity-based costing to determine the cost of serving each of PEF's major markets or service levels and, ultimately, to calculate the profitability of a specific customer. Include the types of data needed and describe how they can be obtained.

ACTIVITY-BASED MANAGEMENT AT STREAM INTERNATIONAL*

All these proposals for cost reduction seem worthwhile. But we don't have the managerial resources to do them all at the same time. How shall we choose among them?

Michael Michalski, Division Director

Stream International was a new company, created in April of 1995, when the Global Software Services group of RR Donnelley was merged with a previously independent company, Corporate Software. In July of 1995, the six senior managers of Stream's Crawfordsville, Indiana facility were about to meet with Division Director Mike Michalski. (See Exhibit 1 for the senior organization chart at Stream's Crawfordsville plant.) The plant had just completed the first three months of an activity-based management (ABM) project. The data collected to date revealed unexpectedly high costs for administrative and support processes such as materials management, quality, billing, and shipping. Michalski had asked the six managers to prepare recommendations for process changes at the plant based on the ABM data. The managers had spent two weeks poring over the activity cost data as they prepared their recommendations for the meeting (see summaries of the five proposals in the Appendix). During the meeting, the senior management team would listen to presentations about the proposals and make a decision about which to implement. The stakes were high for Crawfordsville. The business and operations at the plant had changed dramatically during the past ten years. In addition, the Crawfordsville facility was one of the first in an RR Donnelley-owned company to perform an ABM study, and the results could be pivotal for the success of ABM in Stream and the larger world of RR Donnelley.

Background

In the early 1970s, the Crawfordsville plant was part of RR Donnelley's Book Division. It was the leading printer of religious books, texts, encyclopedias, and other reference books. The huge web presses and extensive storage in the Crawfordsville plant were well suited to this market niche. In the mid-1970s, the Book Division installed several smaller "narrow web" presses in the Crawfordsville plant so that it could enter the trade book market. With the flexibility from the new machines, Donnelley soon became the largest trade book publisher in the United States.

Short response time and a flexible production environment enabled the Book Division to evolve in a new direction in the early 1980s when it became the leading supplier of manuals and documentation for IBM personal computers. In 1987, the division installed a diskette duplication facility in the Crawfordsville plant so that the Book Division could be a full-line supplier to IBM and also attract additional work from other personal computer companies. Two years later, the software documentation business had grown sufficiently that Donnelley created a new business unit called "Documentation Services." By 1993, the growing demand for diskette duplication services was helping to offset declines in traditional printing services. That year the name of the business unit was changed to Global Software Services (GSS). The name change reflected the division's

*Norman Klein and Professor Robert Kaplan prepared this case as the basis for class discussion rather than to illustrate either effective or ineffective handling of an administrative situation.

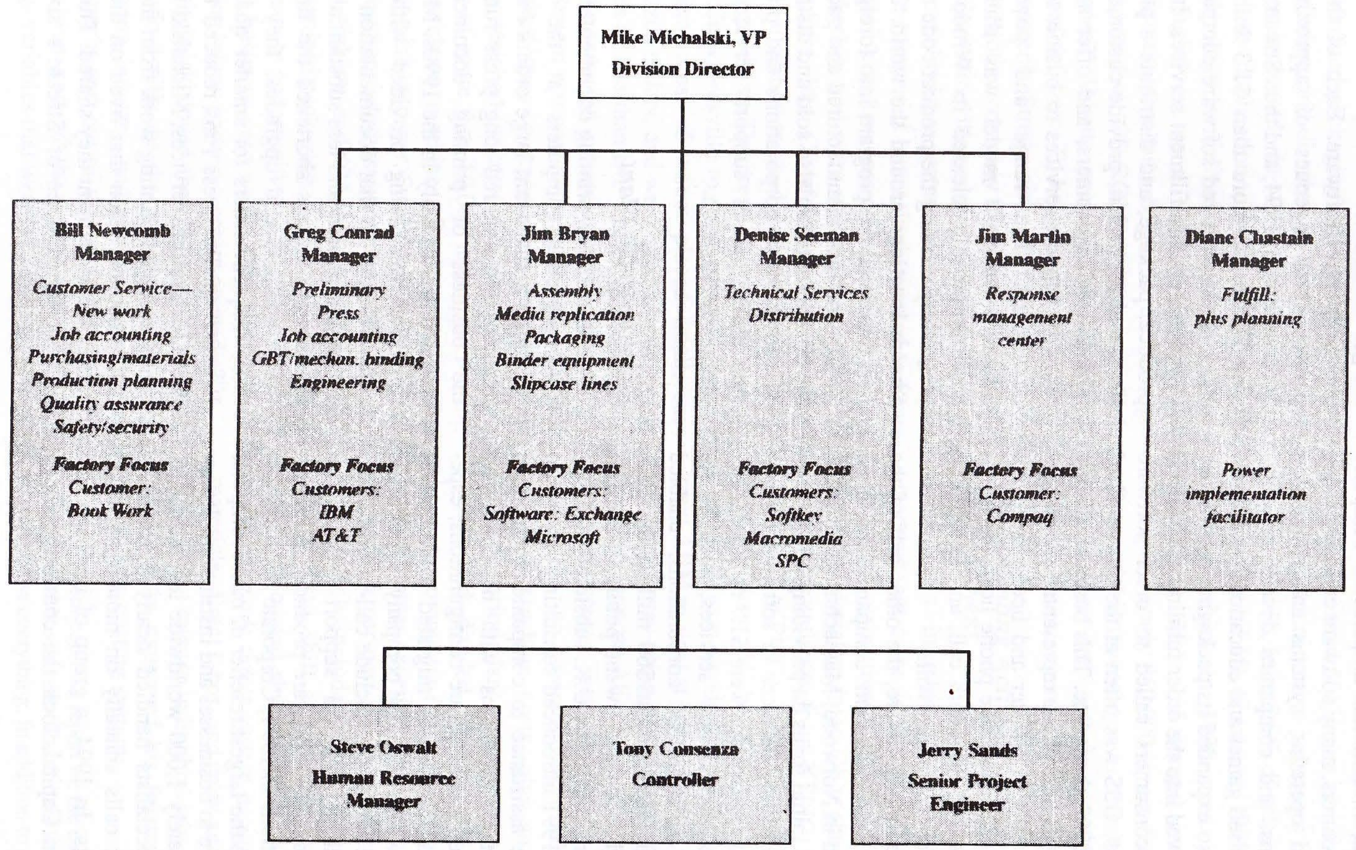

EXHIBIT 1 Organizational Chart for Crawfordsville Facilities

much broader mix of customers, which now included, in addition to personal computer manufacturers, many software companies that supplied operating systems and application programs, and companies developing computer-based games and educational programs. GSS also expanded its packaging capabilities and moved into the order fulfillment business. When consumers called to order software products, GSS was often at the other end of the "1-800" phone line. This business quickly grew to include phone representatives who received calls to register and license software products. In 1994, the phone licensing group celebrated its millionth call, and in 1995, it logged over 2 million calls.

Corporate Software, the other half of the newly formed Stream company, had been founded in Norwood, Massachusetts in 1983, with an initial focus on providing information and consulting services to software companies. First-year sales were $1.7 million. Internal growth and new services, such as reselling software to corporations, enabled sales to reach almost $60 million in 1987, when the company went public. Corporate Software launched a U.K. subsidiary in 1986, and in 1991 introduced consulting services to provide assistance to companies when they encountered problems with new software packages and hardware configurations, especially as companies migrated to Microsoft Windows. In 1993, the company expanded its support services to include call-in help desks and call-in technical support services for major business software products. With two acquisitions in 1994, Corporate Software had become the largest reseller of microcomputer software to businesses and institutions. Its approximately 1,000 worldwide technical support specialists handled nearly 3.5 million support calls annually on more than 1,000 products. In 1994, a group of investors, led by Bain Capital, took the company private again.

Stream was created in April 1995 by a merger between Donnelley's GSS division and Corporate Software. Each of the new partners had revenues of approximately $650 million in 1994, and thus Stream anticipated sales of more than $1.3 billion in 1995. Stream offered software companies a complete set of fulfillment services. It could produce, package, and distribute a product, license or register it, provide customer support to retail customers, and offer a broad range of support services to businesses and institutions. The range and power of Stream's business model was illustrated when Microsoft released its Windows 95 product by sending the product code to nine Stream locations around the world. Stream first translated the program into foreign languages and then manufactured and packaged the product. Stream also sold and distributed Windows 95 to corporations and provided consulting, call-in support services, and product registration.

Crawfordsville Plant

In the mid-1980s, printing documentation for IBM personal computers at the Crawfordsville plant meant large orders for hefty manuals that required long press runs. But the business of printing documentation changed dramatically in the 1990s. More information was being provided within the software itself so that documentation manuals became shorter and less substantial. Also, as software makers shortened the time between versions and upgrades, they placed more frequent orders for smaller quantities. Because smaller press runs reduced the demand for printing services, Michalski had recently accepted printing work from the Donnelley book division that lived on the other side of the huge plant they shared. This work fully occupied three of Stream's six large web presses.

Fortunately, as income from printing diminished, the demand for diskette duplication, customized packaging of software and documentation, and distribution and licensing services increased. In 1994, the demand for diskette duplication peaked at 46 million. Technology for delivering software was continuing to evolve as software and personal computer companies began to use a single compact disc (CD-ROM) to replace multiple magnetic diskette packages for newly purchased software. To keep abreast of these developments, Stream arranged for a partnership with another company to replicate CD-ROMs.

Crawfordsville's commitment to the fulfillment business seemed to be working. Software companies increasingly wanted to focus on their core business of software design and marketing, and were willing to outsource to suppliers, like Crawfordsville, the production, distribution, and support services for their products. This trend, however, was leading Crawfordsville to serve many more customers, most of whom placed small, customized orders, and were expecting response times of less than two weeks, down from the 1980s expected turnaround of two months.

Stream was now doing short runs of several hundred items on expensive machines, specifically designed for customized runs, as well as runs of more than 10,000 items on efficient, high-volume machines. But even more than putting ink on paper, Stream was also involved in customer administration and technical support, diskette and CD-ROM replication, and customized packaging. As Michalski recalled: "The new opportunities forced us to confront what business were we in. Was our business putting ink on paper or content on media?"

Michalski loved the challenge of keeping Crawfordsville ahead of the curve of a rapidly evolving industry, and was well aware that getting in and out of technology at the right time was part of the game. But given the many variables that were so tough to manage, and the rapidly evolving technology and customer base of the business, he needed knowledge and control of his cost structure. For example, administrative expenses had been rising steadily, from 2.9% of sales in 1992 to an estimated 3.4% of sales in 1995. Also, inventory, which in 1990 used just under 100,000 square feet of storage, was projected to require nearly 250,000 square feet in 1995. Some of this inventory was diskettes held on consignment for specific customers, and work-in-process more than one-year old.

Implementing Activity-Based Management

Michalski's introduction to activity-based management came in early 1995, when RR Donnelley executives told him of an initial project undertaken in an Ohio plant with the help of consultants from KPMG Peat Marwick LLP (KPMG). When the ABM concept was explained, Michalski agreed that Crawfordsville was an ideal candidate to be the next ABM project at Donnelley.

Stream was using a traditional job cost accounting system. All machines were in a separate cost center. The cost of the 2- to 15-person crews to operate the machines, the traceable machine costs, plus an allocated share of period plant expense were added together and divided by budgeted machine hours to compute a machine burden rate per hour. All other expenses were applied to jobs based on a per-person crew burden rate per hour, which included direct wages, fringe benefit costs, shift and overtime premiums, plus an allocated share of plant salaried expense. A work ticket system assigned direct materials, direct labor, and crew and machine time burden rates to individual jobs.

Michalski expressed his frustration with the existing costing system:

> The system couldn't report on the costs of individual businesses. The dollars were spread out across everything. In addition to not

> knowing the costs of doing business with external customers or with the Book Division next door, we were throwing resources at problems relying on our instincts to tell us what was worth doing. I needed to know what kinds of process changes mattered most, and how much should I be willing to spend.

Activity-based management promised a more accurate way of understanding and assigning costs to jobs and customers. With ABM, Stream could link the range and extent of services required by each customer, and then estimate how much it was costing to serve the customer. When the project was complete, Stream would also be able to do predictive costing and develop new pricing guidelines. Equally important, ABM would allow Stream to see early profit trends, or better predict the cost of new business activity.

Michalski knew that he had to balance the interests of Stream's various constituencies as he embarked on the ABM project. The new shareholders wanted cost reduction, higher return on net assets, and business growth. Customers valued faster time-to-market, lower prices, and better value for their money. Software companies, like Microsoft and Lotus, were now offering suites containing word processors, spreadsheets, database managers, and graphics presentation packages that had previously been sold separately. These companies received much lower prices from software sold within suites, causing them to place great pressure on suppliers to reduce the costs of documentation, media, and support services.

The employees were especially important. Michalski viewed the ABM effort as an alternative to the brute force approach to solving problems, asking employees to work harder and for extended hours. He brought workers into the picture by explaining the ABM project to worker committees, communicating to them through the biweekly newsletter, and asking for the help of supervisors. He understood the delicate paradox of management wanting to solicit information from employees to learn what process changes should be made, but at the same time having to assure workers that they would not lose their jobs. Fortunately, Michalski knew that the Book Division, with whom he shared the facility, was growing its business through expanded production of trade books, especially those related to personal computers, such as Que's highly popular "... for Dummies" series written for the myriad newly released and continually updated software programs and operating systems. Michalski felt that the Book Division could likely absorb any employees that were no longer needed as a result of process improvements in Stream.

Michalski appointed a three-person team for the initial ABM project. Denise Seeman, a five-year veteran at Crawfordsville, was the project manager. Seeman, initially a supervisor on the floor was now manager of the information technology department, manager of distribution, and of two customer service teams. Kathy Reik, also in the information technology organization, supervised technical services and formerly supervised areas such as production scheduling and materials handling. Karen Session, an accounting supervisor from the controller's division, completed the team.

The project started with the team getting training and project planning from the KPMG consultants. The team, after talking to supervisors and managers, agreed to collect activity information for 12 basic business and support processes. Then, the team and consultants began to create an all-inclusive activity dictionary that listed every kind of work activity done in the plant (other than that performed by direct labor). Eventually, the team identified 161 different activities. (See Exhibit 2 for a summary of the activity dictionary, organized by the 12 basic processes.) Session and Reik then conducted surveys over the next two weeks, asking a sample of approximately

EXHIBIT 2 Summary of ABM Project Dictionary for Crawfordsville

1. **Understand Markets and Customers**
   - 1.1 Determine customer needs and wants
   - 1.2 Measure customer satisfaction
   - 1.3 Monitor changes in market or customer expectations
2. **Develop Vision and Strategy**
   - 2.1 Monitor the external environment
   - 2.2 Define the business concept and organizational strategy
   - 2.3 Design the structure, goals, incentives, and relationships between organizations
3. **Design Products and Services**
   - 3.1 Develop new product/service concepts and plans
   - 3.2 Design, build, and evaluate prototype products/services
   - 3.3 Refine and test existing products/services
   - 3.4 Prepare for production
4. **Market and Sell**
   - 4.1 Market products or services
   - 4.2 Sell products or services
   - 4.3 Accept and enter customer orders
5. **Produce and Deliver**
   - 5.1 Plan for and acquire necessary resources or inputs
   - 5.2 Convert resources or inputs into products
   - 5.3 Make delivery of manufactured product (bulk shipment)
   - 5.4 Fulfill orders (variable quantity fulfilled shipments)
     Includes any fulfilled orders in all buildings
     Includes D.R.O.P.P.
   - 5.5 Deliver revenue-generating service to customer
   - 5.6 Manage production and delivery
6. **Invoice and Service Customers**
   - 6.1 Bill the customer
   - 6.2 Provide after-sales support
   - 6.3 Respond to customer inquiries
7. **Develop and Manage Human Resources**
   - 7.1 Create human resource strategy
   - 7.2 Hire employees
   - 7.3 Train and educate employees
   - 7.4 Recognize and reward employee performance
   - 7.5 Ensure employee well-being and morale
   - 7.6 Plan employee compensation and benefits
8. **Manage Information (excludes prelim computer manufacturing equipment: Scitex, etc.—see 5.6.4)**
   - 8.1 Plan for information resources management
   - 8.2 Develop and deploy information systems
   - 8.3 Manage and maintain existing information systems
   - 8.4 Manage and maintain other communication systems
9. **Manage Financial and Physical Resources**
   - 9.1 Manage financial resources
   - 9.2 Process finance and accounting transactions
   - 9.3 Report information
   - 9.4 Conduct internal audits
   - 9.5 Manage the tax function
   - 9.6 Manage physical resources (building, property, and nonmanufacturing equipment)
10. **Executive Environmental Management Program**
    - 10.1 Execute environmental management program

continued

EXHIBIT 2 Summary of ABM Project Dictionary for Crawfordsville

11. Manage External Relationships
- 11.1 Manage external relationships

12. Manage Improvement and Change
- 12.1 Measure and monitor overall organizational performance
- 12.2 Conduct quality assessments
- 12.3 Benchmark performance
- 12.4 Make process improvements
- 12.5 Implement TQM and employee involvement

250 workers how much time they spent on the 161 activities. While the surveys were under way, Michalski spent extra time on the floor to make sure the workers understood and were comfortable with the process.

Session reflected on the complexity of this initial effort:

> Management really liked seeing costs grouped by activities. But maybe we went into too much detail when we created the dictionary. The activity dollars showed that some of these activities were pretty inconsequential and could have been combined into a higher-level definition.

During the next project phase, Session prepared data files for import. She had to format the general ledger files and personnel data into import files that were downloaded into the personal computer containing the ABC software. The ABC software processed the data into activity costs and provided a variety of reports and graphic presentations of the results.

Early Results

By June 1995, the ABM team had calculated costs for the 161 activities, and the 12 aggregate business processes. (See Exhibit 3 for the expenses and personnel assignments to the 12 business processes, and Exhibit 4 for a list of the 20 activities with the highest personnel costs.) Bill Newcomb, manager of administrative and support activities, recalled the initial surprise from the numbers.

> The costs of some of the activities seemed surprisingly high. But as people delved into the numbers, they came to agree that if that's what I said, it's probably true. The data forced people to think in a new way. The big insight was that we had lots of small volumes of cost involved with an activity, a little here, a little there, and all these little pockets added up to a big number.[1]

The team shared selected parts of the analysis with about 100 people to get their opinions on what to do with this information. Some of the results made a strong and immediate impression on Stream managers. For example, there were large lots of old product that was not turning. Many of the orders placed by IBM in 1992 and 1993 were still sitting in storage in the Crawfordsville facility. Additional storage space had been added to the plant in December 1993 to handle the growing supply of mostly IBM-specific inventory.

Newcomb explained that existing practices had led to a similar problem with work in progress (WIP):

> It's standard publishing practice to print 11,000 items to fill an order for 10,000. Then you will bind 10,500 and store the extra 500 believing it will be useful. But once you store that as WIP, its on your books as an asset, and you can't just throw it away.

The division had acquired additional warehouse space at the Elmore St. facility

[1]Newcomb was pointing to Exhibit 5, which showed the costs of the activity "Respond to Customer Requests" being incurred in seven departments.

Support Processes

	Develop and Manage HR	Manage Information	Manage Financial and Physical Res.
People	474	495	351
Expenses	875	872	1,347
Total process cost	$1,349	$1,367	$1,698
FTE	35.3	34.5	29.3

Business Processes

	Understand Markets and Customers	Develop Vision and Strategy	Design Products and Services	Market and Sell	Produce and Deliver	Invoice and Service Customers
People	77	78	308	215	2,466	417
Expenses	57	60	341	87	7,517	209
Total process cost	$134	$138	$649	$302	$9,983	$626
FTE	1.5	1.8	15.2	10.2	151.0	36.7

Business Processes

	Execute Environmental Management Program	Manage External Relationships	Manage Improvement and Change
People	48	18	396
Expenses	128	19	403
Total process cost	$176	$37	$799
FTE	2.9	0.6	24.1

EXHIBIT 3 Process Costs for Crawfordsville Facilities

Support Processes	Develop and Manage HR	Manage Information	Manage Financial and Physical Res.
People	474	495	351
Expenses	875	872	1,347
Total process cost	$1,349	$1,367	$1,698
FTE	35.3	34.5	29.3

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People	48	18	396
Expenses	128	19	403
Total process cost	$176	$37	$799
FTE	2.9	0.6	24.1

EXHIBIT 3 Process Costs for Crawfordsville Facilities

EXHIBIT 4 Top 20 ABM Activities for Crawfordsville Facilities

TOP 20 ACTIVITIES	SIX-MONTH SALARY AND WAGE DOLLARS (IN THOUSANDS)
Prepare and issue job specifications	$198
Train and educate employees	159
Develop and deploy information systems	156
Make process improvements	146
Track job status and expedite jobs	135
Perform application maintenance	132
Prepare/make-ready equipment/process for production	131
Respond to customer information requests	118
Develop new product/service concepts and plans	117
Provide consulting and technical support	117
Evaluate employee performance	109
Find material to be moved	106
Schedule production lines/equipment and crewing	100
Ensure ISO 9000 compliance	97
Prepare for production	94
Compile and maintain billing information	94
Obtain customer intellectual property	89
Maintain job file and enter transactions for completed jobs	86
Plan for information resources/management	83
Monitor line performance	82
Total	$2,349,000, or 44% of all people activities

Source: Stream ABM model; KPMG analysis.
Note: Stream employee costs for period 7/1/95 to 12/31/95.

three miles away to provide storage for the manuals and documentation produced for newer customers like Microsoft, Intuit, and Macromedia. While large lots of IBM work-in-process and finished goods inventory sat inactive in the main (South St.) Crawfordsville facility, products finished for newer customers had to be shipped immediately to the Elmore St. warehouse, where it was stored, prior to shipment to customers. By December 1994, 80% of the output from the South St. plant was being trucked over to Elmore St. This output was often shipped one week later to the customer.

Diane Chastain, manager of planning and order fulfillment, commented on this practice:

> Some costs of this arrangement were obvious, like the $150,000 spent annually on trucking. But lots of other costs were hidden until they were revealed through the ABM activity analysis. To address this problem, we had to overcome a major psychological hurdle. This business started with IBM in 1983, and it was a big deal to acknowledge how much our business model had changed in recent years.

Selecting the Winning Proposal

As Michalski thumbed through the five proposals that had been presented, he stopped for a moment when he saw the half-million-dollar price tag accompanying Chastain's proposal. At Donnelley, a manager did not request that kind of money without compelling

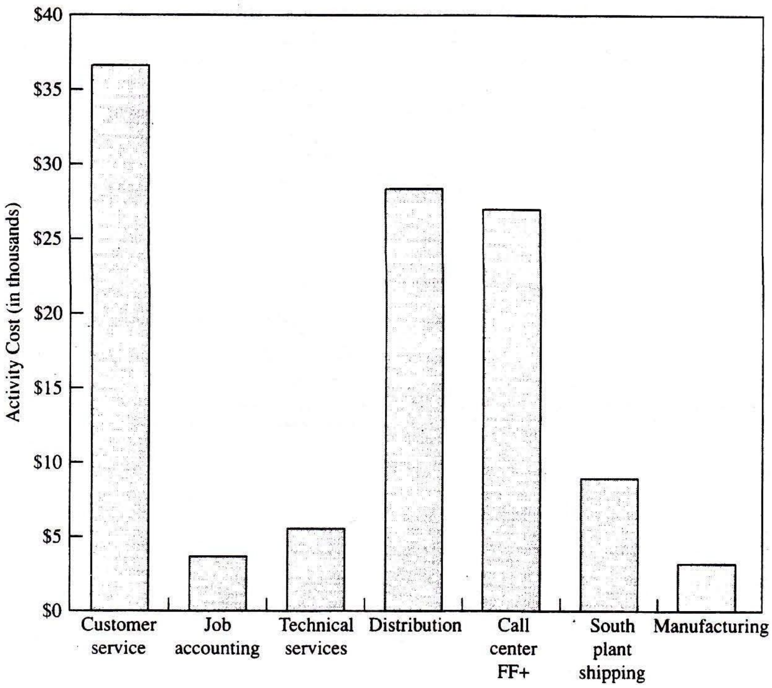


EXHIBIT 5 Costs of the Activity "Respond to Customer Requests"—by Department

financials. He was curious to see just how his managers would respond to the ABM data as they helped him to select the winning proposal. He wondered what kind of criteria his management team would bring to the table to help them make their choice.

Appendix: Five Proposals

Presentation 1: ABM Process Improvement Proposal: Responding to Customer Information Requests, Presented by Bill Newcomb

Problems:

1. Seven Stream departments respond to information requests from customers, with no policy or directives to guide the gathering or reporting of information.
2. Customers frequently request the same information from two different departments.
3. Customers refused a request for a special report by department A will go to department B and get a positive response.

Action Steps:

1. Standardize/reduce ad hoc reporting.
2. Eliminate redundant reporting.
3. Clarify roles/reduce redundant follow-up.
4. Adjust price levels and structure.
5. Generate revenue for select "information services."
6. Create process to share/consolidate client information.

Presentation 2: Price of Quality, Presented by Denise Seeman

Although Stream pays $838,586 annually in quality costs, most of this money is spent gathering information that is never analyzed and never used to drive process improvements.

Cost Reduction Opportunities Could Provide Substantial Savings

ACTIVITY	FTES	HEAD-COUNT	FRAGMEN-TATION	SIX-MONTH ABM COSTS	ANNUAL PEOPLE COSTS	TARGET SAVINGS (25%)
Respond to customer information requests	8.2	66	12%	$118,000	$236,000	$ 59,000
Manage customer complaints	4.9	57	9%	$ 73,000	$146,000	$365,000
Track/expedite jobs	8.5	67	13%	$135,000	$270,000	$675,000
Maintain job files	4.5	34	13%	86,000	$172,000	$ 43,000
Total				$412,000	$824,000	$206,000

A 25% cost reduction would yield approximately $200,000 in annual savings.

Workplan and Resources

TEN-WEEK SCHEDULE	RESOURCES	WEEKLY UPDATE AND FEEDBACK
2–3 weeks—Where are we today?	1 Director/sponsor	
8–10 weeks—Redesign and implementation	1 Project manager	
	1 Systems analyst	
	3 Managers (part time)	
	3 Researchers (full time)	
	KPMG support/involvement	

Problems:

1. Line workers assigned to do quality assurance have never been trained.
2. Inspection methods and sampling protocols have never been reviewed.
3. ISO 9000 documentation is never analyzed. There is no assumption that data will be used for continuous improvement.

Action Steps:

1. Redefine what the Division and our customers need from our Quality Services.
2. Provide the training and direction required.

The analysis will consider:

Pull/Inspect Samples
Improved methods to collect data
Definition of customer reporting requirements

Ensure ISO 9000 Compliance
Isolate and improve hard dollars associated with ISO

Ensure Compliance with Other Requirements (Blue Book)
Measurement definition—related to customer reports and process capabilities
Duplication of effort
What do we do with this information?

Benchmark Performance
Where should we focus?
Currently low dollars; potentially large savings

Make Process Improvements—Fragmented
What are we currently doing with quality information?
Who is doing this, and are they the right people?
What is the return on what we are doing, or have done?
Are we prioritizing by need or potential?
Identify potential

Ensure Process Capabilities
Established operation vs. start-ups

Estimated Results of Project: $257,000
(30% savings of wage dollars)
Plus additional saving from intangibles: benchmarking, process improvements, and best practices

Employee Involvement and Cost

		FTE	HEADCOUNT	ANNUAL COST
5.6.3.2.1	Pull samples	1.35	12	$ 43,462
5.6.3.2.2	Inspect samples	4.0	16	155,735
5.6.3.3	Ensure process capabilities	1.95	20	70,307
12.2.1	Ensure ISO 9000 compliance	7.17	48	194,738
12.2.2	Ensure compliance—other	2.55	31.6	59,711
12.3	Benchmark performance	0.45	5.6	23,410
12.4	Make process improvements	7.19	56.3	291,223
		+ all direct labor employees		$838,586

What Do We Know Today?

Load movement indirect expense = $1,412,048 annually
Managing inventory expense = $ 447,660 annually
Physical facility expense = $ 614,758 annually
(see below for breakdown by activity)

RELATED ANNUAL EXPENSE—MANAGING INVENTORY
LOAD MOVEMENT INDIRECT EXPENSE SUMMARY

ITEM NO.	DESCRIPTION	PEOPLE	EXPENSE	TOTAL	FTES	HEAD-COUNT
5.2.3.1	Find material to be moved	$212,542	$227,103	$439,645	6.80	29
5.2.3.3	Move WIP	58,754	68,473	127,227	2.15	17
5.2.3.4	Move FG within plant	111,552	193,092	304,644	4.25	24
	Move to/from Elmore Street	81,174	77,077	158,251	2.70	13
5.2.3.5.4	Move material to/from outside	24,594	88,017	112,611	0.60	5
5.2.3.8	Material equipment cost/ (depreciation/rent)		269,670	269,670		
	Total	$488,616	$923,432	$1,412,048	16.50	88
Managing inventory expense						
5.6.2.2	Managing WIP	$110,621	65,023	$ 175,824	3.10	36
5.6.2.3	Managing finished goods	108,699	163,136	271,836	3.85	32
	Total	$219,320	$228,159	$ 447,660	6.95	68

Physical facility expense

	SQUARE FEET	$/SQUARE FOOT	TOTAL	
Elmore Street warehouse rent	80,630	$3.00	$ 241,890	
Elmore Street energy, insurance, taxes			76,400	
WIP rent—all areas	45,630	2.53	115,287	
FG rent—rack aisles only	50,512	2.54	128,381	
Outside warehouse			52,800	
Total			$ 614,758	
Total Annualized Expense			$2,474,466	23.45

POTENTIAL BENEFIT $—LOAD STORAGE

1. ***Store all active loads in CSS***	
$318,290	Annual savings in finished goods rent at Elmore Street
(115,000)	Rent 35,000 square feet for long-term storage
(75,000)	Moving expense admin./Mitrak/loads
$128,290	
2. ***Load movement improvement***	
$158,251	Load movement to Elmore
112,611	Move to/from outside storage
91,393	Move FG within plant—30%
38,135	Move WIP within plant—30%
87,929	Find material—20%
26,967	Equipment savings of 10%
$515,286	
3. ***Manage WIP improvement***	
$ 43,956	25% improvement
4. ***Manage FG improvement***	
$ 67,959	25% improvement
5. ***Eliminate outside warehouses***	
$ 52,800	

Total Annualized Potential Benefit—$808,291

Presentation 3: Manage Work in Progress and Finished Goods Inventory Space: ABM Project—July 13, 1995, Presented by Diane Chastain

Problems:

1. We currently have too much inactive inventory stored in the South Street plant, and too much active inventory being shipped to Elmore Street, stored for a week or two, and then shipped to the customer, or end user.
2. We haven't known true cost of storage.
3. The vast majority of WIP inventory is never shipped or used. Storage costs outweigh potential for use.

Action Steps:

1. Eliminate WIP inventory:
   - Define process to store inventory
   - Kill all parts with no known use
2. Exchange warehouses:
   - Install Mitrak-FG in South Street plant
   - Move active loads to South Plant
   - Keep all inactive loads at Elmore

Associated Costs of Implementation Provide Direct and Immediate Payback	
Demolition and rack erection	$ 25,000
Build production office	150,000
Electric, air and data connections	65,000
Equipment for parcel and pick/pack	230,900
Consultant fees	72,400
System hardware (M.A.U., controller, and token rings)	25,000
Pallet flow racks for freight staging	15,000
Total	$583,300

Resources/Timeline

- Define guidelines and process for keeping WIP material by KPMG and CSRs. Goal to complete by 8/15
- WIP inventory reconciliation by 8/31/95
- Analysis and detailed plan to switch active versus inactive inventory to South Plant as outlined by KPMG, Engineering, and fulfillment staff. Goal to move before heavy activity of fourth quarter.

- Press clients to remove inventory or pay higher storage costs
- Redesign South Street for minimum movement layout
- Eliminate outside warehouse (1,001 loads)

Presentation 4: Billing Costs, Presented by Michael Michalski

Problems:
1. It costs Stream $492,000 annually to compile and maintain billing information, to bill the final invoice, and to respond to billing inquiries.
2. Eight different Stream departments are involved in compiling and maintaining billing information, and later responding to billing inquiries.

Action Steps:
1. We need to first understand the process better; to determine which departments are doing what and detect any obvious redundancies.
2. We then want to determine what kinds of information are worthwhile for the division—what data are tied to customer complaints, profitability analysis, etc.
3. We want to centralize the function, simplify the process, and reduce the number of people involved.

See following display for costs and required FTEs by activity.

Presentation 5: Human Resource Management in FF+, Presented by Jim Martin and Molly Day

Problems:
1. HR activities are conducted by 34 different people in FF+* and amount to 10 FTEs.
2. Many activities are duplicated by HR department, payroll, and others in FF+.
3. Phone service reps work under three levels of supervision, at a ratio of less than five reps for every supervisor. (See diagram below for current reporting structure.)
4. Roles of the 14 team leaders, 5 team coordinators, 4 assistant account administrators, 10 account administrators, and 7 supervisors are not clear.

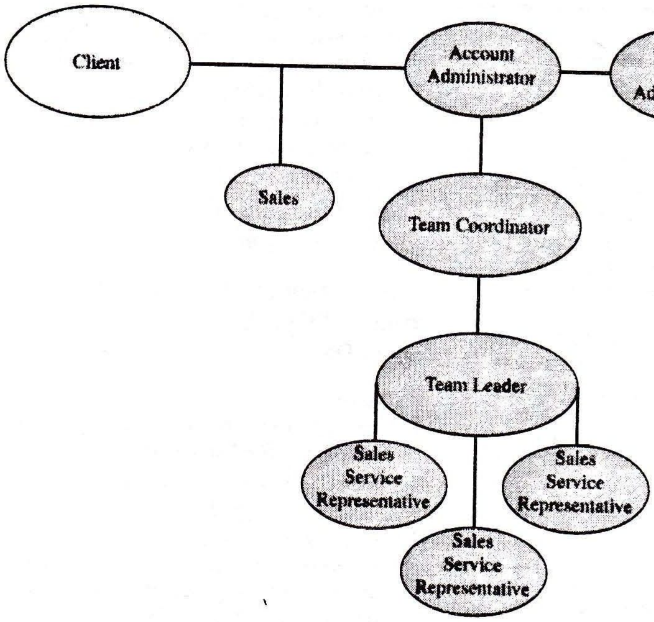
Action Steps:
1. Reduce number of supervisors and number of kinds of supervisory positions.

*FF+ is short for fulfillment plus all other phone activity, which includes product registration, licensing, password listing, and "upselling" related to these activities.

Extended Billing Process—$246,000 per Six-Month Period and 20.6 Full-Time Equivalents

	(8 depts. involved)	(5 depts. involved)	(8 depts. involved)
	6.1.1.2 Compile and maintain other billing information	6.1.2.2 Bill final invoice	6.1.3 Respond to billing inquiries
People	$ 94,000	$57,000	$25,000
Expenses	42,000	14,000	14,000
Total cost	$136,000	$71,000	$39,000
FTEs	10.8	7.7	2.1

Total Net Sales = $108M **Net Sales per FTE = $5.3M**



Current Information Flow

2. Clarify roles.
3. Reduce fragmentation of employee activities.
4. Realize cost savings in salary and wage.
5. Create a model that improves communication with clients as it eliminates redundant supervision.

MosCo, Inc.: A Case Study*

The evening before the annual two-year budget review, Cosmos "Chip" Offtiol, MosCo's director of operations, was confident. While he waited for the latest financial estimates, he thought of the plan he and his staff had methodically prepared which successfully addressed all the crises this new business unit was facing: competitive transfer pricing on an aging product, developing and marketing new products to external customers against an established market leader, reducing manufacturing costs, improving manufacturing utilization, and improving its slim levels of profitability.

When Jonathan Janus, MosCo's controller, solemnly delivered the requested pro-forma income statements, Offtiol's mood dramatically changed. Instead of sustained profit, Chip was shocked to see significant projected operating losses. He wondered why his extensive planning had not improved MosCo's 1995 and 1996 financial results. With less than 24 hours before he was to

*Prepared by Richard J. Block, Digital Equipment Corporation, and Lawrence P. Carr, Babson College, as the basis for class discussion rather than to illustrate effective or ineffective handling of an operational situation. Material prepared with the cooperation of Digital Equipment Corporation and the Digital Semiconductor Business Unit.

offer senior management a viable business plan, he felt abandoned and hopeless.

Background

MosCo, a semiconductor design and manufacturing company, is a wholly owned subsidiary of Computer Systems, Inc. (CSI), a leading manufacturer of client/servers, workstations, and personal computers. During 1993 and 1994, MosCo manufactured and sold to CSI a single product, the ×100, a 100 MHz, 10 nanosecond microprocessor. The ×100 is a .75 micron device packaged in a 339 pin-grid array (PGA) and is used in CSI's servers and workstations. MosCo has sold to CSI 150,000 units of the ×100 in each of the past two years.

Although MosCo sells entirely to its corporate parent, MosCo was required to establish competitive prices for its devices by Q394 [third quarter of 1994]. Previously, the ×100 had been sold to CSI at full cost. Establishing competitive prices was but one of many changes CSI required MosCo to make. In 1995, CSI planned on changing all of its major business units into profit centers. CSI management felt each business unit needed flexibility and independence to react to rapidly changing market conditions. As profit centers, CSI believed each of its business units would be more accountable for their own financial success. Their strategies and annual performance would, as well, be more visible and measurable. For MosCo, this meant the ability to sell their devices to external customers utilizing available manufacturing capacity. MosCo could also recover the large development costs for future products and control their destiny.

MosCo established the competitive market selling price of the ×100 at $850, based on industry price/performance comparisons. CSI approved of this market-based method of establishing transfer prices. It ensured CSI could purchase internally at a competitive price while placing the burden of cost management appropriately on MosCo. MosCo's controller, Jonathan Janus, prepared revised financial statements applying the $850 transfer price to MosCo's 1993 and 1994 shipments (Exhibit 1). Gordon Scott, MosCo's Vice President and General Manager, was pleased to see MosCo had generated profits of $4.9M and $1.9M for 1993 and 1994, respectively, on annual revenues of $127.5M after applying the newly established transfer price. The profit decline in

EXHIBIT 1 MosCo, Inc.—Income Statement

	1993	1994
Revenue		
×100: 150,000 @ $850	$127,500,000	$127,500,000
Cost of Sales		
Wafers: (16,595 @ $45)	$ 746,775	$ 746,775
Packages: (175,000 @ $50)	$ 8,750,000	$ 8,750,000
Mfg. spending	$ 91,112,000	$ 91,112,000
Total cost of sales	$100,608,775	$100,608,775
Gross margin	$ 26,891,225	$ 26,891,225
%	21%	21%
Process development	$ 14,000,000	$ 14,000,000
Product development	$ 5,000,000	$ 5,000,000
Marketing & administration	$ 3,000,000	$ 6,000,000
Operating profit	$ 4,891,225	$ 1,891,225

1994 reflected the establishment and staffing of MosCo's new marketing department. This department was created to identify and open external market opportunities for new products currently under development.

As FY95 approaches, MosCo management is faced with a number of pressures and unknowns. CSI is under severe competitive pressures in their server and workstation product lines and is already demanding a price reduction on the ×100. They also insist MosCo remain profitable. Carlotta Price, head of MosCo's new marketing department, determined from industry studies the price/performance for microprocessors halves every 18 months (Moore's Law). To remain competitive, merchant semiconductor companies were consistently offering some combination of price reductions and/or performance improvements, such that their products' price/performance (price per unit of speed) halved every 1.5 years. Thus, for the ×100, and for every CPU MosCo developed and manufactured, Price believed the market would require similarly timed price/performance offerings. Price knew any price reductions would require offsetting cost reductions if MosCo was to remain profitable and wondered what the manufacturing organization was thinking.

As product development was no longer working on any ×100 performance improvements, Price computed required price reductions on the ×100 following the industry model. The ×100 would continue at the $850 price through Q195, then drop to $637.50 at the start of Q295, drop to $425.00 at the start of Q196, and to $318.75 at the start of Q496. Price was troubled by these prices as she knew CSI was requesting 150,000 units in FY95, but only 75,000 in FY96. CSI indicated it expected a customer shift away from workstations and into CSI's new personal computer line. (Appendix I presents an overview of the semiconductor manufacturing process typically found in a microprocessor supplier like MosCo. Appendix II presents an overview of the product costing process used by MosCo.)

Product cost for the ×100 had remained constant during FY93 and FY94 at approximately $665 (Exhibit 2). Price computed cost reductions of approximately $166.25 per year (to $498.75 in FY95 and $332.50 in 1996) would be necessary to maintain the ×100's current gross margin of −22%. She wondered if manufacturing could achieve a cost reduction that steep.

Concurrently with the ×100 pricing activities, P. J. Watt, head of product development,

EXHIBIT 2 FY94 Product Cost Worksheet for the ×100

DESCRIPTION	COST/WAFER	COST/DIE	CUM COST/DIE
Yielded raw wafer	$ 50.00	$ 1.00	$ 1.00
Wafer production cost	$5,245.15	$104.90	$105.90
Probe production cost	$ 785.71	$ 15.71	$121.62
Probe yield		25%	$486.47
339 PGA package cost		$ 50.00	$536.47
Assembly production cost		$ 9.26	$545.73
Assembly yield		90%	$606.36
Test production cost		$ 32.14	$638.51
Test yield		96%	$665.11
Total ×100 Product Cost			$665.11

Note: Gross die/wafer: 50.

sent an urgent request to Scott, Price, Janus, and Offtiol, requesting $3M in funding. This would accelerate the completion of an integer-only microprocessor, the ×50 and the follow-on CPU, the ×75. The ×50, a new product already under development, could be completed with $1M of the additional funding and made available for volume shipment by the beginning of FY95. The remaining $2M would be spent during FY95 and FY96 to complete development and ready the ×75 for volume shipment by the beginning of FY97.

The ×50 is a 50 MHz, 20 nanosecond CPU, which, like the ×100, is manufactured using the present .75 micron technology. But unlike the ×100, the ×50 does not have a floating-point processor. The elimination of the floating-point processor reduces the size and the power requirements of the CPU. The ×50 and ×75 can be packaged in a 168 pin-grid array (PGA), which costs $15, $35 less than the 339 PGA used by the ×100. However, the testing parameters of the ×50 and ×75 are significantly different than the ×100 and require a Bonn tester, which MosCo does not currently own. This $2M tester, if purchased, will add $1.2M in annual depreciation and other direct operating costs and $800,000 in incremental annual support costs to the present level of manufacturing spending.

The ×50 and ×75 are targeted as entree devices for CSI's personal computer business. NoTel is the market leader in .75 micron integer-only microprocessors. Their N50 CPU (also 50 MHz, 20 nanoseconds) sells for $500. The N50 has just been announced, with volume shipments to coincide with the beginning of MosCo's FY95. MosCo's new marketing department estimates the demand for the ×50 from CSI and potential new external customers could easily exceed 1M units per year. To break into this market, Price recommended heavy market promotion and a price/performance two times the competition. Estimates for unit sales potential from advertising are 100,000 for the first $1M, up to 500,000 for the second $1M, and over 1M for a third million dollar advertising expenditure.

With the increased pricing pressures from both CSI and the external marketplace, product cost reduction became critical. This, coupled with the request from product development for additional funding, had Gordon Scott very concerned. He knew it was important to bring out the ×50 and ×75 quickly, but the pricing pressures for their market entrance and the pricing pressures from CSI on the ×100 seemed almost impossible to meet and still achieve a profit in FY95 and 96. He knew, however, if he didn't maintain a profitable operation, his tenure would be short.

Reduced production costs leading to competitive manufacturing appeared to be the critical factor necessary to sustain MosCo's slim profit levels. Scott asked Offtiol to formulate a series of recommendations to develop and manufacture an expanded CPU product line in FY95 and FY96, and to have them completed by the annual two-year budget review, scheduled to commence in a month. Scott knew soon after MosCo's budget review, he would have to present a credible business plan to CSI management. He worried how he could develop a viable plan in light of the obstacles.

The Offtiol Plan

Offtiol started his preparation by reviewing the detailed ×100 product cost (Exhibits 2, 3, and 4). He immediately assembled a team, comprised of Janus, from Finance, T. Q. Marcel, from Quality, and Beeb Ruby, from Training. The team, led by Marcellus deStepper, the manager of wafer fabrication, conducted a cost review by activity. Chip, like Scott, believed to maintain profitability, significant cost reductions would be necessary. He had recently taken an executive development course in activity-based costing and

EXHIBIT 3 FY94 Used Capacity and Process Costs Worksheet for the ×100

OPERATION	PER YEAR	MFG. SPENDING	COST/UNIT
Planned wafer capacity	16,595		
Engineering test wafers	1,040		
Planned wafer starts	15,555		
Wafer fabrication yield	90%		
Planned wafer production	13999.50	$73,429,500	$5,245.15
Planned probed wafer starts	14,000	$11,000,000	$ 785.71
Gross die/wafer for ×100 = 50	50		
Total gross die thru probe	700,000		
Probe yield for ×100	25%		
×100 probed die output	175,000		
Planned assembly starts	175,000	$ 1,620,000	$ 9.26
×100 assembly yield	90%		
Planned assembly completions	157,500		
Planned test starts	157,500	$ 5,062,500	$ 32.14
×100 test yield	96%		
Planned test output	151,200		
Total Manufacturing Spending		$91,112,000	

knew it was a proven method for better understanding cost structures, cost drivers, and highlighting non-value-added work. Offtiol was excited, given the size of the assignment and his belief there were both cost reduction opportunities in manufacturing and necessary improvements in the current standard cost system. He felt the current standard cost system did not properly capture the complexity of MosCo's production process. He felt an ABC analysis could provide the needed insight necessary to reduce the ×100 product cost by the $166 marketing had requested.

The team mapped the processes of the entire operation and then reassigned costs to the newly defined activities (Exhibits 5a–c). The direct manufacturing operation was now better delineated by equipment use (Exhibit 5b). The manufacturing support organizations were also better understood. Their key activities were costed, then each was aligned to the manufacturing operation it supported (Exhibit 5c). MosCo's ABC team reset the ×100 product cost in line with the true practical capacity of the manufacturing process. The team saw capacity utilization as a major driver of product cost. The old product costing methodology was based on the planned utilization of each manufacturing process with underutilized manufacturing costs absorbed into product costs.

The revised ×100 product cost (Exhibits 6 and 7) was pleasing but not totally surprising to Offtiol. It confirmed his belief in the inaccuracies of the old costing method. The new ×100 product cost of $437.50 was $227.61 lower than the $665.11 original cost before the ABC study. It did not make sense to charge the ×100 for the costs of resources it did not consume. Chip felt he could immediately commit to Price's 1995 product cost reduction request of $166.

To achieve the 1996 product cost goal of $332.50, Chip and his team looked further into the activity-based costing results. The study clearly showed wafer fabrication was the largest area of manufacturing costs. Chip,

EXHIBIT 4 FY94 Spending Summary by Organization

	MANUFACTURING				RESEARCH & DEVELOP		SG&A	
ORGANIZATION	FABRICATION	PROBE	ASSEMBLY	TEST	PROD DEVP	PROC DEVP	MKT & ADM	TOTAL
Direct mfg	$57,000,000	$11,000,000	$1,620,000	$5,062,500				$ 74,682,500
Res & devp					$2,000,0008	$9,000,000		11,000,000
Mkt & adm							$5,000,000	5,000,000
Support orgs								
Facilities	5,500,000				1,000,000	3,000,000	500,000	10,000,000
Yield eng	2,000,000							2,000,000
CIMT	4,000,000				2,000,000	2,000,000	500,000	8,500,000
Qual & rel	3,537,500							3,537,500
Purchasing	1,392,000							1,392,000
Tot support	$16,429,500				3,000,000	$ 5,000,000	$1,000,000	$ 25,429,500
Tot spending	$73,429,500	$11,000,000	$1,620,000	$5,062,500	$ 5,000,000	$14,000,000	$6,000,000	$116,112,000
Fabrication	$73,429,500							
Probe	11,000,000							
Assembly	1,620,000							
Test	5,062,500							
Tot mfg spend	$91,112,000							

EXHIBIT 5A FY94 Activity-Based Spending Summary by Organization

	MANUFACTURING				RESEARCH & DEVELOP		SG&A	
ACTIVITY	FABRICATION	PROBE	ASSEMBLY	TEST	PROD DEVP	PROC DEVP	MKT & ADM	TOTAL
Direct mfg (see Exhibit 5b)	$57,000,000	$11,000,000	$1,620,000	$5,062,500				$74,682,500
RES & DEVP					$2,000,000	$9,000,000		$11,000,000
MKT & ADM								
Marketing							$3,000,000	$3,000,000
Administration							$1,000,000	$1,000,000
Finance/hr							$1,000,000	$1,000,000
Total							$5,000,000	$5,000,000
Tot support (see Exhibit 5c)	$10,392,000	$2,000,000		$3,037,500	$3,000,000	$6,000,000	$1,000,000	$25,429,500
Tot spending	$67,392,000	$13,000,000	$1,620,000	$8,100,000	$5,000,000	$15,000,000	$6,000,000	$116,112,000
Fabrication	$67,392,000							
Probe	$13,000,000							
Assembly	$1,620,000							
Test	$8,100,000							
Tot mfg spend	$90,112,000							

EXHIBIT 5B FY94 Direct Manufacturing Activity-Based Spending Summary

	MANUFACTURING				RESEARCH & DEVELOP		SG&A	
ACTIVITY	FABRICATION	PROBE	ASSEMBLY	TEST	PROD DEVP	PROC DEVP	MKT & ADM	TOTAL
Equipment Capacity: driven by equipment installation								
Depreciation	$30,000,000	$ 3,500,000	$ 520,000	$1,400,000				$35,420,000
Utility costs	$ 5,000,000	$ 1,000,000	$ 50,000	$ 500,000				$ 6,550,000
Property/site	$ 5,000,000	$ 500,000	$ 50,000	$ 100,000				$ 5,650,000
Total	$40,000,000	$ 5,000,000	$ 620,000	$2,000,000				$47,620,000
Equipment Capacity: driven by equipment uptime								
Equip. enginrs	$ 8,000,000	$ 2,000,000		$1,762,500				$11,762,500
Monitor wafer	$ 1,000,000							$ 1,000,000
Opn supplies	$ 1,000,000	$ 1,000,000	$ 100,000	$ 300,000				$ 2,400,000
Total	$10,000,000	$ 3,000,000	$ 100,000	$2,062,500				$15,162,500
Equipment Capacity: driven by production								
Direct labor	$ 5,000,000	$ 2,000,000	$ 800,000	$ 700,000				$ 8,500,000
Monitor wafer	$ 1,000,000							$ 1,000,000
Opn supplies	$ 1,000,000	$ 1,000,000	$ 100,000	$ 300,000				$ 2,400,000
Total	$ 7,000,000	$ 3,000,000	$ 900,000	$1,000,000				$11,900,000
Tot Dir Mfg	$57,000,000	$11,000,000	$1,620,000	$5,062,500				$74,682,500
Tot Dir Mfg (new Bonn tester)				$1,215,000				

EXHIBIT 5C FY94 Support Group Activity-Based Spending Summary

	MANUFACTURING				RESEARCH & DEVELOP		SG&A	
ACTIVITY	FABRICATION	PROBE	ASSEMBLY	TEST	PROD DEVP	PROC DEVP	MKT & ADM	TOTAL
Facilities								
D/i water	$ 1,000,000					$ 500,000		$ 1,500,000
site support	$ 500,000			$ 100,000	$ 500,000	$ 500,000	$500,000	$ 2,100,000
utilities	$ 3,000,000			$ 400,000	$ 500,000	$2,000,000		$ 5,900,000
chemicals	$ 500,000							$ 500,000
Total	$ 5,000,000			$ 500,000	$1,000,000	$3,000,000	$500,000	$10,000,000
Yield Eng: yield improvement: $2,000,000								$ 2,000,000
CIMT								
Shop floor sys	$ 1,000,000			$1,000,000				$ 2,000,000
Networks	$ 500,000			$ 500,000	$1,000,000	$ 500,000	$250,000	$ 2,750,000
Field svc	$ 500,000			$ 500,000	$ 500,000		$250,000	$ 1,750,000
System devp					$ 500,000	$ 500,000		$ 1,000,000
Equip connect						$1,000,000		$ 1,000,000
Total	$ 2,000,000			$2,000,000	$2,000,000	$2,000,000	$500,000	$ 8,500,000
Quality								
Doc control	$ 1,000,000							$ 1,000,000
Fail analysis	$ 500,000			$ 100,000		$ 250,000		$ 850,000
Equip calibrate	$ 500,000			$ 437,500		$ 750,000		$ 1,687,500
Total	$ 2,000,000			$ 537,500		$1,000,000		$ 3,537,500
Purchasing	$ 1,392,000							$ 1,392,000
Tot Sup Spend	$10,392,000	$2,000,000		$3,037,500	$3,000,000	$6,000,000	$1,000,000	$25,429,500
Tot Sup Spend (new Bonn tester)				$ 810,000				

EXHIBIT 6 FY94 Revised Product Cost Worksheet for the ×100

DESCRIPTION	COST/WAFER	COST/DIE	CUM COST/DIE
Yielded raw wafer	$ 50.00	$ 1.00	$ 1.00
Wafer production cost	$3,000.00	$60.00	$ 61.00
Probe production cost	$ 500.00	$10.00	$ 71.00
Probe yield		25%	$284.00
339 PGA package cost		$50.00	$334.00
Assembly production cost		$ 8.00	$342.00
Assembly yield		90%	$380.00
Test production cost		$40.00	$420.00
Test yield		96%	$437.50
Total ×100 Product Cost			$437.50

Note: Gross die/Wafer: 50.

with the help of Janus, computed that if the ×100 wafer cost was reduced from the 1995 level of $3,000/wafer to $1866/wafer, the ×100 total product cost would be lowered by $105 achieving the desired $332.50. To obtain a wafer cost of $1,866, spending reductions of about $25.5M, or 38%, in wafer fabrication would have to be achieved (Chart I). Chip again asked Marcellus deStepper to review the fabrication area for further cost reduction opportunities. Chip asked deStepper to formulate a plan which could reduce direct wafer fabrication spending by about $25.5 million (from $67.4 to $41.9 million).

EXHIBIT 7 FY94 Revised Capacity and Process Costs Worksheet for the ×100

OPERATION	PER YEAR	MFG. SPENDING	COST/UNIT
Planned wafer capacity	26,000		
Engineering test wafers	1,040		
Planned wafer starts	24,960		
Wafer fabrication yield	90%		
Planned wafer production	22,464	$67,392,000	$3,000.00
Planned probed wafer starts	26,000	$13,000,000	$ 500.00
Gross Die/Wafer for ×100 = 50	50		
Total gross die thru probe	1,300,000		
Probe yield for ×100	25%		
×100 probed die output	325,000		
Planned assembly starts	202,500	$ 1,620,000	$ 8.00
×100 assembly yield	90%		
Planned assembly completions	182,250		
Planned test starts	202,500	$ 8,100,000	$ 40.00
×100 test yield 96%			
Planned test output	194,400		
Total Manufacturing Spending		$90,112,000	

Chart I: ×100 1996 Target Product Cost Analysis

MANUFACTURING AREA	COST/ WAFER	COST/DIE	CUM COST/DIE
Desired wafer cost	$1,866.00	$37.32	$ 37.32
Yielded raw wafer cost	50.00	1.00	38.32
Probe cost/wafer	500.00	10.00	48.32
Probe yield		25.0%	193.28
339 PGA package cost		$50.00	243.28
Assembly cost		8.00	251.28
Assembly yield		90.0%	279.20
Test cost		$40.00	319.20
Test yield		96.0%	332.50
Current fabrication spending			$67,392,000
Desired level of spending (22,464 annual wafer production @ $1,866)			$41,917,824
Required spending reduction			$25,474,176
			38%

Note: ×100 gross die/wafer = 50.

deStepper returned in two weeks with an alternative plan (Chart II). His team found nominal spending opportunities by (1) reducing monitor wafer usage, (2) redesigning wafer lot handling procedures, and (3) by the better placement of inspection stations. deStepper's most significant discovery was the 64% increase in capacity attained by increasing equipment uptime (the time equipment is not undergoing repair or preventive maintenance). Higher uptime, however, required an annual investment of about $1.8 million in additional equipment engineers. While this investment would increase wafer fabrication spending to about $69.2 million, wafer fabrication capacity would increase from 26,000 to about 42,700 in annual wafer starts. The increased capacity actually decreased the cost per wafer to $1,845, $21 lower than Offtiol had demanded.

Chart II: deStepper Alternative Capacity and Spending Plan

	CURRENT LEVEL	PROPOSED LEVEL
Total wafer start capacity	26,000	42,707
Engineering wafer starts	1,040	1,040
Production wafer starts	24,960	41,667
Fabrication line yield	90%	90%
Annual wafer completions	22,464	37,500
Annual spending level	$67,392,000	$67,392,000
deStepper's added spending		$ 1,797,120
Proposed spending level		$69,189,120
Cost wafer	$ 3,000	$ 1,845

Offtiol dismissed deStepper's alternative plan outright. "Spending needs to decrease, not *increase!*" he exclaimed, and reiterated his request to reduce fabrication spending by 38%.

Offtiol then focused his team's cost reduction efforts on packaging costs, another major cost component of the ×100. (MosCo had spent close to $8.8 million annually on chip packages.) He asked MosCo's purchasing manager, Polly Nomial, to pressure MosCo's 339 PGA supplier to lower their $50 price. Polly told Chip she had already made this request and was reminded by the vendor that the 339 PGA was a unique design, only used by MosCo for the ×100. With order volumes declining by 50% in a year, Polly said it would be difficult to keep the $50 package price from increasing.

The final area of review was the ×50 proposal. Chip and the team reviewed its product cost, necessary manufacturing process and spending requirements (Exhibits 8 and 9). Chip compared the ×50 product cost (computed assuming all production capacity was used to manufacture the ×50) with the ×100 and noted a few significant cost differences. The reduced size of the ×50 (no floating point processor) increased the number of die able to be placed on each wafer, thus reducing the fabrication cost per die 67% from the ×100 ($61.00 for the ×100; $20.33 for the ×50). The increase in the number of die on each wafer, however, increased the probe time and increased the probe cost per wafer by 25% ($500 for the ×100; $625 for the ×50). He was pleased with the doubling of assembly capacity resulting from the smaller package required by the ×50 (202,500 annual assembly starts for the ×100; 405,000 for the ×50). The increase in assembly throughput reduced the ×50 assembly costs by 50%. Chip was pleasantly surprised at the ×50's lower test costs. Even though the ×50 required a new tester, the lower annual operating costs versus the ×100 along with the reduced testing time (from the elimination of the floating point unit) resulted in a per unit test cost of only $5 versus $40 for the ×100.

With the ×50's cost structure now soundly understood, Chip could better appreciate the high, but achievable, profit margins of the ×50. The margins ranged from 75%, during Q1–Q395 to about 67% in Q495 when the marketing-required price reduction took effect (Chart III). If deStepper could

EXHIBIT 8 FY95 Product Cost Worksheet for the ×50

DESCRIPTION	COST/WAFER	COST/DIE	CUM COST/DIE
Yielded raw wafer	$ 50.00	$ 0.33	$ 0.33
Wafer production cost	$3,000.00	$20.00	$20.33
Probe production cost	$ 625.00	$ 4.17	$24.50
Probe yield		70%	$35.00
168 PGA package cost		$15.00	$50.00
Assembly production cost		$ 4.00	$54.00
Assembly yield		96%	$56.25
Test production cost		$ 5.00	$61.25
Test yield		98%	$62.50
Total ×50 Product Cost			$62.50

Note: Gross die/Wafer: 150.

EXHIBIT 9 FY95 Projected Capacity and Process Costs Worksheet for the ×50

OPERATION	PER YEAR	MFG. SPENDING	COST/UNIT
Planned wafer capacity	26,000		
Engineering test wafers	1,040		
Planned wafer starts	24,960		
Wafer fabrication yield	90%		
Planned wafer production	22,464	$67,392,000	$3,000.00
Planned probed wafer starts	20,800	$13,000,000	$ 625.00
Gross die/wafer for ×50 = 150	150		
Total gross die thru probe	3,120,000		
Probe yield for ×50	70%		
×50 probed die output	2,184,000		
Planned assembly starts	405,000	$ 1,620,000	$ 4.00
×50 assembly yield	90%		
Planned assembly completions	364,500		
Planned test starts	405,000	$ 2,025,000	$ 5.00
×50 test yield	96%		
Planned test output	388,800		
Total Manufacturing Spending		$84,037,000	

achieve the $1866 wafer cost by the start of 1996 (Exhibits 10 and 11), the ×50 could achieve a very respectable margin of about 59% in the second half of 1996 at the required price of $125. Using the capacity available in 1995 and 1996 to produce 50,000 and 215,000 units, respectively, easily convinced Offtiol to fund the ×50 development effort and purchase the new tester. While the product specifications for the ×75 were not yet available, he also agreed to fund its development effort. He felt the ×75 would achieve the same product margins the ×50 demonstrated.

EXHIBIT 10 FY96 Revised Product Cost Worksheet for the ×50 (Reflecting Requested Wafer Fabrication Spending Reduction)

DESCRIPTION	COST/WAFER	COST/DIE	CUM COST/DIE
Yielded raw wafer	$ 50.00	$ 0.33	$ 0.33
Wafer production cost	$1,866.00	$12.44	$12.77
Probe production cost	$ 625.00	$ 4.17	$16.94
Probe yield		70%	$24.20
168 PGA package cost		$15.00	$39.20
Assembly production cost		$ 4.00	$43.20
Assembly yield		96%	$45.00
Test production cost		$ 5.00	$50.00
Test yield		98%	$51.02
Total ×50 Product Cost			$51.02

Note: Gross die/wafer: 150.

EXHIBIT 11 FY96 Projected Capacity and Process Costs Worksheet for the ×50 (Reflecting Requested Wafer Fabrication Spending Reduction)

OPERATION	PER YEAR	MGF. SPENDING	COST/UNIT
Planned wafer capacity	26,000		
Engineering test wafers	1,040		
Planned wafer starts	24,960		
Wafer fabrication yield	90%		
Planned wafer production	22,464	$41,917,824	$1,866.00
Planned probed wafer starts	20,800	$13,000,000	$ 625.00
Gross Die/Wafer for ×50 = 150	150		
Total gross die thru probe	3,120,000		
Probe yield for ×50	70%		
×50 probed die output	2,184,000		
Planned assembly starts	405,000	$ 1,620,000	$ 4.00
×50 assembly yield	90%		
Planned assembly completions	364,500		
Planned test starts	405,000	$ 2,025,000	$ 5.00
×50 test yield	96%		
Planned test output	388,800		
Total Manufacturing Spending		$58,562,824	

Chart III

	Q195–Q395	Q495–Q296	Q396 & Q496
Price	$250.00	$187.50	$125.00
Cost	$62.50	$62.50	$51.02
Margin	$187.50	$125.00	$73.98
Margin	75.0%	66.7%	59.2%
59.2%			

Just as Chip was completing his ×50 product development meeting, Polly called and suggested outsourcing and then disinvesting MosCo's assembly operations. Polly had found an assembly house who could assemble the ×50 in its required 168 PGA for $5 per device (in volume levels of 500,000) with equivalent yields to those MosCo projected. Chip thought this idea had merit until he compared the $5 external assembly cost per device with the internal cost estimate of $4. He quickly concluded outsourcing would only increase the overall product cost and therefore was not a viable option.

A week before the budget review, Chip asked Janus to prepare new proforma income statements for FY94, FY95, and FY96. He wanted to reflect all of his cost reduction targets and product funding levels. He was curious to see the levels of profit he would generate in 1995 and 96 from (1) the revised ×100 product cost, (2) the 1996 cost reduction targets in wafer fabrication and their effect on the ×100 and ×50, (3) the funding of the ×50 and ×75, (4) the purchase of the Bonn tester the ×50 required, (5) the utilization of 1995 and 96 capacity for manufacturing the ×50, (6) the additional advertising expense necessary to fully promote the ×50 in the marketplace and, (7) the selling of the ×100 and ×50 using the marketing department pricing model. Chip was confident his decisions would prove sound and keep MosCo profitable in 1995 and 96.

Now, after a second review of Janus's pro-

EXHIBIT 12A Janus's Proforma Income Statement

	1994 REVISED	1995 RECOM'D	1996 RECOM'D
Revenue	$127,500,000%	$115,312,500%	$ 63,476,562%
Cost of Sales			
Raw material costs	$ 9,496,755	$ 10,348,010	$ 8,282,255
Production costs	$ 90,112,000	59,063,500	$ 27,788,853
Total product cost	$ 99,608,775	$ 69,411,510	$ 36,071,108
Product gross margin	$ 27,891,225	$ 45,900,990	$ 27,405,454
%	21.9%	39.8%	43.2%
Underutilized costs	$ 0	$ 33,073,500	$ 38,873,971
Total cost of sales	$ 99,608,775	$102,485,010	$ 74,945,079
Gross Margin	$ 27,891,225	$ 12,827,490	($11,468,516)
%	21.9%	11.1%	−18.1%
Process development	$ 15,000,000	$ 15,000,000	$ 15,000,000
Product development	$ 6,000,000	$ 6,000,000	$ 6,000,000
Marketing & administration	$ 6,000,000	$ 7,000,000	$ 8,000,000
Operating profit (loss)	$ 891,225	($15,172,510)	($40,468,516)

EXHIBIT 12B FY95 Janus's Proforma Income Statement Worksheet

	×100	×50	FY95
Revenue			
Q1 (37,500 @ $850)	$ 31,875,000		
Q2–Q4 (112,500 @ $637.50)	$ 71,718,750		
Q1–Q3 (37,500 @ $250)		$ 9,375,000	
Q4 (12,500 @ $187.50)		$ 2,343,750	
	$103,593,750	$11,718,750	$115,312,500
Raw Material Costs			
Wafers: (16,595 @ $45)	$ 746,775		
(583 @ $45)		$ 26,235	
Packages: (175,000 @ $50)	$ 8,750,000		
(55,000 @ $15)		$ 825,000	
	$ 9,496,775	$ 851,235	$ 10,348,010
Production Costs			
Fabrication: (14,000 @ $3000)	$ 42,000,000		
(524 @ $3000)		$ 1,572,000	
Probe: (14,000 @ $500)	$ 7,000,000		
(524 @ $625)		$ 327,500	
Assembly: (175,000 @ $8)	$ 1,400,000		
(55,000 @ $4)		$ 220,000	
Test: (157,000 @ $40)	$ 6,280,000		
(52,800 @ $5)		$ 264,000	
	$ 56,680,000	$ 2,383,500	$ 59,063,500
Underutilized Costs			
Fabrication ($67,392,000 − ($42,000,000 + $1,572,000))			$ 23,820,000
Probe ($13,000,000 − ($7,000,000 + $327,500))			$ 5,672,500
Assembly ($1,620,000 − ($1,400,000 + $220,000))			$ 0
Test ($8,100,000 − $6,280,000 + $2,025,000 − $264,000)			$ 3,581,000
			$ 33,073,500

EXHIBIT 12C FY96 Janus's Proforma Income Statement Worksheet

	×100	×50	FY96
Revenue			
Q1–Q3 (56,250 @ $425)	$23,906,250		
Q4 (18,750 @ $318.75)	$ 5,976,562		
Q1–Q2 (107,500 @ $187.50)		$20,156,250	
Q3–Q4 (107,500 @ $125)		$13,437,500	
	$29,882,812	$33,593,750	$63,476,562
Raw Material Costs			
Wafers: (7,991 @ $45)	$ 359,595		
(2448 @ $45)		$ 110,160	
Packages: (86,875 @ $50)	$ 4,343,750		
(231,250 @ $15)		$ 3,468,750	
	$ 4,703,345	$ 3,578,910	$ 8,282,255
Production Costs			
Fabrication: (6,950 @ $1,866)	$12,968,700		
(2,203 @ $1,866)		$ 4,110,798	
Probe: (6,950 @ $500)	$ 3,475,000		
(2,203 @ $625)		$ 1,376,875	
Assembly: (86,875 @ $8)	$ 695,000		
(231,250 @ $4)		$ 925,000	
Test: (78,187 @ $40)	$ 3,127,480		
(222,000 @ $5)		$ 1,110,000	
	$20,266,180	$ 7,522,673	$27,788,853
Underutilized Costs			
Fabrication ($41,917,824 − ($12,968,700 + $4,110,798))			$24,838,326
Probe ($13,000,000 − ($3,475,000 + $1,376,875))			$ 8,148,125
Assembly ($1,620,000 − ($695,000 + $925,000))			$ 0
Test ($8,100,000 − $3,127,480 + $2,025,000 − $1,110,000)			$ 5,887,520
			$38,873,971

forma income statements (Exhibits 12a–c), Offtiol had become very anxious. He had to present a viable set of recommendations to MosCo's senior management the following day. He thought he and his team had explored and included all viable options in Janus's statements. Finally, Chip concluded the cause of the projected FY95 and FY96 losses was the overly aggressive pricing model. He decided he would present Janus's projections, highlight the losses in spite of the cost reductions reflected, and suggest keeping the ×100 price at $850 for all of 1995, and $637.50 for all of 1996. The $23.9M increase in FY95 revenue would turn the approximately $15.2 million loss into an $8.7 million profit. But the $17.9M increase in FY96 revenue would only improve the loss of about $40.5 million to about $22.6 million. Chip was convinced Scott would also agree Price's pricing model was too aggressive. He was certain Scott would approve a revised ×100 price and be receptive to a higher price for the ×50, which could offset the remaining projected 1996 loss. Chip felt it would take a combination of his cost reduction efforts and higher prices to maintain MosCo's profitability and thus demonstrate to CSI MosCo's ability to transform itself into a competitive business unit.

EXHIBIT 13 Product Specifications

	×100	×50	N50
Function	CPU/CISC	CPU/CISC	CPU/CISC
Technology	CMOS .75u	CMOS .75u	CMOS .75u
Frequency	100 MHZ	50 MHZ	50 MHZ
Selling Prices			
Actual: 1994 Q1			
1994 Q2			
1994 Q3	$850.00		
1994 Q4			
Proposed: 1995 Q1		$250.00	$500.00
1995 Q2	$637.50		
1995 Q3			
1995 Q4		$187.50	$375.00
1996 Q1	$425.00		
1996 Q2			
1996 Q3		$125.00	$250.00
1996 Q4	$318.75		
Raw wafer cost	$ 45	$ 45	$ 45
Wafer production cost	$ 3000	$ 3000	
Probe cost/wafer	$ 500	$ 625	
Gross die/wafer	50	150	200
Good die thru test (eqs)	10.8	98.8	141.0
Probe yield	25%	70%	75%
Package type	339 PGA	168 PGA	168 PGA
Package cost	$ 50	$ 15	$ 15
Assembly cost	$ 8	$ 4	
Assembly yield	90%	96%	
Test cost	$ 40	$ 5	
Test yield	96%	98%	

Discussion Questions

Review Offtiol's cost reduction assessments, pricing beliefs, and 1995 and 1996 recommendations to improve MosCo's profitability. Has he proposed appropriate or optimal actions? Specifically:

(1) What caused the 1995 ×100 product cost to drop by $227 after reflecting the results of the activity-based costing approach?

(2) What are the cost drivers of process manufacturing? What are the other cost drivers contributing to total product cost?

(3) Was it practical or plausible to reduce wafer fabrication spending by 38%, or about $25.5 million as Offtiol demanded deStepper do?

(4) Should Offtiol have explored cost reduction opportunities in other manufacturing or nonmanufacturing areas? If so, where?

(5) Was Offtiol's ABC team staffed appropriately?

(6) Is there still underutilized manufacturing capacity when the ×50 is manufactured?

(7) Is Price's pricing model too aggressive? If so, why?

(8) What pricing advantages does MosCo's competitor, NoTel, have, due to their N50's having 33% more die on each wafer than the ×50?

(9) What other manufacturing, development, and/or pricing actions could be taken to improve MosCo's financial performance in 1995 and 1996? Can Offtiol's recommendations be improved?

EXHIBIT 14 FY95 & FY96 Capacity Availability

	TOTAL CAPACITY AVAILABLE	×100 CAPACITY USED		CAPACITY AVAILABLE FOR ×50		MAXIMUM USED BY ×50		AVAILABLE CAPACITY	
		FY 95 (150,000)	FY 96 (75,000)	FY95	FY96	FY95	FY96	FY95	FY96
Fab starts	26,000 (w)	16,595	7,991						
Eng'r starts	1,040 (w)	1,040	1,040						
Prod'n starts	24,960 (w)	15,555	7,723	9,405	17,237	582	2,447	8,823	14,790
Prod'n completes	22,464 (w)	14,000	6,950	8,464	15,514	524	2,202	7,940	13,312
×100 probe starts	26,000 (w)	14,000	6,950	12,000	19,050				
×50 probe starts	20,800 (w)			9,600	15,240	524	2,202	9,076	13,038
339 PGA assy starts	202,500 (d)	175,000	86,875	27,500	115,625				
339 PGA assy completes	188,250 (d)	157,500	78,187						
168 PGA assy starts	405,000 (d)			55,000	231,250	55,000	231,250	0	0
168 PGA assy completes	388,800 (d)			52,800	222,000	52,800	222,000	0	0
×100 test starts	202,500 (d)	157,500	78,187					45,000	124,313
×100 test completes	194,400 (d)	151,200	75,060					43,200	119,340
×50 test starts	405,000 (d)			405,000	405,000	52,800	222,000	352,200	183,000
×50 test completes	396,900 (d)			396,900	396,900	51,744	217,560	345,156	179,340

Note: w = wafers; d = die.

Appendix I: Overview of the Semiconductor Manufacturing Process[1]

Semiconductor devices are made from silicon, which is material refined from quartz. Silicon is used because it can be easily altered to promote or deter electrical signals. Electronic switches, or transistors, that control electrical signals can be formed on the surface of a silicon crystal. This is done by the precisely controlled addition of certain elements designed in microscopically small patterns.

Silicon is first melted to remove impurities and grown into long crystals (ingots), which vary in size from .5 inches to 16 inches in diameter (typical sizes in use today are 6 and 8 inches). The purified silicon is sliced into wafers on which integrated circuits will be patterned. As the size of an integrated circuit is extremely small, hundreds, even thousands, of circuits can be formed on a wafer at the same time.

Integrated circuits (typically referred to as "chips" or "die") are an array of transistors made up of various connected layers, designed to perform specific operations. Each layer is a specific circuit pattern (approximately 20 are used in present processes). A glass plate (called a reticle), is used to pattern each layer on the wafer during the fabrication process.

Fabrication In the fabrication process, blank wafers are first insulated with a film of oxide, then coated with a soft light-sensitive plastic called photoresist. The wafers are masked by a reticle and flooded with ultraviolet light, exposing the reticle's specific circuit pattern on the unmasked portion of the wafer. Exposed photoresist hardens into the proper circuit layer outline. Acids and solvents are used to strip away unexposed photoresist and oxide, baring the circuit pattern to be etched by either chemicals or superhot gases. More photoresist is placed on the wafer, masked, and stripped, then implanted with chemical impurities, or dopants, that form negative and positive conducting zones. Repeating these steps builds the necessary layers which are required for the integrated circuit design to be completed on the wafer.

Probe In the probe process, an electrical performance test of the functions of each of the completed integrated circuits is performed while each of the die is still on the wafer. The nonfunctioning die are marked with ink; the functioning die are left unmarked and moved to assembly.

Assembly In the assembly process, each of the die is diced from the wafer with a diamond saw. The good die are placed in the cavity of a ceramic package. The bonding pads from the die are connected by very thin aluminum wires into the leads of the package. This creates the necessary electrical connection from the chip to the package. The ceramic package is then sealed with a metal lid placed over the exposed die in the package.

Test Once the device is completely packaged, it is tested to ensure all electrical specifications of the integrated circuit are met.

The completed packaged semiconductor device is now ready to be soldered to a printed circuit board, which in turn will be installed into a computer system.

Appendix II: Overview of the Product Costing Process

Semiconductor product costing is a multiple-step process, where manufacturing costs measure value added to raw material as it is produced. Value added is typically defined as

[1]Summarized from the *Semiconductor Manufacturing Mini-Process Overview Guide*, rev. C, U.S. Semiconductor Manufacturing Training and Development Group, Digital Semiconductor Business Unit, Digital Equipment Corporation, May 1992.

production or capacity throughput divided by spending. The cost system collects, accumulates, and yields material and manufacturing costs through each stage of production.

1. First, the costs of raw materials used and the unit costs of each stage of manufacturing are established.
2. Next, raw wafer and wafer production costs are converted to die costs. In wafer fabrication and probe, manufactured material is in wafer form. As such, the unit costs of the raw wafer and manufacturing in these stages are initially captured as cost/wafer. In assembly, where the wafer is cut into die, the unit of measure also changes to die. Thus, to complete the costing of the final product which is in die form, cost/wafer must be converted to cost/die.
3. Finally, the unit die costs are accumulated in the sequence of the manufacturing process and yielded at each stage. Yield refers to the production units successfully manufactured in each stage. The semiconductor manufacturing process typically loses much of its production due to misprocessing or nonfunctioning die. Yielding the accumulated unit cost at each manufacturing stage applies the cost of lost production units to the cost of good production units.

In MosCo, the unit production cost of each major manufacturing stage (wafer fabrication, probe, assembly, test) has been determined by applying that stage's annual spending to the annual volume of production (Exhibits 2 and 6) or capacity (Exhibits 3 and 7).

Exhibits 3 and 7 highlight the computation of unit cost at each stage of manufacturing. In wafer fabrication and probe, the production unit is a wafer. Unit cost through these two stages is computed as wafer cost. In assembly and test, the wafer has been diced to remove the die. The good die continue through assembly; the nonfunctioning die are discarded. Unit cost through these two manufacturing stages is computed as die cost.

At each stage of production, production loss (or yield) is experienced. Yield loss is typically greatest during probe, when each die on the wafer is first tested to determine if it is functioning as designed. At probe, the effectiveness and quality of the wafer fabrication process, through which the multiple circuit layers have been placed on the wafer, are revealed. In wafer fabrication, the wafers used solely for engineering testing (to ensure equipment is properly calibrated, and not used for production) are also eliminated (treated similar to production yield loss) in the calculation of wafer cost.

Exhibits 2 and 6 highlight the computation of product cost. The unit cost of each manufacturing stage is listed. For the raw wafer, wafer fabrication and probe, the unit cost (wafer) is converted to die cost. The material cost is reflected at the manufacturing stage where it is introduced. To determine a final or complete product cost, the cost per die is accumulated through each manufacturing stage and yielded for the production loss experienced in that stage. Yielding the accumulated die cost has the effect of placing the total cost of manufacturing on the good production units (or expected good production units if the total production capacity costing method is used).

Exhibit 2 highlights the accumulation of costs the ×100 incurs during manufacturing. The cost and application of raw material can be seen at the start of wafer fabrication and assembly. Wafer to die conversion, based on the ×100's specification of 50 die on each wafer, is used to compute the equivalent die cost from the raw wafer, and at wafer fabrication and probe. Finally, the treatment of production loss (yield) can be seen throughout the costing process, as the accumulated cost at each stage of production is increased by the planned or expected yield at that stage, resulting in an accumulated cost which reflects the total cost of production applied to the good die produced or expected after each stage.