4

Activity-Based Cost Systems

Activity-based costing (ABC) developed to provide more-accurate ways of assigning the costs of indirect and support resources to activities, business processes, products, services, and customers. ABC systems recognize that many organizational resources are required not for physical production of units of product but to provide a broad array of support activities that enable a variety of products and services to be produced for a diverse group of customers. The goal of ABC is *not* to allocate common costs to products. The goal is to measure and then price out all the resources used for activities that support the production and delivery of products and services to customers.

ABC attempts to first identify the activities being performed by the organization's support resources. Then it traces the resource expenses of the support resources to the activities, ending up with the total cost of performing each of the organization's support activities. In the next stage, ABC systems trace activity costs to products by identifying a cost driver for each activity (called an activity cost driver), calculating an activity cost driver rate, and using this rate to drive activity costs to products. For each product (or service or customer) the quantity of each cost driver it used during a period is multiplied by the standard cost driver rate. The procedure may sound complicated, but actually it is quite simple to illustrate and even to implement in practice. For example, Exhibit 4-1 shows how a single resource category, *indirect labor*, is decomposed into six different activities performed and then linked, via appropriate activity cost drivers, to cost objects such as products, services, and customers.

We start by extending the discussion in Chapter 3 of assigning the cost of service and support department resources beyond production centers to incorporate activities that support production processes. Subsequently, in this chapter, we describe the second stage of a cost assignment process, in which cost center and activity costs are traced to products.[1]

Activity-based cost systems expand the type of "production cost centers" used to ac-

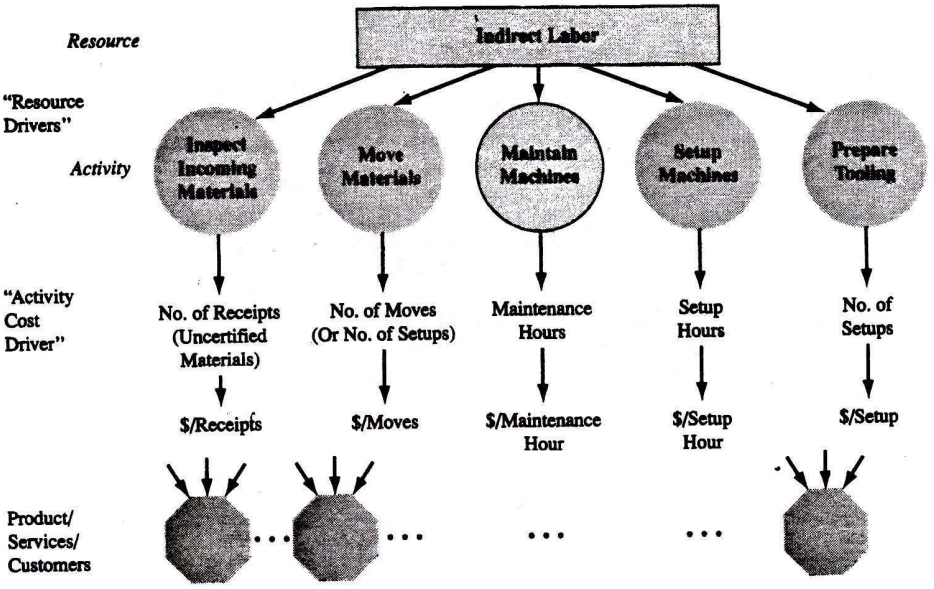


EXHIBIT 4-1 Activity-Based Costing: Expenses Flow from Resources to Activities to Products, Services, and Customers

cumulate costs. Rather than focus only on the location or organization of responsibility centers, ABC systems focus on the actual activities performed by organizational resources. ABC systems retain, as in traditional systems, activities that convert materials into finished products such as machining products and assembling products within production cost centers. But, in addition, ABC systems recognize that some resources perform work such as setting up machines, scheduling production orders, inspecting products, improving products, and moving materials. These are support activities; they are not directly involved in the physical process of converting raw materials to intermediate and finished products. For service organizations, lacking direct materials and easily traceable direct labor, almost all activities can be considered support: handling customer relationships and enhancing existing services, as well as actually delivering the primary service (a checking account transaction, a phone call, a medical procedure, an airline flight) to the customer.

ASSIGNING SERVICE DEPARTMENT COSTS TO ACTIVITIES

The costs of many service departments cannot be assigned to production departments via direct charging or a cost driver that reflects a cause-and-effect relationship between the service department and the production department. These untraceable, or "common-cost," service department expenses include scheduling, product engineering, plant administration, information systems, purchasing, materials handling, and plant-level expenses, such as property taxes, building depreciation, insurance, heat, and light. We argued, in Chapter 3, that for cost control and cost responsibility purposes these seemingly common expenses should not be assigned to production centers.

Activity-based cost systems provide a mechanism for establishing causal relationships between expenses that must be treated as common or joint in traditional cost systems. Let us illustrate the ABC resource cost assignment process with a simple example.[2] Consider the materials handling department of the Williams Corporation, which is responsible for receiving raw materials and purchased parts, transporting them to the stockroom, and releasing items to the production floor when they are needed for scheduled production lots. The monthly cost for this department is $50,000. The average number of labor hours worked each month in the plant is 40,000 hours.

In the past, the Williams Corporation had a traditional overhead allocation system in which the costs of indirect support departments were allocated to production departments using direct labor hours (dlh). With this procedure, the burden rate for the materials handling department would be:

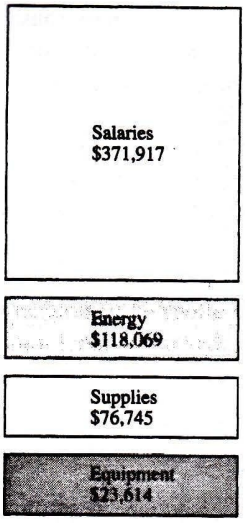
$$\begin{aligned}\text{Materials handling burden rate} &= \$50{,}000/40{,}000 \text{ dlh} \\ &= \$1.25/\text{dlh}\end{aligned}$$

and a production department that used 6000 direct labor hours in a month would receive an assignment of $7,500 of materials handling expenses. Such an assignment, however, assumes that each hour of direct labor worked in a department requires $1.25 of resources from the materials handling department. Because this assumption is highly unlikely to be even approximately valid, we refer to such an assignment as an allocation; it uses a resource driver, such as direct labor hours, that bears no causal relationship to the demand for or consumption of resources in the materials handling department. For example, one department that does long runs of standard products may make relatively few demands on the materials handling department resources, whereas another department that does many short runs of customized products containing a large number of unique components may make quite heavy demands on the materials handling department. The direct labor resource driver fails to distinguish the large variation in demands for materials handling resources from the two quite different production departments.

In an ABC system, the designer links resource expenses to activities performed. Classifying spending by activities performed accomplishes a 90 degree shift in thinking about expenses (see Exhibit 4-2).

The resource cost drivers collect expenses from the financial system and drive them to the activities being performed by the organizational resources. Thus, after going through this step, organizations learn, usually for the first time, how much they are spending on activities such as purchasing materials and introducing new products.

One does not need extensive time-and-motion studies to link resource spending to activities performed. The goal is to be approximately right, rather than precisely wrong, as are virtually all traditional product costing systems. Many traditional standard cost systems calculate product costs out to six significant digits ($5.71462 per unit), but, because of arbitrary allocation procedures, the first digit is usually wrong. The data to link resource expenses to activities performed can be collected from employee surveys in which individuals, other than the front-line employees who are actually doing production work, are asked to fill in a survey form in which the activity dictionary is listed and they estimate the percentage of time they spend on any activity (in excess, say, of 5% of their time) on the list.





	Salaries	*Energy*	*Supplies*	*Equipment*
Process customer orders				$144,846
Purchase materials				$136,320
Schedule production				$72,143
Move materials				$49,945
Set up machines				$47,599
Inspect items				$45,235
Maintain product information				$27,747
Perform engineering changes				$17,768
Expedite orders				$16,704
Introduce new products				$16,648
Resolve quality problems				$15,390

Total $590,345

EXHIBIT 4-2 Tracing Organizational Expenses to Activities

Often, cost system designers interview department managers, like Jennifer Cassell, the manager of the materials handling department. An example of an edited and abbreviated transcript of such an interview is presented below:

Interview with Jennifer Cassell

Q: How many people work in your department?
A: Twelve, not counting me.
Q: What do the people do?
A: Well, everyone does a little bit of everything; it varies from week to week, even from day to day.
Q: Sure, but are there some major activities that seem to be done on a regular basis?
A: I suppose we have three principal activities that would take up at least 90% of our time. The largest is receiving, checking, and logging in incoming shipments of purchased parts. About half our people are involved in this activity, receiving, inspecting a few items in each shipment, updating the documentation, and placing the shipment in the parts storage area.
Another 25% of the people, about three folks, do the same set of activities for raw materials, like steel, aluminum, and plastics.
Q: What's the other major activity?
A: Oh, the remaining three people would typically be working with the production control people. My people get copies of the production schedule, and their job is to kit together the purchased

parts and raw materials needed for each production run. Then they disburse the parts and materials to the workstation on the floor when and where they are needed.

Q: Is there anything else?

A: Each week some new task shows up, perhaps go to quality training, or lend a hand in final goods shipment if they're handling a rush order and are short of help, or even help in process inspection, if needed, since my people are really well trained in statistical process control.

Q: Cumulatively, are all these special, ad hoc tasks a big time drain?

A: Not really, it seems like a big bother when it happens, but realistically it's probably 5% or less of our time.

Q: What about your job. Do you do any direct work with the incoming materials?

A: Occasionally, if someone is sick or on vacation, but mostly my job is coaching, training, making sure the system is working well, and that we're meeting the needs of our internal customers.

Q: What determines how long it takes to process an incoming shipment? Does it matter whether it's raw materials or a purchased part, whether it's a large or a small shipment?

A: Purchased parts are straightforward; just look at one or two, check that they're in conformance, and then take them to the storage area. Almost always, we can get the parts to storage in one trip. Raw materials can come in larger sizes, and some of those big orders can take a while to check and to move into storage. But even that is relatively rare. I would say the time required to process either a shipment of parts or of raw materials depends much more on how many shipments we get than on the size of the shipments.

Q. What about the activity of disbursing parts and materials to the floor?

A. Again, volume is not a driver here; work is driven more by how many production runs we have to get ready for than the size of any particular run. For 80% or 90% of production runs, we can handle all parts and materials requirements with one trip to the workstation.

Identifying Activities and Mapping Resource Costs to Activities

Ignoring the minor activities that are done on an ad hoc basis and that collectively account for less than 5% of the work of the materials handling department, Jennifer Cassell has identified three principal activities performed by people in her department:

- Receiving purchased parts
- Receiving raw materials
- Disbursing parts and material to workstations

We use the information in the interview to map the $50,000 resource cost to the three activities. For simplicity, we will assume that each of the twelve employees (not

counting Cassell) is about equally skilled and equally paid. This assumption enables us to use the time percentages for assigning resource costs to the three activities:

ACTIVITY	PERCENTAGE OF EFFORT	ACTIVITY COST
Receiving purchased parts	50%	$25,000
Receiving raw materials	25	12,500
Disbursing parts/materials	25	12,500

In this example, we have assumed that all employees' efforts cost the same. If, however, the people doing the materials receiving raw materials activity were more skilled and more highly paid, then we could not use simple percentage assignments. We would have to trace their higher costs to the receiving raw materials activity and use the lower wages for the labor performing the other two activities. Also, if for inspecting purchased parts, a special set of expensive testing equipment had been acquired, then the cost of this equipment should be assigned only to the receiving purchased parts activity. In this case, the percentage assignments of people and their time would be used to assign only the compensation cost of the individuals but not of the equipment they used.

A final consideration is the assumption that we should spread the cost of the department manager, Jennifer Cassell, across all three activities proportional to the time worked by each of the employees under her supervision. This assumption seems reasonable if she provides general coaching and assistance. A more detailed assignment of her costs would be required if she spent disproportionately more of her time with employees performing one of the three activities, or if, for a significant part of her time, she performed one or more of the three activities. We would then assign that portion of her time actually working with parts and materials to the appropriate activity or activities. The remaining time, consisting of general supervision, would then be spread across the three activities using some appropriate metric (such as hours of work or number of activities performed).

This process enables all organizational expenses to be traced to activities performed. And, as the above example clearly shows, many of these newly defined activities are not associated with directly fabricating or assembling the product or servicing a customer. They are support or infrastructure activities. But, as we will see, the costs of these activities can be assigned to products (and services and customers) just as easily as more traditional production costs such as materials, direct labor, and machine production costs.

Estimates or Allocations?

Earlier we argued against assigning costs to products using allocations—in which the cost driver did not represent actual demands by the product on the resource whose cost was being assigned. At first glance, the process of interviewing Jennifer Cassell and using her approximate estimates of time and effort to assign the resource costs in her department might appear to be an example of an allocation process. In fact, however, the procedure of driving resource costs to activities performed requires an **estimation** process of the underlying quantity variable linking resource supply to activities performed. It is not an **allocation** process that arbitrarily assigns a cost by a measure unrelated to the work being performed. In principle, analysts could

install elaborate monitoring and measuring devices to learn exactly the quantity and cost of resources used for the various activities. But such elaborate instrumentation is rarely required, especially to obtain reasonably accurate costs of products, services, and customers. Thus, we use surrogate or approximate measures to obtain data inexpensively since the surrogates are accurate enough for the decisions that will be made using product and customer cost information. The surrogates, such as estimates of time spent in various activities, although reliable enough for these purposes, would not be accurate or precise enough to drive day-to-day productivity improvements and cost reduction. Thus, we see how the data requirements can differ substantially between the two principal uses of costing information: cost control and productivity enhancements versus costing of products, services, and customers.

ASSIGNING SERVICE DEPARTMENT COSTS: SOME FIXED AND SOME VARIABLE[3]

The resources under the control of Jennifer Cassell's materials handling department were assumed to be "fixed" in the conventional definition of the term. She and the twelve people in her department came to work each day and expected to be paid whether parts and materials shipments arrived or not or whether materials had to be disbursed to the factory floor or not. This situation is typical of many support departments. Commitments to service and support departments are made to acquire personnel, space, equipment, and technology. The supply of these resources will not vary with short-term fluctuations in the demand for services from these service and support departments.

Some support departments, however, may have a mixture of committed resources and resources whose supply may vary with demands for service. Consider the Inspection Department in the Williams Company. This department has some assigned space where work is performed and some specialized equipment. But people are assigned, as needed, to perform inspections. In this case, the resource costs of the inspection department require two different driver rates for assigning inspection costs. The committed expenses for space and equipment will be assigned on the basis of the capacity (or some standard volume measure) provided by these resources, whereas the expenses of the flexible resources, the inspectors, are assigned on the basis of actual demands for their services.

For example, assume that budgeted monthly expenses for the Inspection Department are $80,000. Of this amount, $60,000 represents the cost of the committed resources, and $20,000 represents the cost of the flexible resources. The equipment has a practical capacity of 5,000 inspections per month; the budget for the inspectors reflects an expected volume of 4,000 inspections. The table below shows the calculation of how the cost driver rate for assigning the cost of the Inspection Department is calculated:

Inspection Department: Committed and Flexible Resource Costs

RESOURCE CATEGORY	BUDGETED EXPENSE	ACTIVITY LEVEL: NO. OF INSPECTIONS	DRIVER RATE
Committed	$60,000	5,000 (capacity)	$12
Flexible	$20,000	4,000 (budgeted)	5
Total	$80,000		$17

The $12 rate charges for the cost of resources that are committed (supplied) and are therefore "fixed," independent of the actual demands for services. The $5 rate charges for the resources that are supplied flexibly, as needed, to perform the services demanded of the department.

This distinction, between the costs of committed and flexible resources, can be maintained for all organizational resources. It is quite simple, with today's data bases and systems, to identify which costs assigned to production departments, primary activities, and, eventually, to products are flexible in the short run. This identification will enable information about short-run contribution margin and variable costing to be readily at hand even while the costs of all resources used, whether committed or flexible, by production departments, activities, and products, can be calculated and reported as well.

ACTIVITY COST DRIVERS

The second stage of an activity-based cost system assigns activity costs to products. This assignment is done by selecting activity cost drivers that link the performance of activities to demands made by individual products. Cost drivers are not unique to ABC systems, of course. Traditional cost systems used simple drivers, such as direct labor dollars, direct labor hours, machine hours, units produced, or materials processed for allocating production cost center costs to products.

Consider the example of a typical German cost system, perhaps the most elaborate and detailed in the world. The number of cost centers in German companies is unusually high. For instance, one German $150 million manufacturing company, producing electric and electronic switches with only three manufacturing stages, uses about 100 cost centers: 15 of them are direct production cost centers, the other 85 are mostly indirect responsibility centers. Big plants of other companies, such as Siemens or Mercedes, can have between 1,000 and 2,000 cost centers. The German companies use such a large number of cost centers so that they can develop flexible budgets that give managers great visibility of cost incurrence at the individual cost center. The large number of cost centers enables them to have individual cost centers with highly homogeneous work processes.

For each cost center, the cost system designer makes a choice about the appropriate cost driver. A cost center doing manual assembly of components would use a direct labor cost driver. A cost center consisting of automatic machines would use machine hours as the cost driver. A cost center doing continuous processing of materials, such as in a chemical process, would use pounds or gallons of materials processed as the cost driver. Thus, a comprehensive cost system could consist of hundreds of different cost centers, each with its own cost driver, chosen to be representative of the nature of work performed at that cost center.

Although these systems are wonderful for providing cost visibility and control at the responsibility and cost center level, they are inadequate for assigning cost center costs to products. The fundamental problem is that many organizational resources are required not for physical production of units of product but to provide a broad array of support activities that enable a variety of products and services to be produced for a diverse group of customers. Despite the use of two or three different types of cost drivers (labor hours, machine hours, materials processed, units produced) in systems with hun-

dreds of cost centers, the cost drivers all share a common and critical characteristic. The quantity of a cost driver used by an individual product is proportional to the physical volume of product produced. That is, if production of a product increases by 10%, then the labor hours, the machine hours, and the materials processed for this product would all increase by 10%. Therefore, the indirect and support costs assigned to this product would increase by 10%.

But many resources of indirect and support departments are not used in proportion to physical volume. Therefore, assigning these costs using cost drivers that are proportional to volume creates significant errors in the costs assigned to individual products. Traditional cost systems, organized around production centers, emphasize work that is proportional to the number of units produced. We call such work *unit-level activities*.

> **Unit-level activities** represent work performed for every unit of product or service produced. The quantity of resources used by unit-level activities is proportional to products' production and sales volumes. Cost drivers for unit-level activities include labor hours, machine hours, and materials quantity processed.

Analysis of many of the activities done by support resources, however, reveals that much of the work they perform is associated with batch, or product-sustaining, activities.[4]

> **Batch-level activities** include setting up a machine for a new production run, purchasing materials, and processing a customer order. The important distinction, between batch and unit-level activities, is that the resources required to perform a batch-level activity are independent of the number of units in the batch (number of components produced after a setup, number of items in a purchase order, or the number of products in a customer shipment).

Traditional cost systems view the expenses of resources performing batch-level activities as *fixed*, because they are independent of the number of units processed in a batch activity. But, of course, as more batch-level activities are demanded (to perform the many setups in a plant producing a wide variety of products and components, to purchase all the components required in a complex product's bill of materials, and to satisfy the many small customized orders for individual customers), the organization must eventually supply additional resources to perform these activities. Thus, one of the advances made by activity-based cost systems over traditional cost systems is the ability to measure and assign the cost of handling production orders, material movements, setups, customer orders, and purchasing to the products, customers, and services that triggered the activity.

> **Product-sustaining activities** represent work performed to enable the production of individual products (or services) to occur. Extending this notion outside the factory leads to **customer-sustaining activities,** which represent work that enables the company to sell to an individual customer but that is independent of the volume and mix of the products (and services) sold and delivered to the customer. Examples of product- and customer-sustaining activities include maintaining and updating product specifications, special testing and tooling for individual products and services, technical support provided for individual products and services, and customer market research and support.

Exhibit 4-3 shows the cost hierarchy of unit, batch, product-sustaining, and customer sustaining activities. It illustrates that costs to sustain a product may not be related

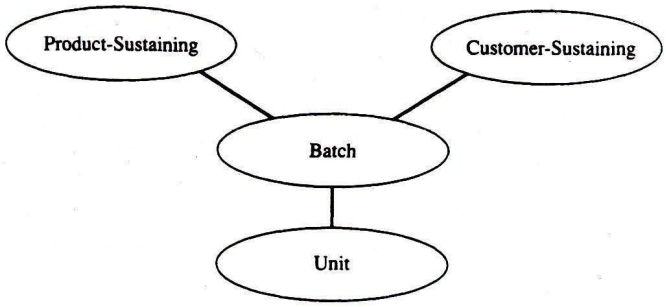


EXHIBIT 4-3 ABC Hierarchy of Activities

to individual customers, and, conversely, many customer-related costs may be independent of the products that the organization sustains in its product line.

The costs of product- and customer-sustaining activities are easily traced to the individual products and services for whom the activities are performed, but the *quantity* of resources used in product- and customer-sustaining activities are, by definition, independent of the production and sales volumes for the products and customers. Again, traditional cost systems with their narrow distinction between fixed and variable costs relative to production volumes cannot trace product- and customer-sustaining resources to individual products and customers.

The linkage between activities and cost objects, such as products, services, and customers, is done by **activity cost drivers**. An activity cost driver is a quantitative measure of the output of an activity. Activity-based cost systems require, in addition to traditional unit-level drivers such as labor and machine hours, the use of activity cost drivers that can trace batch, product-sustaining, and customer-sustaining activity costs to products and customers. For each individual activity, the designer selects an appropriate activity cost driver (as shown earlier in Exhibit 4-1).

Examples of activities and associated batch or product-sustaining activity cost drivers are shown in the following table:

ACTIVITY	ACTIVITY COST DRIVER	BATCH (B) OR PRODUCT-SUSTAINING (P)
Run machines	Number of machine hours	B
Set up machines	Number of setups or setup hours	B
Schedule production jobs	Number of production runs	B
Receive materials	Number of material receipts	B
Support existing products	Number of products	P
Introduce new products	Number of new products introduced	P
Modify product characteristics	Number of engineering change notices	P

To assign activity costs to individual products requires knowledge of the *quantity* of the activity cost driver for every individual product. That is, in addition to knowing the

materials content, and the direct labor and machine hours required at each production cost center, the ABC system must know, product by product, the quantity of each activity cost driver; for example, for each product, the system must have information on drivers such as:

- Number of setups
- Number of material purchases
- Number of material moves
- Number of engineering change notices

This is a large increase in the amount of information that must be collected. Fortunately, the increased availability of integrated information systems, particularly newly installed enterprisewide systems, enables activity cost driver information to be much more accessible, at low cost, than in the past.

Let us illustrate how to work with activity cost drivers by extending our simple example of the materials handling department in the Williams Corporation. We determined earlier that the materials handling burden rate was $1.25 per direct labor hour ($50,000 department cost per month/40,000 average direct labor hours per month).

Consider a low-volume product, Widget A. About 100 units of Widget A are produced each month. It takes one hour of direct labor to produce each Widget A. With the company's traditional cost system, $125 of materials handling expense were allocated to Widget A each month.

The new ABC system at Williams identified three primary activities done by the materials handling department: receive parts, receive materials, and disburse parts to the production floor. For each of these activities, the ABC system designers chose an appropriate cost driver, and then collected the quantity of the cost driver. They then divided the assigned activity expense by the quantity of the activity cost driver to obtain the activity cost driver rate. The calculations are shown below:

	RECEIVE PARTS	RECEIVE MATERIALS	DISBURSE PARTS AND MATERIALS
Activity cost driver	No. of parts receipts	No. of materials receipts	No. of production runs
Activity cost	$25,000	$12,500	$12,500
Driver quantity	2,500 receipts	1,000 receipts	500 runs
Activity cost driver rate	$10/receipt	$12.50/receipt	$25/run

Widget A is quite a complex product, with more than 50 separate purchased parts and several different types of raw materials required to assemble a finished product. Producing the 100 units of Widget A during the month typically requires one production run, 20 purchased parts shipments, and four raw materials shipments (many shipments are required even for only one production run because of the large number of different parts and materials required to produce Widget A). Using the activity

cost drivers to assign materials handling costs to Widget A yields the following computation:

ACTIVITY	QUANTITY OF ACTIVITY COST DRIVER	ACTIVITY COST DRIVER RATE	ACTIVITY COST
Receive parts	20	$10/receipt	$200
Receive materials	4	12.50/receipt	50
Disburse materials	1	25/run	25
Total materials handling costs			$275

The per widget cost of materials handling of $2.75 (= $275/100) is more than twice the $1.25 cost assigned by the traditional direct labor allocation system. The assignment is much higher because of the complexity of Widget A—it requires many different raw materials and purchased parts—and also because production runs are relatively short for this low-volume product.

Selecting Activity Cost Drivers

The selection of an activity cost driver reflects a subjective tradeoff between accuracy and the cost of measurement. Because of the large number of potential activity-to-product linkages, designers attempt to economize on the number of different activity cost drivers. For example, activities triggered by the same event—prepare production orders, schedule production runs, perform first part inspections, or move materials—can all use the same activity cost driver: number of production runs or lots produced.

ABC system designers can choose from different types of activity cost drivers:

1. Transaction
2. Duration
3. Intensity or direct charging

Transaction drivers, such as the number of setups, number of receipts, and number of products supported, count how often an activity is performed. Transaction drivers can be used when all outputs make essentially the same demands on the activity. For example, scheduling a production run, processing a purchase order, or maintaining a unique part number may take the same time and effort independent of which product is being scheduled, which material is being purchased, or which part is being supported in the system.

Transaction drivers are the least expensive type of cost driver but could be the least accurate, because they assume that the same quantity of resources is required every time an activity is performed. For example, the use of a transaction driver such as the number of setups assumes that all setups take the same time to perform. For many activities, the variation in use by individual products is small enough that a transaction driver will be fine for assigning activity expenses to the product. If, however, the amount of resources required to perform the activity varies considerably, from product to product, then more accurate and more expensive cost drivers are required.

Duration drivers represent the amount of time required to perform an activity. Duration drivers should be used when significant variation exists in the amount of activity required for different outputs. For example, simple products may require only 10–15 minutes to set up, whereas complex, high-precision products may require 6 hours for setup. Using a transaction driver, such as number of setups, will overcost the resources required to set up simple products and will undercost the resources required for complex products. To avoid this distortion, ABC designers would use a duration driver, such as setup hours, to assign the cost of setups to individual products.

Examples of duration drivers include setup hours, inspection hours, and direct labor hours. They are more accurate than transaction drivers, but they are much more expensive to implement because the model requires an estimate of the duration each time an activity is performed. With only a transaction driver (number of setups), the designer would need to know only how many times a product was set up, information that should be readily available from the production scheduling system. Knowing the setup time for each product is an additional, and more costly, piece of information. Some companies estimate duration by constructing an index based on the complexity of the output being handled. The index would be a function of the complexity of the product or customer processed by the activity, assuming that complexity influences the time required to perform the activity. The choice between a duration and a transaction driver is, as always, one of economics, balancing the benefits of increased accuracy against the costs of increased measurement.

For some activities, however, even duration drivers may not be accurate. **Intensity drivers** directly charge for the resources used each time an activity is performed. In our setup example, a particularly complex product may require special setup and quality control people, as well as special gauging and test equipment each time the machine is set up to produce the product. A duration driver, such as setup cost per hour, assumes that all setup hours on the machine are equally costly, but it does not reflect extra personnel, especially skilled personnel and expensive equipment that may be required on some setups but not on others. In these cases, activity costs may have to be charged directly to the product, on the basis of work orders or other records that accumulate the activity expenses incurred for that product.

Intensity drivers using direct charging are the most accurate activity cost drivers but are the most expensive to implement; in effect they require a job order costing system to keep track of all the resources used each time an activity is performed. They should be used only when the resources associated with performing an activity are both expensive and variable each time an activity is performed.

The choice among a transaction, duration, or direct charging (intensity) cost driver can occur for almost any activity. For example, for performing engineering change notices (to upgrade and support existing products), we could use:

- Cost per engineering change notice (assumes that all engineering change notices consume the same quantity and cost of resources)
- Cost per engineering change hour used for the engineering change notice done for an individual product (allows for engineering change notices to use different amounts of time to perform but assumes that all engineering hour costs are the same)
- Cost of engineering resources actually used (number of engineering hours, price per hour of engineers used, plus cost of equipment such as engineering workstations) on the job

Similarly, for a sales activity, such as support existing customers, we could use either a transaction, a duration, or an intensity driver. For example,

- Cost per customer (assumes that all customers cost the same)
- Cost per customer hour (assumes that different customers use different amounts of sales resource time, but each hour of support time costs the same)
- Actual cost per customer (actual or estimated time and specific resources committed to specific customers)

Often, ABC analysts, rather than actually record the time and resources required for an individual product or customer, may simulate an intensity driver with a weighted index approach. They ask individuals to estimate the relative difficulty of performing the task for one type of product or customer or another. A standard product or customer may get a weight of 1; a medium complexity product or customer may get a weight of 3 to 5, and a particularly complex (demanding) product or customer may get a weight of, say, 10. In this way, the variation in demands for an activity among products and customers can be captured without an overly complex measurement system. Again, the important message is to make an appropriate tradeoff between accuracy and the cost of measurement. The goal is to be approximately right; for many purposes, transaction drivers or estimates of relative difficulty may be fine for estimating resource consumption by individual products, services, and customers.

Activity cost drivers are the central innovation of activity-based cost systems, but they are also the most costly aspects of ABC systems. Often, project teams get carried away with the potential capabilities of an activity-based cost system to capture accurately the economics of their organization's operations. The teams see diversity and complexity everywhere and design systems with upwards of 500 activities. But, in selecting and measuring the activity cost drivers for such a system, a reality check takes hold. Assuming that each different activity requires a different activity cost driver,[5] and that the organization has, say, 5,000 individual products and customers (not an atypically low number for many organizations), then the analyst must be able to enter up to 2,500,000 pieces of information (500 × 5,000): the quantity of each activity cost driver used by each individual product and customer. This is why most ABC systems settle down, for product and customer costing purposes, to having no more than 30–50 different activity cost drivers, most of which can be accessed and traced to individual products and customers relatively simply in their organization's existing information system.[6]

DESIGNING THE OPTIMAL SYSTEM

Is ABC just a more complex and expensive way to perform cost allocations? No. An activity-based cost system has the capability of tracing back from any cost assignment to underlying economic events. For example, setup costs are assigned on the basis of setups performed for individual products. Product support costs can be traced back to

work performed to maintain products in the organization. And customer administration costs can be traced back to handling customer orders, responding to customer requests, and marketing existing and new products to particular customers.

ABC systems may use many **estimates**. For example, a system may use a transaction driver to approximate the resources used each time an activity is performed rather than a detailed cost collection (direct charging, or intensity, driver) for each occurrence of an event. Or the system may estimate the cost of a machine hour by averaging acquisition costs, maintenance costs, and operating costs of the machine over some period of time. These estimates are made, not because actual costs are impossible to trace to particular events, but because the cost of doing a very detailed and actual cost tracing is judged to be greatly in excess of the value or benefits of doing detailed, actual cost tracing. In principle, if more accurate cost attribution were desired, the ABC designer could install a more precise (and much more expensive) measurement system, and the task would be accomplished. So one should not confuse the extensive use of estimates in an ABC cost model (which is a design judgment made, on a cost/benefit basis) from arbitrary allocations, which are absent from a properly designed ABC system. When arbitrary allocations are used, no cause-and-effect relationship can be established between the cost object to which the cost has been assigned and the resources whose cost has been assigned. In an ABC system, every cost assignment to an activity, or a product, service, or customer, should be transparent and traceable, via cause-and-effect relationships, to the demand for resources by the cost object (whether an activity, product, service, or customer).

The goal of a properly constructed ABC system is not to have the most accurate cost system. Consider a target where the bull's-eye represents the actual cost of resources used each time a product is made, a service delivered, and a customer served.[7] To hit this bull's-eye each time requires an enormously expensive system. But a relatively simple system—perhaps 30–50 activities and using good estimates and many transaction drivers, with few intensity drivers or direct charging—should enable the outer and middle rings of the target to be hit consistently; that is, activity and process costs will be accurate to within 5% or 10%. Traditional cost systems virtually never even hit the target, or even the wall on which the target is mounted, as their highly distorted costs approximate firing a shotgun at a barn but shooting directly up in the air or to the sides. Good engineering judgment should be used; 90% or more of the benefits from a more accurate cost system can be obtained with relatively simple ABC systems.

The goal should be to have the best cost system, one that balances the cost of errors made from inaccurate estimates with the cost of measurement (see Exhibit 4-4). Traditional cost systems are inexpensive to operate, but they lead to large distortions in reporting the cost of activities, processes, products, services, and customers. Consequently, managers may make serious mistakes in decisions made on the basis of this information; there is a high cost of errors. But attempting to build an ABC system with 1,000 or more activities, and directly charging actual resource costs to each activity performed for each product, service, and customer would lead to an enormously expensive system. The cost of operating such a system would greatly exceed the benefits in terms of improved decisions made with this slightly more accurate information.

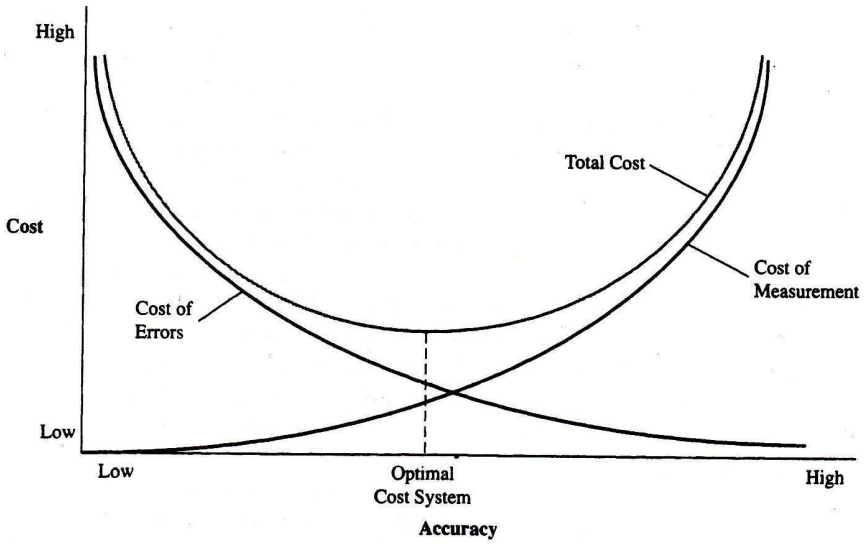


EXHIBIT 4-4 Activity-Based Costing—Designing the Optimal ABC System

SUMMARY

Activity-based cost systems provide more accurate cost information about business activities and processes and about the products, services, and customers served by these processes than do traditional cost systems. ABC systems focus on organizational activities as the key element for analyzing cost behavior in organizations by linking organizational spending on resources to the activities and business processes performed by those resources. Activity cost drivers, collected from diverse corporate information systems, then drive activity costs to the products, services, and customers that create the demand for (or are benefiting from) the organizational activities. These procedures produce good estimates of the quantities and the unit costs of the activities and resources deployed for individual products, services, and customers. Just how to use and interpret this more accurate information is the subject of the next two chapters.

ENDNOTES

1. We retain the convention, used in earlier chapters, of using the word *products* to represent not only products produced but also services delivered and customers served. Some people refer to products, services, and customers as *cost objects*. We prefer to use the more familiar word *product* rather than the technical term *cost object*.
2. This example is taken from R. Cooper and R. S. Kaplan, "Measure Costs Right: Make the Right Decisions," *Harvard Business Review* (September–October 1988), p. 99.
3. See R. S. Kaplan, "Flexible Budgeting in an Activity-Based Costing Framework, *Accounting Horizons* (June 1994), pp. 104–09; and L. F. Christenson and D. Sharp, "How ABC Can Add Value to Decision Making," *Management Accounting* (May 1993), pp. 38–42.

4. The characterization of unit, batch, and product-sustaining activities is due to R. Cooper, "Cost Classifications in Unit-Based and Activity-Based Manufacturing Cost Systems," *Journal of Cost Management* (Fall 1990), pp. 4–14.
5. For product and customer costing purposes, this assumption is correct because any two activities that share a common cost driver (such as number of setups on a particular machine or number of customer requests) can be combined into a single activity without any loss of accuracy. For understanding activity and process costs, however, ABC designers may keep the activities separate even when they share a common cost driver to give visibility to all the individual activities triggered by an incidence of an activity cost driver (a setup or a customer request).
6. With the increased use of integrated, enterprisewide systems, a large number of potential activity cost drivers for ABC systems become automatically available.
7. R. Cooper, "The Rise of Activity-Based Costing—Part Three: How Many Cost Drivers Do You Need and How Do You Select Them?" *Journal of Cost Management* (Winter 1989), p. 34–46.

CASES

THE CLASSIC PEN COMPANY

Jane Dempsey, controller of the Classic Pen Company, was concerned about the recent financial trends in operating results. Classic Pen had been the low-cost producer of traditional BLUE pens and BLACK pens. Profit margins were over 20% of sales.

Several years earlier Dennis Selmor, the sales manager, had seen opportunities to expand the business by extending the product line into new products that offered premium selling prices over traditional BLUE and BLACK pens. Five years earlier, RED pens had been introduced; they required the same basic production technology but could be sold at a 3% premium. And last year, PURPLE pens had been introduced because of the 10% premium in selling price they could command.

But Dempsey had just seen the financial results (see Exhibit 1) for the most recent fiscal year and was keenly disappointed.

> The new RED and PURPLE pens do seen more profitable than our BLUE and BLACK pens, but overall profitability is down, and even the new products are not earning the margins we used to see from our traditional products. Perhaps this is the tougher global competition I have been reading about. At least the new line, particularly PURPLE pens, is showing much higher margins. Perhaps we should follow Dennis's advice and introduce even more specialty colored pens. Dennis claims that consumers are willing to pay higher prices for these specialty colors.

Jeffrey Donald, the manufacturing manager, was also reflecting on the changed environment at Classic Pen:

> Five years ago, life was a lot simpler. We produced just BLUE and BLACK pens in long production runs, and everything ran smoothly, without much intervention. Difficulties started when the RED pens were introduced and we had to make more changeovers. This required us to stop production, empty the vats, clean out all remnants of the previous color, and then start the production of the red ink. Making black ink was simple; we didn't even have to clean out the residual blue ink from the

previous run if we just dumped in enough black ink to cover it up. But for the RED pens, even small traces of the blue or black ink created quality problems. And the ink for the new PURPLE pens also has demanding specifications, but not quite as demanding as for RED pens.

We seem to be spending a lot more time on purchasing and scheduling activities and just keeping track of where we stand on existing, backlogged, and future orders. The new computer system we got last year helped a lot to reduce the confusion. But I am concerned about rumors I keep hearing that even more new colors may be introduced in the near future. I don't think we have any more capability to handle additional confusion and complexity in our operations.

Operations

Classic produced pens in a single factory. The major task was preparing and mixing the ink for the different-colored pens. The ink was inserted into the pens in a semiautomated process. A final packing and shipping stage was performed manually.

Each product had a bill of materials that identified the quantity and cost of direct materials required for the product. A routing sheet identified the sequence of operations required for each operating step. This information was used to calculate the labor expenses for each of the four products. All of the plant's indirect expenses were aggregated at the plant level and allocated to products on the basis of their direct labor content. Currently, this overhead burden rate was 300% of direct labor cost. Most people in the plant recalled that not too many years ago the overhead rate was only 200%.

Activity-Based Costing

Jane Dempsey had recently attended a seminar of her professional organization in which a professor had talked about a new concept, called activity-based costing (ABC). This concept seemed to address many of the problems she had been seeing at Classic. The speaker had even used an example that seemed to capture Classic's situation exactly.

The professor had argued that overhead should not be viewed as a cost or a burden to be allocated on top of direct labor. Rather, the organization should focus on activities performed by the indirect and support resource of the organization and try to link the cost of performing these activities directly to the products for which they were performed. Dempsey obtained several books and articles on the subject and soon tried to put into practice the message she had heard and read about.

Activity-Based Cost Analysis

Dempsey first identified six categories of support expenses that were currently being allocated to pen production:

EXPENSE CATEGORY	EXPENSE
Indirect labor	$20,000
Fringe benefits	16,000
Computer systems	10,000
Machinery	8,000
Maintenance	4,000
Energy	2,000
Total	$60,000

She determined that the fringe benefits were 40% of labor expenses (both direct and indirect) and would thus represent just a percentage markup to be applied on top of direct and indirect labor charges.

Dempsey interviewed department heads in charge of indirect labor and found that three main activities accounted for their

work. About half of indirect labor was involved in scheduling or handling production runs. This proportion included scheduling production orders; purchasing, preparing, and releasing materials for the production run; performing a first-item inspection every time the process was changed over, and some scrap loss at the beginning of each run until the process settled down. Another 40% of indirect labor was required just for the physical changeover from one color pen to another.

The time to change over to BLACK pens was relatively short (about 1 hour) since the previous color did not have to be completely eliminated from the machinery. Other colors required longer changeover times; RED pens required the most extensive changeover to meet the demanding quality specification for this color.

The remaining 10% of the time was spent maintaining records on the four products, including the bill of materials and routing information, monitoring and maintaining a minimum supply of raw materials and finished goods inventory for each product, improving the production processes, and performing engineering changes for the products. Dempsey also collected information on potential activity cost drivers for Classic's activities (see Exhibit 2) and the distribution of the cost drivers for each of the four products. Dempsey next turned her attention to the $10,000 of expenses to operate the company's computer system. She interviewed the managers of the Data Center and the Management Information System departments and found that most of the computer's time (and software expense) was used to schedule production runs in the factory and to order and pay for the materials required in each production run.

Because each production run was made for a particular customer, the computer time required to prepare shipping documents and to invoice and collect from a customer was also included in this activity. In total, about 80% of the computer resource was involved in the production run activity. Almost all of the remaining computer expense (20%) was used to keep records on the four products, including production process and associated engineering change notice information.

The remaining three categories of overhead expense (machine depreciation, machine maintenance, and the energy to operate the machines) were incurred to supply machine capacity to produce the pens. The machines had a practical capacity of 10,000 hours of productive time that could be supplied to pen production.

Dempsey believed that she now had the information she needed to estimate an activity-based cost model for Classic Pen.

EXHIBIT 1 Traditional Income Statement

	BLUE	BLACK	RED	PURPLE	TOTAL
Sales	$75,000	$60,000	$13,950	$1,650	$150,600
Material costs	25,000	20,000	4,680	550	50,230
Direct labor	10,000	8,000	1,800	200	20,000
Overhead @ 300%	30,000	24,000	5,400	600	60,000
Total operating income	$10,000	$ 8,000	$ 2,070	$ 300	$ 20,370
Return on sales	13.3%	13.3%	14.8%	18.2%	13.5%

EXHIBIT 2 Direct Costs and Activity Cost Drivers

	BLUE	BLACK	RED	PURPLE	TOTAL
Production sales volume (no. of units)	50,000	40,000	9,000	1,000	100,000
Unit selling price	$1.50	$1.50	$1.55	$1.65	
Materials/unit cost	$0.50	$0.50	$0.52	$0.55	
Direct labor hr/unit	0.02	0.02	0.02	0.02	2,000
Machine hour/unit	0.1	0.1	0.1	0.1	10,000
No. of production runs	50	50	38	12	150
Setup time/run (hours)	4	1	6	4	
Total setup time (hours)	200	50	228	48	526
Number of products	1	1	1	1	4

Required

1. Estimate the costs for the four pen products using an activity-based approach.
2. What are the managerial implications from the revised cost estimates?

WESTERN DIALYSIS CLINIC (ABC and Healthcare)*

Western Dialysis Clinic is an independent, nonprofit full-service renal dialysis clinic. The clinic provides two types of treatments. Hemodialysis (HD) requires patients to visit a dialysis clinic three times a week, where they are connected to special, expensive equipment to perform the dialysis. Peritoneal dialysis (PD) allows patients to administer their own treatment daily at home. The clinic monitors PD patients and assists them in ordering supplies consumed during the home treatment. The total and product-line income statement for the clinic is shown below:

*This case is adapted from T. D. West and D. A. West, "Applying ABC to Healthcare," *Management Accounting* (February 1997), pp. 22–33.

CLINIC INCOME STATEMENT	TOTAL	HD	PD
Revenues			
Number of patients	164	102	62
Number of treatments	34,067	14,343	20,624
Total revenue	$3,006,775	$1,860,287	$1,146,488
Supply costs			
Standard supplies (drugs, syringes)	664,900	512,619	152,281
Episodic supplies (for special conditions)	310,695	98,680	212,015
Total supply costs	975,595	611,299	364,296

continued

CLINIC INCOME STATEMENT	TOTAL	HD	PD
Service costs			
General overhead (occupancy, administration)	785,825		
Durable equipment (maintenance, depreciation)	137,046		
Nursing services (RNs, LPNs, nursing administrators, equipment technicians)	883,280		
Total service costs	1,806,151	1,117,463	688,688
Total operating expenses	$2,781,746	$1,728,762	$1,052,984
Net income	$ 225,029	$ 131,525	$ 93,504
Treatment Level Profit			
Average charge per treatment		$129.70	$55.59
Average cost per treatment		120.53	51.06
Profit per treatment		$ 9.17	$ 4.53

The existing cost system assigned the traceable supply costs directly to the two types of treatments. The service costs, however, were not analyzed by type of treatment. The total service costs of $1,800,000 were allocated to the treatments using the traditional ratio-of-cost-to-charges (RCC) method developed for government cost-based reimbursement programs. With this procedure, since HD treatments represented about 61% of total revenues, HD received an allocation of 61% of the $1,800,000 service expenses (approximately $1,100,000).

For many years, the clinics such as West received much of their reimbursement on the basis of reported costs. Starting in the 1980s, however, payment mechanisms shifted, and West now received most of its reimbursement on the basis of a fixed fee not the cost of service provided. In particular, because HD and PD procedures were categorized by the government as a single category—dialysis treatment—the weekly reimbursement for each patient was the same: $389.10. As a consequence, the three HD treatments per week led to a reported revenue per HD treatment of $129.70, and the seven PD treatments per week led to a reported revenue per PD treatment of $55.59. Both procedures appeared to be profitable, according to the clinic's existing cost and revenue recognition system. David Thomas, the controller of Western Dialysis was concerned, however, that the procedures currently being used to assign common expenses may not be representative of the underlying use of the common resources by the two different procedures. He wanted to understand their costs better so that Western's managers could make more-informed decisions about extending or contracting products and services and about where to look for process improvements. Thomas decided to explore whether activity-based costing principles could provide a better idea of the underlying cost and profitability of HD and PD treatments.

Phase I

In his initial analysis, Thomas decided to focus on the General Overhead category. But rather than continue to use the RCC method for allocating equipment and nursing costs, he asked the clinic staff for their judgments about how these costs should be allocated. On the basis of the staff's experience and judgment, they felt that HD treatments used about 85% of these resources, and PD about 15%.

Thomas decomposed the General Overhead category into four resource cost pools. Then, for each pool, he chose a cost driver that represented how that resource was used by the two treatments. A summary of his analysis is presented below:

GENERAL OVERHEAD RESOURCE COST POOL	SIZE OF POOL	COST DRIVER
Facility costs (rent, depreciation)	$233,226	Square feet of space
Administration and support staff	354,682	Number of patients
Communications systems and medical records	157,219	Number of treatments
Utilities	40,698	Kilowatt usage (estimated)
Total	$785,825	

Thomas then went to medical records and other sources to identify the quantities of each cost driver for the two treatment types:

GENERAL OVERHEAD COST DRIVER	HD	PD	TOTAL
Square feet	18,900	11,100	30,000
Number of patients	102	62	164
Number of treatments	14,343	20,624	34,967
Estimated kilowatt usage	563,295	99,405	662,700

Required

(1) Prepare the revised set of cost estimates and treatment profit and loss statements for HD and PD, using the information gathered during Phase I. What led to any major difference between the RCC method for allocating cost and the Phase I ABC method?

Phase II

Thomas was uncomfortable with the consensus estimate that nursing and equipment costs should be split 85:15 between HD and PD treatments, respectively. In particular, he knew that just the nursing resource category contained a mixture of different types of personnel: registered nurses (RNs), licensed practical nurses (LPNs), nursing administrators, and machine operators. He thought it was unlikely that each of these categories would be used in the same proportion by the two different treatments. In the next phase of analysis, Thomas disaggregated the nursing service category into four resource pools and, as with general overhead, selected an appropriate cost driver for each resource pool (see below):

NURSING SERVICES RESOURCE POOL	SIZE OF POOL	COST DRIVER
Registered nurses	$239,120	Full-time equivalents (FTEs)
Licensed practical nurses	404,064	Full-time equivalents
Nursing administration and support staff	115,168	Number of treatments
Dialysis machine operators	124,928	Number of clinic treatments
Total	$883,280	

NURSING SERVICES COST DRIVER	HD	PD	TOTAL
RNs, FTE	5	2	7
LPNs, FTE	15	4	19
Total number of dialysis treatments	14,343	20,624	34,967
Number of clinic dialysis treatments	14,343	0	14,343

Thomas felt that the 85:15 split was still reasonable for the durable equipment use, and, in any case, the relatively small size of this resource expense category probably did not warrant additional study and data collection.

Required

(2) Use the information on the distribution of nursing and machine operator resources to calculate revised product-line income statements and profit and loss for individual treatments.

(3) Analyze the newly produced information and assess its implications for managers at Western Dialysis Clinic. What decisions might managers of the clinic make with this new information that might differ from those made using information from the RCC method only?

(4) What improvements, if any, would you make in developing an ABC model for Western Dialysis Clinic?

PAISLEY INSURANCE COMPANY: Activity-Based Costing in a Service Industry* (Bill Cotton)

The Paisley Insurance Company sells a range of insurance products to a variety of residential and commercial customers. The Billing Department (BD) at Paisley provides account inquiry and bill-printing services for the two major classes of customers—residential and commercial. At present the BD services 60,000 residential and 10,000 commercial customer accounts.

The profitability of the company is currently being affected significantly by two factors. First, increased competition in the insurance industry has led to lower insurance premiums being charged by competitors, so Paisley must find ways of reducing

*This case is based on an illustration used in "Implementing Activity-Based Costing—The Modeling Approach," a workshop sponsored by the Institute of Management Accountants and Sapling Corporation.

its operating costs. Second, the demand for insurance services will increase in Paisley's main geographic area because of plans for housing developments and commercial construction. The new housing development department estimates that demand from residential customers will increase by almost 20%, and commercial demand will increase by 10% during the next year. Because the BD is currently operating at full capacity, it needs to find ways to create capacity to service the increase in demand. A local service bureau has offered to take over the BD functions at an attractive lower cost (compared with the current cost). The service bureau's proposal is to provide all the functions of BD at $3.50 per account regardless of the type of account.

Exhibit 1 depicts the present traditional costing system in the BD. Note that all the costs associated with the BD are indirect; they cannot presently be traced specifically and exclusively to either customer class in an economically feasible way. The BD used a traditional costing system that allocated all support costs on the basis of the number of account inquiries generated by each of the two customer classes. Exhibit 1 shows that the cost of resources used in the BD in May 1997 was $282,670. BD received 11,500 account inquiries during the month, so the cost per inquiry was $24.58 ($282,670/11,500). There were 9,000 residential account inquiries, 78% of the total. Thus, residential accounts were charged with 78% of the support costs, and commercial accounts were charged with 22%. The resulting cost per account is $3.69 and $6.15 for residential and commercial accounts, respectively.

Management believed that the actual consumption of support resources was much greater than 22% for commercial accounts because of their complexity. For example, commercial accounts average 50 lines per bill compared with only 12 lines per bill for residential accounts. Management was also concerned about activities such as correspondence (and supporting labor) resulting from customer inquiries, because these activities are costly but do not add value to Paisley's services from the customer's perspective. However, management wanted a more thorough understanding of key BD activities and their interrelationships before making important decisions that would affect Paisley's profitability. The company decided to perform a study of the BD using activity-based costing.

The ABC study was performed by a team of managers from the BD and the chief financial officer from the head office of Paisley. The first task of the ABC team was to determine resources, activities, and related cost drivers. Through interviews with appropriate people, the team identified the following activities and related activity cost drivers.

ACTIVITIES	ACTIVITY COST DRIVERS
Account billing	Number of lines
Bill verification	Number of accounts
Account inquiry	Number of labor hours
Correspondence	Number of letters

All the resources shown in the indirect cost pool of Exhibit 1 support these four activities. That is, labor, building occupancy, telecommunications, computer, printing machines, and paper are resources supporting account billing, bill verification, account inquiry, and correspondence. Cost drivers were chosen on the basis of two criteria:

1. There had to be a reasonable cause-and-effect relationship between the driver unit and the

consumption of resources or the incurrence of supporting activities.

2. Data on the cost driver units had to be available at reasonable cost.

The second step of the ABC team was to develop a process-based map representing the flow of activities and resources and their interrelationships. This map was developed by interviewing key personnel. Once the linkages between activities and resources were identified and checked, a process map was drawn to provide a visual representation of the operations at the BD. Exhibit 2 is a process map that depicts the flow of activities and resources at the BD. Note that there are no costs on Exhibit 2. The management team focused first on understanding business processes. Costs were not considered until the third step, after the key interrelationships of the business were understood.

In examining Exhibit 2, consider residential accounts. Three key activities support these accounts: account inquiry, correspondence, and account billing. Account inquiry activity consumes the time of personnel who perform this task. The people who perform the account inquiry activity, in turn, use telecommunication and computer resources, occupy space, and are supervised. Correspondence is sometimes necessary as a result of inquiries. The people performing the correspondence activity also require supervision. The account billing activity is performed by billing personnel using printing machines. The printing machines occupy space and require paper and computer resources. The people occupy space, use telecommunications, and are supervised. The costs of each of the resources consumed were determined during Step 3: data collection.

During Step 3, the ABC team collected relevant data concerning costs and the physical flow of the cost driver units among resources and activities. Using the process map as a guide, a member of the accounting staff collected the required cost and operational data. Sources of data included the accounting records, special studies, and, sometimes, "best estimates of managers."

The total indirect costs for May 1997 were split into the new cost pools as follows:

Account inquiry	$102,666
Correspondence	17,692
Account billing	117,889
Bill verification	44,423
	$282,670

The count of activity cost driver units for the month was determined to be:

Number of lines on bills	1,220,000
Number of commercial accounts	10,000
Number of labor hours	1,650
Number of letters	1,400

The consumption of cost driver units by each type of account was as follows:

Residential Accounts (60,000)	
Labor hours	900
Letters	900
Lines	720,000
Commercial Accounts (10,000)	
Labor hours	750
Letters	500
Lines	500,000

Bill verification was required for commercial accounts only.

Required

(1) Prepare an ABC analysis of the BD costs associated with residential accounts and commercial accounts. That is:
   (a) Calculate the cost per driver unit for each activity
   (b) Calculate the cost per account for each customer class

(2) Interpret your results, and recommend how this ABC data can be used by BD management.

(3) What are the benefits and costs of developing an ABC model for this application?

EXHIBIT 1 Billing Department—Traditional Costing System, May 1997

INDIRECT COST POOL	
Labor: supervisors	$ 16,800
Labor: Account inquiry	59,200
Labor: Billing	33,750
Building occupancy	23,500
Telecommunications	29,260
Computer	89,000
Printing machines	27,500
Paper	3,660
Total indirect costs	$282,670
Number of inquiries	11,500
Cost per inquiry	$24.58

$$\text{Cost per residential account} = \frac{9{,}000 \text{ inquiries} * \$24.58}{60{,}000 \text{ accounts}} = \$3.69$$

$$\text{Cost per commercial account} = \frac{2{,}500 \text{ inquiries} * \$24.58}{10{,}000 \text{ accounts}} = \$6.15$$

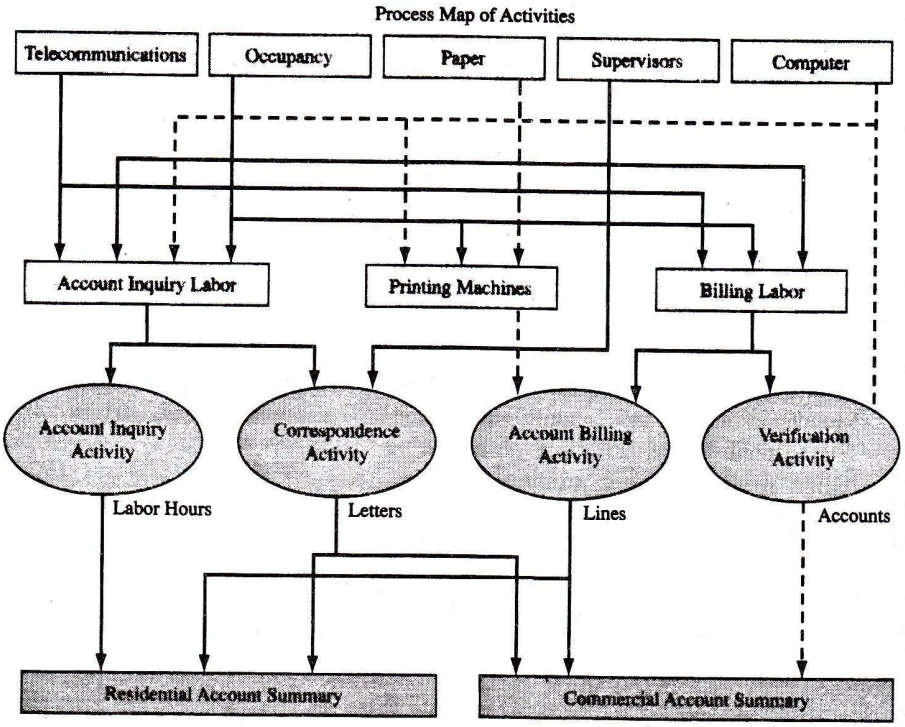


EXHIBIT 2 The Paisley Insurance Company Billing Department

BEDFORD MINING (Paul Foote)*

"Good news and bad news!" exclaimed the Director of Research of Bedford Mining. "We have developed a method to produce a new improved product that will provide a net 50% increase in sales measured in volume. But we have no idea if our margins will increase or decrease!" This long-awaited announcement of a new product development immediately riveted everyone's attention on the speaker. The reference to margin changes was a commentary on the inability of the Finance and Marketing departments to provide the research staff with understandable, accurate, and timely costing and marketing information.

"How can I price new products when we do not even know what it costs us to produce our existing products?" questioned the vice president of marketing. The controller retorted, "We can tell you the cost of each product in our Product Line Report!" "Oh, come on," pleaded the vice president of marketing, "you know as well as I those reports are prepared for accountants by accountants and don't tell us anything about the real world. Our customers already think we are overcharging them. Sometimes we worry we are bringing in unprofitable business. Competitors are dropping like flies, and some days we wonder if we are the only sucker left. Most days our bids are too high; on other days no one objects to our price increases, and we wonder if our prices are too low."

"Since we already provide you with every report known to man, what additional information could we possibly provide you?" asked the controller. After thinking for a moment, the vice president of operations stated, "I don't know exactly what I need, but I certainly know we need a change! And I can tell you that I'll know it when I see it!"

Manufacturing and Financial Information

At Bedford Mining, the raw ore is exposed in an open pit mine through a continuous stripping process to remove the overburden. The raw ore is then loaded into large dump trucks that drive the ore to a conveyor system. Before being conveyed out of the mine to the refiner, the raw ore is blended to maintain a consistent blend. This practice eliminates adjustments in the refinery and maximizes the different ores and ore grades throughout the mine.

In the refinery, the raw ore is partially crushed and screened and blended with a weak solution of raw ore and water. The mixture is thickened through a series of tanks. After reaching a certain chemical content, the mixture is allowed to dry. Dried product is screened into particular mesh sizes and is either sent to bulk storage, loaded in bulk, or packaged and shipped.

Fifty thousand tons of Product A are expected to be mined, refined, shipped, and invoiced to customers next year. There will be no changes to inventory. The mine and refinery adjust to customers' requests to receive products just-in-time, allowing them to delay cash expenditures and reduce warehouse space requirements. Increased competition, in combination with a generally restrained domestic and international economic outlook, provided the mine and refinery with some unused capacity. Quality programs instituted at the mine and refinery reduced the customers' inspection costs and allowed the mine and refinery to respond quickly to customer orders.

Manufacturing costs are generated by a standard variable cost system that includes

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EXHIBIT 1 Cost of Goods Sold: Existing Costing System

	COST PER TON	PRODUCT A (50,000 TONS) TOTAL COST	COST PER TON	PRODUCT B (25,000 TONS) TOTAL COST
Materials	$150	$ 7,500,000	$120	$3,000,000
Labor and benefits	75	3,750,000	75	1,875,000
Variable overhead	35	1,750,000	40	1,000,000
Fixed overhead	60	3,000,000	55	1,375,000
Total	$320	$16,000,000	$290	$7,250,000

the costs of raw materials from the mine and feeds from suppliers. The cost of labor, primarily performing maintenance and operations, is predetermined by a 3-year contract. Variable overhead allocations are based on the consumption of materials and labor. Fixed overhead includes depreciation, amortization of the mine asset, insurance, property tax, and environmental compliance.

Selling costs are related to servicing existing and potential customer accounts. Commissions are paid to distributors who sell the product directly to customers. Shipping costs include the cost of third-party truck and rail delivery. General expenses include the salaries and expenses of support departments such as finance, legal, and administrative.

The finance staff had analyzed the costs for the existing product (A) and the proposed product (B) using the company's existing costing system (Exhibit 1). Profit before tax was calculated using the predictions generated from the current cost system (Exhibit 2). This analysis suggested that Product B would be unprofitable and therefore should not be introduced. After the senior management meeting, discussed above, however, the controller recommended that an activity-based cost analysis be performed and the outcome be compared with the predictions from the existing costing system.

Activity Analysis

Performing an activity-based analysis provides an entirely different perspective on the assignment of costs between the two products. Rather than use a few large overhead pools, activity-based costing assigns the costs to each activity performed, within a relevant production rate, leaving a much smaller portion of costs to be arbitrarily allocated. The following is a simplification of the results of the workflow analysis:

1. Stripping and mining costs for Product A would be $190 per ton and $110 per ton for Product B.

EXHIBIT 2 Profit before Tax: Existing Costing System

STATEMENT OF OPERATIONS	PRODUCT A	PRODUCT B	TOTAL
Sales	$47,000,000	$13,000,000	$60,000,000
Cost of goods sold	16,000,000	7,250,000	23,250,000
Gross margin	$31,000,000	$ 5,750,000	$36,750,000
Selling cost	6,500,000	1,000,000	7,500,000
Shipping cost	14,000,000	5,600,000	19,600,000
General expenses	4,000,000	500,000	4,500,000
Profit before tax	$ 6,500,000	$(1,350,000)	$ 5,150,000

2. Blending costs for both Product A and Product B would be $10 per ton.
3. Crushing costs for Product A and Product B would be $15 per ton.
4. Thickening costs for Product A would be $49 per ton and $0 per ton for Product B. The workflow analysis revealed that thickening was not necessary for the new product, and therefore it assigned no cost for this process. Under the current system, the $49 per ton cost would have been automatically assigned to Product B costs.
5. Drying and sizing costs for Product A would be $76 per ton and $100 per ton for Product B. Because of its chemical properties, Product B would not require sizing, thereby eliminating $100 per ton of cost to the customer.
6. Packaging costs for Product A would be $124 per ton and $20 per ton for Product B. Customers were expected to take most of Product B in bulk, eliminating most packaging costs.
7. Delivery costs for Product A would be $197 per ton and $106 per ton for Product B. Product B would be sold primarily to existing customers and therefore would use the available room in containers already charged at a flat rate.
8. Commissions for Product A would be $100 per ton and $111 per ton for Product B. Product B costs would be higher because of increased advertising and promotion by the distributors to introduce the new product.

Required

Should Product B be introduced?

THE ROSSFORD PLANT*
(Robert Colson and Mark MacGuidwin)

Having heard a professor speak on some of the shortcomings of current cost account systems, I decided to undertake a review of the cost accounting system at our Rossford Plant. I was particularly concerned whether the overhead costs were being allocated to products according to the resource demands of the products. Costing our products accurately has become more important for strategic purposes because of pressures to unbundle sets of original equipment windows for the automakers.

Mark MacGuidwin, Corporate Controller, Libbey-Owens-Ford Co.

Background

Libbey-Owens-Ford Co. (L-O-F), one of the companies in the Pilkington Group, has been a major producer of glass in the United States since the turn of the century. Its Rossford Plant produces about 12,000,000 "lites" of tempered glass per year. (A lite is a unit such as rear window, which is called a "back lite," or a side window, which is called a "side lite.") The plant makes front door windows, quarter windows, back windows, and sunroofs. About 96% of the lites produced are sold to original equipment (OE) automotive customers; the remaining 4% are shipped to replacement depots for later sale to replacement glass wholesalers. Lite sizes range from 0.73 square feet for certain quarter windows to about 13 square feet for the back lite of a Camaro or Firebird. The average size is approximately 4 square feet.

The Rossford Plant comprises two production processes: float and fabrication ("fab"). The float process produces raw float glass, the raw material for automotive windows. Blocks of float glass are transferred to the fab facility, where lites are cut to size, edged, shaped, and strengthened. The final product is then inspected, packed, and shipped.

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Parts of the Rossford Plant date to the founding of the company. Unlike other L-O-F plants, which were designed around the automated Pilkington float-tank process with computer-controlled cutting and finishing operations, the Rossford Plant was designed for the older process of polishing plate glass to final products. Pilkington float tanks were installed in the plant during the 1970s, and the cutting processes were substantially automated during the 1980s. However, the finishing processes have not yet been automated to the extent that they have been at the other plants.

Mark MacGuidwin, Corporate Controller of L-O-F, and Ed Lackner, Rossford's Plant Controller, became concerned during 1987 about the cost allocation process at Rossford for several reasons. First, the process had not been critically evaluated since the automation of the cutting processes. Second, the overhead cost structure at Rossford differed dramatically from that of other L-O-F plants. A larger pool of indirect costs was allocated to equipment centers. Third, they believed that the cost allocation process at Rossford was not accurately assigning costs to units of product. And fourth, changes in the company's competitive environment were raising strategic issues that demanded accurate product cost information for pricing, product mix, and production scheduling purposes.

Relationship of Size to Profit

In his investigation, MacGuidwin discovered what he believed were two key observations made by the vice presidents of engineering and manufacturing. Historically, in the automotive glass business, original equipment (OE) customers purchased a complete set of windows for a car model from a single glass manufacturer. Therefore, from the glass manufacturer's perspective, it was only necessary that the markup on cost for the entire set, or bundle, of glass units be adequate for profitability. Despite the buying habits of these OE customers, however, firms in the industry quoted selling prices for individual units of glass within each set. As easy benchmarks, the selling prices were customarily set in proportion to the size in square feet of the units, with smaller lites priced lower than larger lites.

The managers knew, however, that the cost of producing automotive glass is not related proportionately to the size of the unit produced. The production process involves two principal fabricating operations: cutting the unit from a larger block of glass and then bending it to the necessary shape and strengthening it in a tempering furnace. Neither the cutting nor the tempering cost is proportional to the size of the unit produced. Only a limited number of units can be fed into either a cutting machine or a tempering furnace regardless of the size of the units, with little or no difference in feed rates or resource consumption related to size.

The joint effect of these two observations is an understanding in the glass industry of the average relationship between unit size and unit profit that is depicted in Exhibit 1. Margin percentages for passenger car lites are somewhat higher than the industry average.

Recent changes in the competitive structure of the OE automotive glass industry have led to the possibility of "unbundling" sets of windows. Major customers are considering not only allowing different manufacturers to supply units for the same car model (for example, windshields from one supplier and rear windows from another) but also setting target prices based on the manufacturing costs of the units, a process already begun by General Motors. Under these circumstances, the costs reported by the accounting system for individual units of glass would now have far more strategic implications than in the past.

Current Product Costing Process

Exhibit 2 shows the cost center groupings for the production process. The float and fabricating operations report to the same plant manager and have a common support staff. Raw glass is transferred from float to fab at standard variable plus standard fixed cost. (Profits are measured only at the point of sale of the finished product to the customer.) Direct labor and overhead costs are assigned to units of final product as follows:

1. Direct labor costs are assigned to equipment centers (lines of machines in PC&E and furnaces in Tempering) on the basis of standard crew sizes. Thus, a labor cost per equipment hour is developed for each of the several machines and furnaces according to crew sizes and standard wage and fringe benefit rates.
2. Overhead costs, both variable and fixed, that are directly traceable to a specific equipment center are pooled to develop a rate per equipment hour for that center.
3. A standard feed rate is established for each lite for each applicable cutting machine and furnace, and costs are applied to product on the basis of costs per equipment hour per units fed per hour. (Feed rates to different tempering furnaces differ substantially.)
4. General (indirect) plant overhead costs are allocated in two steps:
   a. 20% of the total is allocated to the float process, and 80% to fabricating, then
   b. the 80% allocated to fabricating is assigned to units of product at a flat rate per square foot (approximately $1 per square foot in 1987, adjusted for differing yield rates).

The costs classified as general plant overhead amount to 30% of the total indirect costs of the plant. General plant includes approximately 100 salaried employees involved in plant management, engineering, accounting, materials control, pollution control, quality control, maintenance management, research and development, production management, and human resources. It also includes depreciation of equipment and buildings not assigned to operating departments, property taxes and insurance, general plant maintenance, and postretirement costs.

MacGuidwin decided to limit his initial analysis to the automotive glass fabricating facility at the Rossford Plant. He and Lackner were confident that the process of assigning costs to units of raw float glass was sufficiently accurate. They also believed that the direct costs of labor and overhead associated with the PC&E and Tempering Furnace equipment centers were being properly attached to units of product on the basis of the units' standard feed rates per hour. The rates had been set with downtime assumptions intended to cover mechanical and electrical problems, stockouts, and part changeovers.

"On the whole, Ed Lackner and I felt pretty good about what we were discovering," commented MacGuidwin, "Over two-thirds of the costs of the plant were being assigned to units of product on the basis of metered usage of our two constraining resources, machine time in the PCB center and furnace time in the Tempering center."

"On the other hand," Lackner pointed out, "we had a potential problem with our general plant costs. For years we had been assigning them to units produced on the basis of square footage. We knew that this allocation base didn't capture activities that were driving the overhead costs, but we didn't know whether the allocation process was substantially distorting the final product costs. Until recently it didn't matter how these costs were allocated because unit price and cost differentials did not enter into any strategic decisions."

Alternative Allocation Method

The allocation of general plant overhead costs between float and fab seemed reasonable to the two controllers. They analyzed a

number of factors that could have been driving the allocation, including the number of hourly employees, the space occupied, and the variable costs incurred. They also interviewed managers concerning where time was spent by employees in the overhead base. All indicators pointed to the appropriateness of assigning 20% of the general plant costs to float and 80% to fab.

"The principal outcome of our analysis was to propose and implement on a test basis an alternative method for reallocating the 80% allocated to fab," explained MacGuidwin. "Under the old method, we allocated a flat rate per square foot produced. This might be reasonable if each square foot of glass costs the same to make in the PC&E and Tempering departments. But we knew from our production engineers and from our own tracking of direct costs in those cost centers that this was just not the case."

To test an alternative cost assignment method, MacGuidwin and Lackner chose four parts with the following characteristics:

1. A small, high-volume, low-profit-margin part (Truck Vent)
2. A small, high-volume, moderate-profit-margin part (Passenger Car Rear Quarter Window)
3. A large, high-volume, moderate-profit-margin part (Passenger Car Front Door)
4. A large, moderate-volume, high-profit-margin part (Passenger Car Back Lite, Heated)

As indicated in the following table, the direct costs of fabricating these parts differ substantially:

PART	SQUARE FEET PER UNIT	COST PER SQUARE FOOT CUTTING	FURNACE
Truck vent	0.77	$2.870	$1.676
Passenger car rear quarter	0.73	1.494	3.312
Passenger car front door	5.03	0.340	0.634
Passenger car back lite	7.07	0.206	0.682

The input measure selected as the basis for allocating general plant overhead costs to units of product was the scarcest (bottleneck) resource in the facility: time spent in the tempering furnaces. The production plan indicated a furnace capacity of 48,500 hours per year. Dividing the portion of the costs assigned to fab by the furnace capacity resulted in a rate of $503 per furnace hour.

Using the feed rates of the individual pieces, MacGuidwin was able to compute a new standard cost for each of the four products. Table 1 shows the standard cost per square foot, the cost per lite, and the gross margin percentage of each product under both the old and new methods of allocating general plant overhead. The corporate controller seemed pleased with the results:

> Although the results shown for the four products are not as dramatic as I've seen for some manufacturers, they do indicate a need to rethink and reanalyze our cost allocation system. Basically, the new method of allocating general plant overhead represents more closely what the engineering and

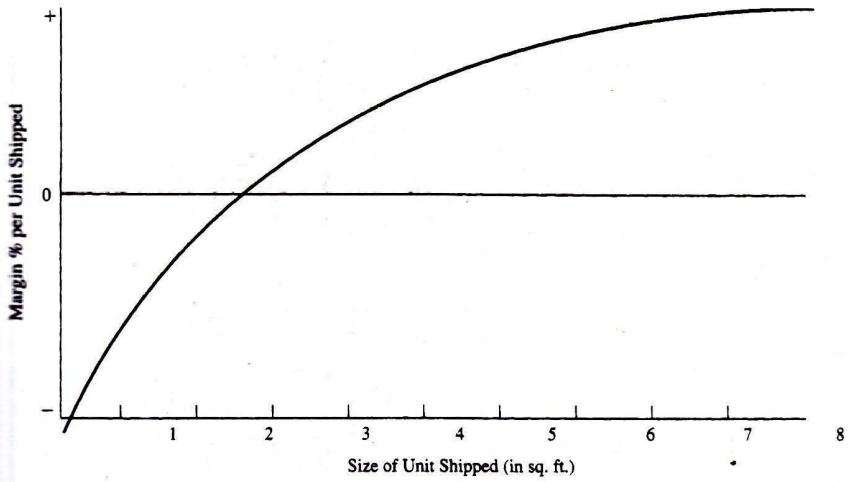


EXHIBIT 1 Unit Size/Unit Profit Relationship

manufacturing vice presidents were telling me about cost incurrence. The old system allocated a large pool of indirect costs equally to output, whereas the new system makes some attempt to associate those costs with the resource demands placed on our productive capacity by individual products. The old method clearly distorted our product costs. The new method should work better as long as we produce at plant capacity.

Required

(1) What is the cost object before the change in the product costing system? After the change? Why did MacGuidwin and Lackner change the focus of the system?

(2) What are the characteristics of a good product costing system?

(3) How do the process control and product costing functions of Rossford's cost accounting system interact? What conversion costs are treated as direct product costs in the system?

(4) In your opinion, is the new cost assignment method for general plant costs better than the old method? Why or why not?

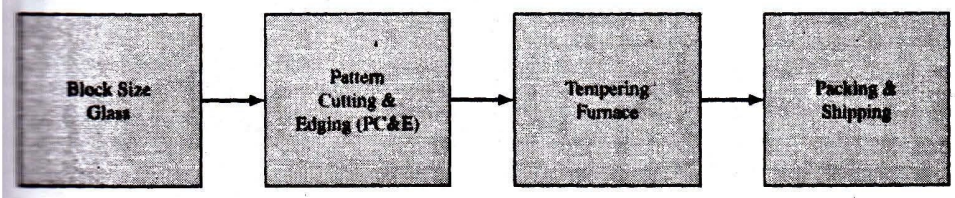


EXHIBIT 2 Production Cost Centers

TABLE 1 Unit Data under Old and New Allocation Methods

	TRUCK VENT				PASSENGER CAR FRONT DOOR			
	OLD		NEW		OLD		NEW	
	AMOUNT	PERCENT	AMOUNT	PERCENT	AMOUNT	PERCENT	AMOUNT	PERCENT
Cutting	$2.870	47	$2.870	42	$ 0.340	12	$ 0.340	14
Furnace	1.676	27	1.676	24	0.634	23	0.634	25
General plant	1.020	17	1.740	25	1.036	38	0.800	32
All other costs	0.566	9	0.566	8	0.716	26	0.716	29
Std. cost per sq. ft.	$6.132	100	$6.852	100	$ 2.726	100	$ 2.490	100
Sq. ft. per lite	0.770		0.770		5.030		5.030	
Cost per lite	$4.722		$5.276		$13.712		$12.525	
Selling price	$2.820		$2.820		$16.820		$16.820	
Gross margin (percent)	(67)		(87)		18		26	

	PASSENGER CAR REAR QUARTER				PASSENGER CAR BACK LITE			
	OLD		NEW		OLD		NEW	
	AMOUNT	PERCENT	AMOUNT	PERCENT	AMOUNT	PERCENT	AMOUNT	PERCENT
Cutting	$1.494	21	$1.494	16	$0.206	5	$0.206	6
Furnace	3.312	47	3.312	36	0.682	18	0.682	20
General plant	1.022	14	3.020	33	1.064	28	0.674	20
All other costs	1.266	18	1.266	14	1.810	48	1.810	54
Std. cost per sq. ft.	$7.094	100	$9.094	100	$2.726	100	$2.490	100
Sq. ft. per lite	0.730		0.730		7.070		7.070	
Cost per lite	$5.179		$6.637		$26.597		$23.840	
Selling price	$6.680		$6.680		$56.120		$56.120	
Gross margin (percent)	22		1		53		58	

THE PORTABLES GROUP*
(John Jonez and Michael Wright)

Tektronix, Inc., headquartered in Portland, Oregon, is a world leader in the production of electronic test and measurement instruments. The company's principal product since its founding in 1946 has been the oscilloscope (scope), an instrument that measures and graphically displays electronic signals. The two divisions of the Portables Group produce and market high- and medium-performance portable scopes.

Through the 1970s, Tektronix experienced almost uninterrupted growth based on a successful strategy of providing technical excellence in the scope market and continually improving its products in terms of both functionality and performance for the dollar. In the early 1980s, however, the lower-priced end of the division's medium-performance line of scopes was challenged by an aggressive low-price strategy of several Japanese competitors. Moving in from the low-price, low-performance market segment in which Tektronix had decided not to compete, these companies set prices 25% below the U.S. firm's prevailing prices. Rather than moving up the scale to more highly differentiated products, the group management decided to block the move.

The first step was to reduce the prices of higher-performance, higher-cost scopes to the prices of the competitors' scopes of lower performance. This short-term strategy resulted in reported losses for those instruments. The second step was to put in place a new management team whose objective was to turn the business around. These managers concluded that, contrary to conventional wisdom, the Portables Group divisions could compete successfully with foreign competition on a cost basis. To do so, the divisions would have to reduce costs and increase customer value by increasing operational efficiency.

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Production Process Changes

The production process in the Portables Group divisions consisted of many functional islands, including etched circuit board (ECB), insertion, ECB assembly, ECB testing, ECB repair, final assembly, test, thermal cycle, test/QC, cabinet fitting, finishing, boxing for shipment, and shipment. The new management team consolidated these functionally oriented activities into integrated production lines in open work spaces that allowed visual control of the entire production area. Parts inventory areas were also placed parallel to production lines so that, at each workstation, operators would be able to pull their own parts. This arrangement in essence created an early warning system that nearly eliminated line stoppages due to stockouts.

Additional steps were taken in the early to mid 1980s to solve managerial and technical problems, including implementation of just-in-time (JIT) delivery and scheduling techniques, total quality control (TQC), movement of manufacturing support departments into the production area, and implementation of people involvement (PI) techniques to move responsibility for problem solving down to the operating level of the divisions. The results of these changes were impressive: substantial reductions in cycle times, direct labor hours per unit, and inventory and increases in output dollars per person per day

and operating income. The cost accounting group had dutifully measured these improvements, but it had not effectively supported the strategic direction of the divisions.

Cost Accounting System

Direct Material and Direct Labor Exhibit 1 shows the breakdown of the total manufacturing cost of the newest portable scopes produced with the latest technologies. In most cases, materials and labor are easily traced to specific products for costing purposes. Before the mid-1980s, however, the divisions' attempts to control direct labor had been a resource drain that actually *decreased* productivity.

There were approximately 25 production cost centers in the Portables Group plant. Very detailed labor efficiency reports were prepared monthly for each cost center and each major step in the *production* process. In addition, an efficiency rating for each individual employee was computed daily. Employees reported the quantity of units produced and the time required to produce them, often overestimating the quantity produced to show improved efficiency against continually updated standards. The poor quality of collected data resulted in semiannual inventory write-downs when physical and book quantities were compared. Michael Wright, Financial Systems Application Manager, commented on the problems:

> The inadequacy of our efficiency reporting system became clear when we analyzed one of our new JIT production lines. On a JIT manufacturing line, once the excess inventory has been flushed out, it is essentially impossible for any person to work faster or slower than the line moves. However, if one person on the line is having a problem, it immediately becomes apparent because the product flow on the line stops. Corrective action is then taken, and the line is started up again.
>
> On that line, the system told us that the efficiency of each of the workers was decreasing. However, stepping back from the detail of the situation allowed us to look at the overall picture. We found that the costs incurred on the line were going down and its product output was going up. Obviously, it was becoming more, not less, efficient.

The quantity of direct labor data collected and processed also was a problem. Production employees often spent 20 minutes per day completing required reports when they could have been producing output. In addition, the accounting staff was processing 35,000 labor transactions per month to account for what amounted to 3% of total manufacturing cost. "Transactions cost money," observed John Jonez, Group Cost Accounting Manager, "and lots of transactions cost lots of money."

In response to these problems, the group accounting staff greatly simplified its procedures. It abandoned the measurement of labor performance for each operation and greatly reduced the number of variances reported. Labor transactions fell to less than 70 per month, allowing the staff to spend more time on overhead allocation and other pressing issues.

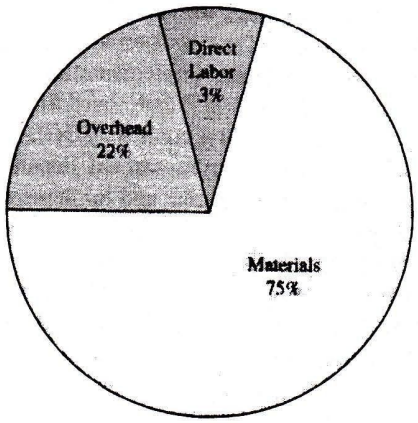


EXHIBIT 1 Manufacturing Costs

Overhead The product costing system allocated all manufacturing overhead costs in

products on the basis of standard direct labor hours. A separate rate was computed for each manufacturing cost center. This system led to rapidly increasing rates; the direct labor content of the group's products had been continually decreasing for years, while overhead costs were increasing in absolute terms. Jonez noted the problems:

> Because the costing system correlated overhead to labor, our engineers concluded that the way to reduce overhead costs was to reduce labor. The focus of cost reduction programs therefore had been the elimination of direct labor. However, most of this effort was misdirected, because there was almost no correlation between overhead cost incurrence and direct labor hours worked. Our system penalized products with proportionately higher direct labor, but it wasn't those products that caused overhead costs. We proved that. We attacked direct labor and it went down, but at the same time overhead went up.
>
> We knew that we needed a new way to allocate overhead. More fundamentally, we needed a way for the cost accounting system to support the manufacturing strategy of our group. The objective was clear—to provide management with accounting information that would be useful in identifying cost reduction opportunities in its operating decisions as well as provide a basis for effective reporting of accomplishments.

Approach to Method Change

Initial Steps The first step taken by Wright and Jonez in developing a new overhead allocation method was to establish a set of desirable characteristics for the method. They decided that it must accurately assign costs to products, thus providing better support for management decisions than the old method. It must support the JIT manufacturing strategy of the Portables Group. It also must be intuitively logical and easily understandable by management. And finally, it must provide information that is accessible by decision makers.

The next step was to interview the engineering and manufacturing managers who were the primary users of product cost information. These users were asked, "What is it that makes your job more difficult? What is it that makes certain products more difficult to manufacture? What causes the production line to slow down? What is it that causes overhead?" The answers to those questions were remarkably consistent; there were too many unique part numbers in the system. This finding revealed a major flaw in the ability of the direct labor–based costing method to communicate information critical for cost-related decisions. Manufacturing managers realized that there were substantial cost reduction opportunities through the standardization of component parts, but there was no direct method to communicate this idea to design and cost-reduction engineers who made part selection decisions.

Although difficult to quantify, some costs are associated with just carrying a part number in the data base. Each part number must be originally set up in the system, built into the structure of a bill of materials, and maintained until it is no longer used. Moreover, each part must be planned, scheduled, negotiated with vendors, purchased, received, stored, moved, and paid for. Having two parts similar enough that one could be used for two applications requires unnecessary duplication of these activities, and therefore unnecessary costs.

Standardizing parts results in several indirect benefits. Fewer unique part numbers usually means fewer vendors and greater quality of delivered parts. It also means smoother JIT production, fewer shutdowns of manufacturing lines, and greater field reliability. These observations led to a preliminary consensus on the need to develop a product costing method that would quantify and communicate the value of parts standardization.

Cost Analysis Jonez described the next steps:

> To confirm our assessment, we segmented the total manufacturing overhead cost pool. The costs of all cost centers comprising the pool were categorized as either material-related or conversion-related based upon rules developed in conjunction with operating managers. [See Exhibit 2.]
>
> Material-related costs relate to procurement, scheduling, receiving, incoming inspection, stockroom personnel, cost-reduction engineering, and information systems. Conversion-related costs are associated with direct labor, manufacturing supervision and process-related engineering. Application of the rules resulted in an approximately 55/45 split between material overhead (MOH) and conversion overhead (COH). This finding further confirmed the inadequacy of the existing method, which applied all overhead based on direct labor.

The accounting analysts decided to focus their initial efforts on the MOH pool. To improve their understanding of the composition of the pool and thus assist them in developing a method for its allocation, Wright and Jonez consulted operating managers and further segmented it into:

1. Costs due to the value of parts
2. Costs due to the absolute number of parts used
3. Costs due to the maintenance and handling of each different part number
4. Costs due to each use of a different part number

The managers believed that the majority of MOH costs were of type 3. The costs due to the value of parts (type 1) and the frequency of the use of parts (types 2 and 4) were considered quite small by comparison.

The analysts therefore concluded that the material-related costs of the Portables Group would decrease if fewer different part numbers were used in its products. This cost reduction would result from two factors. First, greater volume discounts would be realized by purchasing larger volumes of fewer unique parts. Second, material overhead costs would be lower. "It was the latter point that we wanted our new allocation method to focus on," commented Wright. "Our goal," continued Jonez, "was to increase customer value by reducing overhead costs. Our strategy was parts standardization. We needed a tactic to operationalize the strategy."

Required

(1) Using assumed numbers, develop a cost allocation method for material overhead (MOH) to quantify and communicate the strategy of parts standardization.
(2) Explain how use of your method would support the strategy.

EXHIBIT 2 Rules for Overhead Segmentation by Cost Center Classification

1. **Production** The overhead costs of any cost center containing direct labor employees are assigned 100% to the COH pool.
2. **Group/Division/Product Group Staff** The total costs of any manufacturing staff cost center are assigned 50% to the COH pool and 50% to the MOH pool.
3. **Group/Division/Product Group Support** The total costs of any manufacturing support cost center (e.g., Material Management or Information Systems) are assigned 100% of the MOH pool.
4. **Manufacturing Cost-Reduction Engineering** The total costs of any cost-reduction engineering cost center are assigned 100% to the MOH pool.
5. **Manufacturing Process-Related Engineering** The total costs of any process-related engineering cost center are assigned 100% to the COH pool.

(3) Is any method that applies the entire MOH cost pool on the basis of one cost driver sufficiently accurate for product decisions in the highly competitive portable scope market? Explain.

(4) Are MOH product costing rates developed for management reporting appropriate for inventory valuation for external reporting? Why or why not?

JOHN DEERE COMPONENTS WORKS (A) (ABRIDGED)*

The phone rang in the office of Keith Williams, manager of Cost Accounting Services for Deere & Company. On the line was Bill Maxwell, accounting supervisor for the Gear and Special Products Division in Waterloo, Iowa. The division had recently bid to fabricate component parts for another Deere division. Maxwell summarized the situation:

> They're about to award the contracts, and almost all of the work is going to outside suppliers. We're only getting a handful of the parts we quoted, and most of it is low-volume stuff we really don't want. We think we should get some of the business on parts where our direct costs are lower than the outside bid, even if our full costs are not.

Williams asked, "How did your bids stack up against the competition?" Maxwell replied:

> Not too well. We're way high on lots of parts. Our machinists and our equipment are as efficient as any in the business, yet our costs on standard, high-volume products appear to be the highest in the industry. Not only are we not competitive with outside suppliers, but our prices are also higher than two other Deere divisions that quoted on the business.

Deere & Company

The company was founded in 1837 by John Deere, a blacksmith who developed the first commercially successful steel plow. One hundred years later, Deere & Company was one of seven full-line farm equipment manufacturers in the world and, in 1963, had displaced International Harvester as the number one producer. During the 1970s, Deere spent over a billion dollars on plant modernization, expansion, and tooling.

During the three-decade, post–World War II boom period, Deere expanded its product line, built new plants, ran plants at capacity, and still was unable to keep up with demand. Deere tractors and combines dotted the landscape throughout America.

During this same period, Deere had diversified into off-the-road industrial equipment for use in the construction, forestry, utility, and mining industries. In 1962, it also began building lawn and garden tractors and equipment. By the mid-1980s, Deere had the broadest lawn and garden product line in the world.

The collapse of farmland values and commodity prices in the 1980s, however, led to the worst and most sustained agricultural crisis since the Great Depression. Several factors exacerbated the crisis. The high dollar reduced U.S. exports and thus hurt both American farmers and American farm equipment producers. Farmers had been encouraged to go into heavy debt to expand and buy land, so when land values and farm prices plummeted, the number of farm foreclosures skyrocketed. Few farmers were in a position to buy new equipment, and resale of repossessed equipment further reduced the market for new equipment.

*This case was prepared by Research Associate Artemis [illegible], under the supervision of Professor Robert S. Kaplan. Copyright © 1987 by the President and Fellows of Harvard College. Harvard Business School case 187–107.

In response, Deere adjusted its level of operations downward, cut costs where possible, increased emphasis on pushing decision making downward, and restructured manufacturing processes. Although outright plant closings were avoided, Deere took floor space out of production, encouraged early retirements, and did not replace most of those employees who left. Employment was reduced from 61,000 at the end of 1980 to about 37,500 at the end of 1986. It implemented new manufacturing approaches such as just-in-time production and manufacturing cells that grouped a number of operations for more efficient flow-through production and placed quality control directly at the point of manufacture. To add production volume, Deere wanted its captive component divisions to supply other companies and industries.

John Deere Component Works

For many years, all the parts for tractors were made and assembled at the tractor works in Waterloo. To generate more production space in the 1970s, Deere successfully split off parts of tractor production. Engine machining and assembly, final tractor assembly, and product engineering each were moved into new plants in the Waterloo area. By the end of the decade, the old tractor works buildings were used only for component production, ranging from small parts to large, complex components such as axles and transmissions. The old tractor works buildings in Waterloo were renamed the John Deere Component Works (JDCW).

In 1983, JDCW was organized into three divisions. The Hydraulics Division, which was soon consolidated into a nearby, refurbished warehouse, fabricated pumps, valves, and pistons. The Drive Trains Division made axles, transmissions, and drive trains. The Gear and Special Products Division made a variety of gears, shafts, and screw machine parts and performed heat treating, cast iron machining, and sheet metal work.

As part of a vertically integrated company, JDCW had been structured to be a captive producer of parts for Deere's equipment divisions, particularly tractors. Thus, it had to produce a great variety of parts whose volume, even in peak tractor production years, was relatively low. During the 1970s, operations and equipment had been arranged to support tractor production of approximately 150 units per day; by the mid-1980s, however, JDCW was producing parts for less than half as many tractors. The lower volume of activity had a particularly adverse effect on JDCW's screw machine and sheet metal businesses, because their machines were most efficient for high-volume production.

Internal Sales and Transfer Pricing Virtually all of JDCW's sales were internal. Deere equipment-producing factories were required to buy internally major components, such as advanced design transmissions and axles, that gave Deere a competitive advantage. For smaller components, corporate purchasing policy placed JDCW in a favored, but not exclusive, position for securing internal business.

Corporate policy stated that transfers between divisions would take place at full cost (direct materials + direct labor + direct overhead + period overhead). Corporate also had a make-buy policy that when excess capacity was available, buying divisions should compare component divisions' direct costs, rather than full costs, with outside bids. (Direct costs equal full costs less period overhead.) Thus, for example, if JDCW full costs were $10, its direct costs $7, and an outside bid $9, the make-buy decision rule held that the buying division should buy from JDCW. But the transfer

pricing policy required the buyer to pay $10 to the component division. Bill Maxwell described the conflict:

> The equipment divisions looked only at price and acted like profit centers rather than cost centers. They are starting to act in the interest of their factory rather than the corporation as a whole. The transfer pricing policy wasn't a problem until times got bad and capacity utilization went down. At Component Works, we said to our sister divisions, "You should look at our direct costs and buy from us." They replied, "We don't want to pay more than it would cost us from outside vendors."

In practice, equipment divisions did not always follow the corporate guidelines for internal sourcing, and JDCW lost a portion of the equipment factories' business to outside vendors.

Turning Machine Business

Deere's effort to push decision making down into more manageable units encouraged divisions to view their product lines as standalone businesses that sold to external markets. By early 1984, JDCW operations were so far below capacity that managers realized they could not wait for the agricultural market to turn around. In the Gear and Special Products Division, several people thought that turning machine products offered a promising niche.

Turning machines transformed raw materials (primarily steel barstock) into finished components and were the most autonomous of the division's operations. As one manager put it, "We could shut down the turning machine area and not affect the rest of the plant—except that we would then have to buy machined parts from outside suppliers." Only the master schedule connected the area with the activities of the rest of the plant.

The turning machine operations were organized into three departments. These departments were distinguished by the diameter of the barstock its machines could handle and by the number of spindles on each machine. A six-spindle machine could handle six different orientations, for example, and thus make more-complex parts than a four-spindle machine.

Turning Machine Capabilities and Operations Turning machines automatically fabricated small metal parts. Raw barstock was brought to a staging area near the machines by an overhead crane, the amount depending on the lot size to be run. Barstock (in round, square, or hexagonal sections) was fed horizontally by the operator into the back of the machine. Multiple stations each performed different operations simultaneously on what would become parts; when the longest cycle time (they ranged from a few seconds to 6 minutes) was completed, a machine indexed to the next position. Small parts, such as pinions, collars, gears, bushings, and connectors continually emerged from the final station. Finished parts were transported in 50-pound baskets stacked in trailers that carried up to 1,500 pounds.

Once set up, automatic turning machines were very fast, had excellent repeatability, and were particularly good at drilling, threading, grooving, and boring out large holes. New, the machines could cost as much as $500,000 each; their replacement value was estimated at about half that amount.

Operators were assigned to a battery of two or three specific machines; they did their own setups and tool changes. Setups, like runs, were timed; operators punched in and out, creating a record of how long setups actually took. Operators were also responsible for quality, machine cleanup, and housekeeping in their areas. After a first-part in-

spection by an inspector, operators ran the lot. Roving inspectors also checked samples from each lot or basket for conformance to quality standards.

Layout Component Works had 120 automatic turning machines lined up in four long rows in an 80,000-square-foot building (almost the size of two complete football fields). The chip and coolant recovery system was constructed under the floor, running the entire length of the building. It was connected up to each machine, much as houses are connected to a sewer system, to carry off the tremendous amount of chips generated by the machines as well as to cool and lubricate the machines. The layout of the cooling system made it infeasible to redesign the turning machine layout into cellular configurations that would group attendant secondary and finishing operations together.[1] Machines could be shifted around or dedicated to certain parts, but owing to the prohibitive expense of duplicating a chip coolant system, they were forced to remain in rows in S Building.

During the 1970s, secondary operations had been moved off the main floor in S Building to make room for more turning machines; this move increased materials handling distances for most parts. For example, the enormous heat treatment machines were located about one-quarter mile from the main turning machine area.

Process Engineering To bring a new part into production required extensive process engineering activities. Operations had to be sequenced, and tooling requirements had to be specified for each spindle. If the appropriate specialized tooling did not exist, it had to be either purchased or designed and built (usually outside). Both setups and runs had to be timed and standards established. Process engineers had to make sure that the process they had designed would in fact make the part correctly. Data bases then had to be set up for each machine.

All of these activities had to be conducted whether or not the part number ever ran. John Gordon, head of the process engineering group for turning machines, commented, "We have to do as much work for a part we run once a year—or one we never ever run—as for one we set up every month or that runs every day."

Recently, process engineering and production people had begun to make changes in how they ran turning machine parts. . . . As Andy Edberg, head of process engineering for the division, noted, "Turning machines are extremely high-volume machines, so you want to dedicate them if possible." Process engineers were starting to outsource some low-volume parts or to transfer them to more labor-intensive processes. Edberg pointed to the fundamental nature of the shift:

> We always made all the components for tractors, so we ran lots of part numbers but never really looked at the costs of individual parts. What was important was the efficiency of the whole rather than the efficiency of making the parts.

Competition and Strategy By 1984, Gear and Special Products had roughed out a general strategic thrust toward marketing machine parts to the outside world such as automobile OEMs [original equipment manufacturers]. Initial efforts to gain outside business, however, soon made it obvious that competing in the external market was going to be harder than anticipated. Competition came in two forms: captive producers of other vertically integrated companies (about whom Deere found it difficult to obtain infor-

[1] Secondary operations included heat treating, cross-drilling, plating, grinding, and milling; most parts required one or more secondary operations.

mation) and independent machine shops. The latter had sprung up around geographical clusters of end users. On the East Coast, the independent shops fed the defense industry, particularly shipyards; on the West Coast, they supplied the aircraft industry; and in Michigan and Indiana, they sold to the automotive industry. Dick Sinclair, manufacturing superintendent, observed:

> The key to successful competition in the outside market is price. We found we have a geography problem. We are not in the midst of heavy users, and it is expensive to ship steel both in and out. We also found our range of services to be less useful than we thought they would be.

Bid on 275 Turning Machine Parts

Both excess capacity and its new thrust toward developing stand-alone business motivated Gear and Special Products to bid on 275 of the 635 parts Deere & Company offered for bid in October 1984. All 635 parts had high potential for manufacture on automatic turning machines. Gear and Special Products bid on a subset for which it had the capability, and where the volume was large enough to exploit the efficiencies from its multiple-spindle machines. The buying group consisted of several equipment factories plus a corporate purchasing group; its aims were to consolidate turning machine purchasing by dealing with just a few good vendors and to gain improved service, quality, and price for these parts. Gear and Special Products had one month to prepare its bid.

Results of the bid are summarized below (dollars are in thousands and represent the annual cost for the quantity quoted):

Comparison—JDCW vs. Vendor

	PARTS WITH JDCW LOW TOTAL COST	PARTS WITH JDCW LOW DIRECT COST	TOTAL JDCW DIRECT COST HIGH	TOTAL ALL PARTS
Part numbers	58	103	114	275
JDCW direct cost	$191	$403	$1,103	$1,697
JDCW full cost	272	610	1,711	2,593
Low outside quote	322	491	684	1,507
Percent of $ value	22%	33%	45%	100%
% JDCW of low vendor:				
Direct cost	58	82	161	113
Full cost	82	124	250	172

The purchasing group awarded Gear and Special Products only the 58 parts for which it was the low bidder on a full-cost basis. Most of these were low-volume parts that the division did not especially want to make. Gear and Special Products could be the source for the 103 parts on which its direct costs were below the best outside bid only if it agreed to transfer the parts at the same price as the low outside bidder. The division passed on this "opportunity."

The bidding experience generated a good deal of ferment at Gear and Special Products and confirmed the feeling of many that "we

didn't even know our costs." Sinclair recalled:

> Some of us were quite alarmed. We had been saying, "Let's go outside," but we couldn't even succeed inside. Deere manufacturing plants in Dubuque and Des Moines also quoted and came in with lower prices—not across the board, but for enough parts to cause concern. If we weren't even competitive relative to other Deere divisions, how could we think we could be successful externally? And when we looked at the results, we knew we were not costing things right. It was backwards to think we could do better in low-volume than high-volume parts, but that's what the cost system said.

JDCW Standard Cost Accounting System

A standard cost accounting system was used throughout Component Works. . . . The standard or full cost of a part was computed by adding up the following:

- Direct labor (run time only)
- Direct material
- Overhead (direct + period) applied on direct labor
- Overhead (direct + period) applied on material dollars
- Overhead (direct + period) applied on ACTS [actual cycle time standard, see below] machine hours

Establishing Overhead Rates Once a year, the JDCW accounting department reestablished overhead rates on the basis of two studies, the normal study and the process study. The normal study determined the standard number of direct labor and machine hours and total overhead for the following year by establishing a "normal volume." In order to smooth out sharp swings, normal volume was defined as the long term "through the business cycle" volume. One of the measures for setting normal volume was the number of drive trains produced per day.

The process study broke down projected overhead at normal volume among JDCW's 100-plus processes, such as painting, sheet metal, grinding, turning machines, and heat treating. To determine the overhead rate for each process, accounting computed the rate from actual past charges, and then asked, "Do we expect any changes?" (Accumulated charges were collected by charging the specific process code as production took place.) Applying judgment to past rates, next year's normal volume, and any probable changes, accounting established a new overhead rate for each process for the coming year.

Evolution of Bases for Overhead Rates For many years, direct labor run time was the sole basis for establishing overhead rates at Component Works. Thus if $4,000,000 in overhead was generated by $800,000 of direct labor, the overhead rate was 500%. In the 1960s, a separate materials overhead rate had been established. This rate included the costs of purchasing, receiving, inspecting, and storing raw material. These costs were allocated to materials as a percentage markup over materials costs. Over time, separate rates had been established for steel, castings, and purchased parts to reflect the different demands these items placed on the materials handling resources.

Both labor- and materials-based overhead were subdivided into direct and period overhead. Direct (or variable) overhead, such as the costs of setups, scrap, and materials handling, varied with the volume of production activity. Period (or fixed) overhead included accounts, such as taxes, depreciation, interest, heat, light, and salaries, that did not vary with production activity.

In 1984, Component Works introduced machine hours as well as direct labor and materials to allocate overhead. With the increased usage of automated machines, direct

labor run time no longer reflected the amount of processing being performed on parts, particularly when one operator was responsible for several machines. Every process was studied and assigned a machine hour or ACTS (actual cycle time standard) rate. Labor hours was retained for processes in which labor time equaled machine time; if these were different, ACTS hours were used to allocate overhead. Total overhead (other than materials overhead) was then split between direct labor overhead and ACTS overhead. As before, each overhead pool was subdivided between direct and period overhead.

Launching a Cost Study for Turning Machines

Keith Williams had been aware that the existing standard cost system, although satisfactory at an aggregate level, was ineffective for costing and bidding individual parts. He was experimenting with other ways to apply overhead to products. When Maxwell called him in November 1984, Williams realized that the situation at Gear and Special Products provided an opportunity to demonstrate the weaknesses of the current system and to develop a new approach that would be more useful for decision making.

After his phone conversation with Maxwell, Williams quickly put together a proposal to management at Deere & Company, and to the Division Manager of Gear and Special Products. The study would focus on one cost center—the three turning machine departments—because turning machine ACTS hours were the highest chunk of costs in the bid; more than 60% of total machining for the parts occurred on the turning machines. To conduct the study, Williams chose Nick Vintila, who had begun his career at Deere as a manufacturing supervisor at Component Works. During his second year, Vintila had worked in the turning machine area. Not only had he become very familiar with its operation, but he had worked with people such as Gordon, then in methods, and Edberg, then a manufacturing superintendent, who would now also be working on the cost study. Vintila had subsequently served as a liaison between systems development and manufacturing to implement a labor reporting system that tied into Manufacturing Resource Planning System, and then became an accounting supervisor at the Tractor Works.

As a first step, Williams and Vintila studied a sample of 44 of the 275 bid parts (see Exhibit 1). This examination showed: (a) an enormous range of variation among quotes for many parts; (b) a large dispersion between JDCW and vendor quotes, ranging from 50% to 60% on some parts and 200% to 300% on others; (c) that JDCW estimated standard costs exceeded vendor prices by 35%, on average; and (d) that JDCW appeared to be most cost-effective on low-volume and low-value parts. (See Exhibit 2 for summary measures of the characteristics of the 44 sample parts.) These findings raised numerous questions about the validity of the standard cost system for determining costs of individual parts and reaffirmed the need for an alternative costing method.

Vintila spent the first half of 1985 working full-time on what became known as the ABC—activity-based costing—study. After detailed study of the shop process flow, he and Williams learned that use of overhead resources could be explained by seven different types of support activities: direct labor support, machine operation, setup hours, production order activity, materials handling, parts administration, and general and administrative overhead. Vintila then went through each overhead account (e.g., engineering salaries, crib attendant costs), asking others

EXHIBIT 1 Comparison of JDCW vs. Outside Vendor Bids for Sample of 44 Parts

			JDCW EST		COMPETING VENDOR QUOTES							% TO JDCW to VDR. 2		
PART NUMBER	PART DESCRIPTION	QUOTE VOLUME	DIR. COST	MFG. COST	1	2	3	4	5	6	7	DIR. COST.	MFG. Cost.	DIRECT LABOR $ EACH
Component Works Low on Full-Cost Basis:														
F382	Fitting	4,009	$ 2,248	$ 3,153	$ 3,940	$ 9,822	$13,550					23%	32%	$0.05
S209	Spacer	950	183	291	399	522	551	$ 1,244	$ 1,244			35	56	0.03
P594	Pin	692	297	430	692	796	817	1,012	1,509			37	54	0.03
T815	Stud	3,150	719	1,162	1,712	1,859	2,158	2,300	3,131	$ 9,356		39	62	0.03
P675	Pin	3,596	1,703	2,649	3,587	3,740	6,024	7,947				46	55	0.07
H622	Hub	4,450	3,207	4,365	5,687	6,324	6,743	7,518	8,463	12,875	$12,875	51	69	0.05
S245	Spacer	4,912	1,249	1,917	2,210	2,335	2,536	3,276	3,585	4,076		53	82	0.03
R647	Sprocket	5,167	6,792	9,196	11,907	12,142	12,400	13,124	16,116	16,674	17,516	56	76	0.10
T501	Stud	4,879	902	1,492	1,537	1,610	1,625	1,820	2,196	2,976	6,294	56	93	0.03
S071	Spacer	5,661	4,896	6,885	8,378	8,433	10,133					58	82	0.09
C784	Cap	71,200	13,101	19,537	17,088	22,072	22,606	23,332	29,832	41,253		59	89	0.04
P583	Pin	3,402	2,775	4,285	4,380	4,467	4,826	5,233	5,391	17,200		62	96	0.09
R410	Sprocket	792	878	1,226	658	1,349	2,162	2,273	2,866	2,946	3,983	66	91	0.08
Total or Average		112,860	$ 38,949	$ 56,590		$ 75,471						52%	75%	$0.05
Component Works Low on Direct-Cost Basis:														
R918	Rocker	1,091	$ 663	$ 1,063	$ 905	$ 1,036						64%	103%	$0.05
P220	Pin	3,204	6,685	11,754	9,048	10,413	$12,655	$14,642	$18,711			64	113	0.45
P057	Pin	1,281	979	1,675	1,460	1,487	2,306	2,985				66	113	0.09
T566	Stud	2,452	7,925	12,037	9,563	11,843	12,628	13,461	18,568			67	102	0.42
P736	Pin	38,955	6,837	10,475	9,181	10,167	11,492	11,492	13,323	22,983		67	103	0.03
P904	Pin	950	1,170	1,801	1,606	1,729	1,767	1,995	3,420			68	104	0.10

H355	Hub	1,155	1,947	3,090	2,552	2,872	2,979	3,026	4,775	6,846		68	108	0.13
P423	Pin	3,402	2,661	4,157	2,994	3,912	5,137	5,477	11,805			68	106	0.09
B605	Bolt	10,561	2,239	3,373	2,893	3,273	3,485	3,707	3,970	4,718	$ 4,718	68	103	0.03
H346	Hub	1,088	2,223	3,570	3,007	3,122	3,151	3,242	3,438	4,034	4,128	71	114	0.15
H554	Hub	1,490	1,551	2,214	1,967	1,997	2,077	2,216	2,298	2,459	2,459	78	111	0.06
P244	Pin	7,383	7,438	10,948	7,591	8,786	9,498	10,705	11,270	12,677	23,773	85	125	0.11
L209	Lever	5,351	2,480	3,827	1,578	2,745	3,692	4,334	4,486	4,548	4,826	90	139	0.05
R316	Roller	18,058	2,470	4,610	2,257	2,691	3,250	4,050	4,231	4,939	4,984	92	171	0.03
S451	Spacer	2,785	645	1,226	390	697	852	1,104	1,253	1,276	1,306	93	176	0.04
P333	Pin	4,258	6,818	12,088	6,898	7,324	9,197	11,113	12,008			93	165	0.32
P379	Pin	6,807	6,984	10,249	5,037	7,352	7,760	9,394	9,421	21,919		95	139	0.11
P682	Pin	3,402	4,037	5,880	2,824	4,208	5,035	5,817	11,533			96	140	0.08
Total or Average		113,673	$ 65,753	$104,038		$ 85,654						77%	121%	$0.08
Cumulative		226,533	$104,703	$160,629		$161,125						65%	100%	$0.08
Component Works Not Cost Competitive:														
H265	Hub	4,464	$ 15,311	$ 24,341	$13,570	$ 15,236	$17,275	$17,454	$17,901	$20,489		100%	160%	$0.57
A152	Shaft	2,972	7,749	12,841	6,685	7,667	8,470	10,877				101	167	0.38
R717	Sprocket	4,869	6,834	10,003	6,205	6,707	7,421	7,839	7,887	8,868	$ 9,450	102	149	0.16
S771	Spacer	11,092	971	1,689	909	942	1,053	1,275	1,852	2,107	2,203	103	179	0.02
R428	Sprocket	3,180	4,374	6,888	3,637	4,226	4,285	4,293	4,624	4,709	5,599	103	163	0.18
R946	Roller	5,904	6,254	10,727	4,815	6,022	6,199	6,494	7,947	9,269	19,837	104	178	0.14
R157	Roller	3,181	1,651	2,934	1,082	1,565	1,645	1,749	1,890	1,917	2,004	106	188	0.08
B823	Button	18,200	3,296	5,622	2,347	3,094	3,257	3,276	3,314	3,516	6,042	107	182	0.03
T863	Stud	7,120	11,136	17,790	8,231	8,590	9,185	13,243	24,706			130	207	0.37
T237	Stop	4,258	12,719	18,713	7,877	8,516	9,112	9,623	10,228	16,606		149	220	0.35
N281	Nut	8,500	6,350	11,322	3,392	3,789	4,114	6,375	7,548	8,925	15,640	168	299	0.18
T166	Stud	5,645	8,766	16,014	3,912	5,024	5,701	13,209				174	319	0.41
T586	Stud	10,000	15,957	27,273	7,525	8,900	9,540	11,000	11,520	26,700		179	306	$0.40
Total or Average		89,385	$101,367	$166,157		$ 80,278						126%	207%	$0.21
Total/Avg. all Parts		315,918	$206,069	$326,786		$241,403						85%	135%	$0.11

EXHIBIT 2 Characteristics of Sample of 44 Parts

CATEGORY	NUMBER	VOLUME	DIRECT LABOR $	ACTS HOURS PER 100 PARTS	ANNUAL ACTS HOURS	DL $/ MATERIALS $
Low on full-cost basis	13	4,009*	0.05	0.04	19	21%
		[692; 71,200]	[0.03; 0.10]	[0.3; 1.5]	[2; 266]	[9; 51]
Low on direct-cost basis	18	3,402	0.09	1.2	31	23%
		[950; 38,955]	[0.03; 0.45]	[0.3; 2.8]	[10; 159]	[9; 224]
Not cost competitive	13	5,645	0.18	1.5	70	57%
		[2972; 18,200]	[0.02; 0.57]	[0.2; 3.4]	[18; 150]	[22; 480]
Total	44					

**Top number is the median value in that category.*
The range [minimum; maximum] appears beneath the median.

and himself, "Among the seven activities, which cause this account to occur? What creates work for this department?" He began to estimate the percentages of each overhead account that were driven by each of the seven activities. He conducted specific studies to estimate the total volume of each of the seven overhead driving activities (such as number of production orders, total machine hours). This work was circulated among people like Maxwell, Edberg, Gordon, and Sinclair, who, drawing on their experience and judgment, accepted the seven activities as the key overhead drivers and adjusted the final percentages for allocating budgeted items to each activity. (See Appendix A for a description of the seven overhead drivers and how Vintila arrived at the seven overhead rates.) When the ABC method was used to allocate overhead, 41% of the overhead shifted to activity bases 3–7 (see Exhibits 3 and 4). The data needed to estimate the cost of a particular part are shown in Exhibit 5.

The detailed work to design the ABC system had now been completed. The next step for Williams and Vintila was to test and gain acceptance for their new costing approach.

Appendix A: John Deere Component Works Activity-Based Costing (A)

ABC Activities for Applying Overhead to Turning Machine Parts The ABC study used the accounting estimate of normal volume and total overhead costs as its starting point. Overhead costs were then allocated to seven rather than just two activities. A separate overhead rate was derived for each activity. (see Exhibits 3 and 4 for comparison of the two methods.) Vintila used the following approach to apportion overhead and to develop overhead rates:

1. *Direct Labor Support* overhead was generated by incentive employees working on parts. It included allowances for benefits, break periods, and a percentage of supervision, personnel, payroll, and industrial engineering salaries. All direct labor support overhead costs were summed ($1,898,000 in 1985) and divided by the total amount of direct labor dollars ($1,714,000) to derive an overhead rate for this activity (111%).

2. *Machine Operation* overhead was generated by operating the turning machines, plus an allocation of facility and capacity charges. This activity received most of the

EXHIBIT 3 1985 Turning Machine Overhead Allocation Using Standard Cost System

	APPLIED BASED ON DIRECT LABOR (DL)		APPLIED BASED ON MACHINE HOURS		TOTAL $000s	TOTAL % TOTAL
Direct Overhead						
Maintenance	$ 32	0.3%	$1,038	10.2%	$ 1,070	10.5%
Labor allowances	459	4.5	0	0.0	459	4.5
Machine setups	0	0.0	524	5.2	524	5.2
Other OH lab	130	1.3	164	1.6	294	2.9
Scrap & misc.	80	0.8	96	0.9	176	1.7
Employee benefits	1,296	12.7	556	5.5	1,852	18.2
Total direct OH	$1,997	19.6%	$2,378	23.4%	$ 4,375	43.0%
Period Overhead						
Maintenance	$ 127	1.2%	$ 527	5.2%	$ 654	6.4%
Salaries	796	7.8	826	8.1	1,622	15.9
Depreciation	0	0.0	1,790	17.6	1,790	17.6
Gen. & misc.	227	2.2	717	7.0	944	9.3
Employee benefits	354	3.5	432	4.2	786	7.7
Total period OH	$1,504	14.8%	$4,292	42.2%	$ 5,796	57.0%
Total overhead	$3,501	34.4%	$6,670	65.6%	$10,171	100.0%
Overhead base	$1,714 DL$		242,000 ACTS hrs			
Direct overhead rate	117%		$ 9.83 per hr			
Period overhead rate	88%		17.73 per hr			
Total overhead rate	205%		$27.56 per hr			

costs of machine maintenance, small tools, jigs, and dies, as well as smaller proportions of inspection and defective work, engineering and supervision salaries. Allocations were also made for depreciation, taxes, interest, and utilities. The total dollars required to operate the machines ($4,045,000) were divided by the total number of machine hours (242,000) to develop the $16.70 per hour overhead rate for this activity.

Whereas the standard cost system used the same ACTS rate for all machines, Vintila examined the machines individually and ultimately developed separate rates for four different-sized machines. He gathered data on several factors to create machine-specific estimates of the costs of running them. For example, kilowatt-hours multiplied by the load factor was used to generate utilities cost; replacement costs to estimate the share of insurance, taxes, and depreciation; square footage to calculate a proportion of facilities costs; and the "spindle factor" to allocate tooling and maintenance costs. The spindle factor took into account the number of spindles on a machine; when multiplied by its annual load (or ACTS hours), it provided a basis for allocating tooling and maintenance costs according to size and use of the machine. For all of these factors, Vintila obtained percentages by dividing the total (e.g., replacement costs of all machines) by that for the particular machine. To obtain an overall direct overhead rate for a machine, he divided all its direct overhead by its ACTS hours.

Once this information had been generated

EXHIBIT 4 1985 Turning Machine Overhead Allocation Using ABC Method

	Direct Labor (DL) Support Overhead		Machine Operation Overhead		Machine Setup Overhead		Production Order Overhead		Material-Handling Overhead		Part Admin. Overhead		General and Administration Overhead		Total	
	$000s	% Total	$000s	% Total	$000s	% Total	$000s	% Total	$000s	% Total	$000s	% Total	$000s	% Total	$000s	% Total
Direct Overhead																
Maintenance	$ 0	0.0%	$ 899	8.8%	$ 45	0.4%	$ 62	0.6%	$ 63	0.6%	$ 0	0.0%	$ 0	0.0%	$ 1,069	10.5%
Labor allowances	329	3.2%	47	0.5%	61	0.6%	10	0.1%	12	0.1%	0	0.0%	0	0.0%	459	4.5%
Machine setups	0	0.0%	146	1.4%	378	3.7%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	524	5.2%
Other OH lab	0	0.0%	67	0.7%	0	0.0%	106	1.0%	122	1.2%	0	0.0%	0	0.0%	295	2.9%
Scrap & Misc.	0	0.0%	141	1.4%	0	0.0%	30	0.3%	6	0.1%	0	0.0%	0	0.0%	177	1.7%
Employee benefits	1,100	10.8%	339	3.3%	246	2.4%	77	0.8%	90	0.9%	0	0.0%	0	0.0%	1,852	18.2%
Total direct OH	$1,429	14.0%	$1,639	16.1%	$ 730	7.2%	$285	2.8%	$293	2.9%	$ 0	0.0%	$ 0	0.0%	$ 4,376	43.0%
Period Overhead																
Maintenance	$ 10	0.1%	$ 333	3.3%	$ 40	0.4%	$ 9	0.1%	$ 8	0.1%	$238	2.3%	$ 17	0.2%	$ 655	6.4%
Salaries	270	2.7%	179	1.8%	62	0.6%	243	2.4%	0	0.0%	421	4.1%	448	4.4%	1,623	16.0%
Depreciation	27	0.3%	1,424	14.0%	226	2.2%	25	0.2%	0	0.0%	43	0.4%	45	0.4%	1,790	17.6%
Gen. & Misc.	59	0.6%	323	3.2%	19	0.2%	152	1.5%	0	0.0%	90	0.9%	298	2.9%	941	9.3%
Employee benefits	103	1.0%	147	1.4%	34	0.3%	103	1.0%	2	0.0%	207	2.0%	190	1.9%	786	7.7%
Total period OH	469	4.6%	$2,406	23.7%	$ 381	3.7%	$532	5.2%	$ 10	0.1%	$999	9.8%	$998	9.8%	$ 5,795	57.0%
Total overhead	$1,898	18.7%	$4,045	39.8%	$1,111	10.9%	$817	8.0%	$303	3.0%	$999	9.8%	$998	9.8%	$10,171	100.0%
Overhead base	$1,714 DL$		242,000 annual ACTS hours		32,900 annual setup hours		7,150 annual orders		15,600 annual loads		2,050 part nos.		$10,887 value added*			
Direct overhead rate	83.4%		$ 6.77 per hour*		$22.18 per hour		$ 39.86 per order		$18.78 per load		—		—			
Period overhead rate	27.4%		$ 9.94 per hour		$11.58 per hour		$ 74.41 per order		0.64 per load		$487 per part		9.1%			
Total overhead rate	111.0%		$16.71 per hour		$33.76 per hour		$114.27 per order		$19.42 per load		$487 per part		9.1%			

$ 1,714 DL$
1,898 DL$ OH
4,045 Mach. oper. OH
1,111 Setup OH
817 Prod. order OH
303 Mat. h. OH
999 Part. adm. OH
$10,887 Value added

**Rates shown are averages across all turning machines. In practice, separate machine overhead rates were calculated for each major class of machines.*

EXHIBIT 5 Elements for Costing Part A103 in 1985

$6.44 materials cost/100 parts	
Materials Overhead Rates:	
2.1%	Direct
7.6%	Period
0.185	Direct labor hours/100 parts
0.310	ACTS hours/100 parts
$12.76	Labor rate for screw machine operation
4.2 hr	Machine setup time
0.176 lb	Part weight
8,000 quote volume (annual volume as specified by user)	
2 runs/year	
6-spindle machine rates: (under ABC systems)	Direct: $8.99 Period: $7.61

for each of the machines, similar-sized machines were grouped, and a single overhead rate was determined for each group. In this way, machines that happened to have a lower load would not be penalized by a higher rate.

3. *Setup Hours* overhead was generated by changing the job to be run. It included actual setup costs; a small share of machine and small tool maintenance, supervision, and engineering salaries; and a share of depreciation and other facility costs. These costs ($1,111,000) were divided by the estimated number of setup hours (32,900) to arrive at an hourly overhead rate ($33.80).

The number of setup hours was estimated through an examination of production control data that showed the average setup time to be 4 hours. This figure was multiplied by the average number (4) of annual runs per part number and by the 2,050 parts in the system.

4. *Production Order Activity* was generated by shop activity resulting from each production order. The largest cost was material control salaries. Percentages of crib attendant costs, inspection, defective work, and manufacturing costs were also applied. The sum was divided by the total number of annual production orders (7,150) to yield a cost of $114 per production order.

5. *Materials Handling* overhead arose from moving barstock to the machines and then moving the parts to the next operation. The major cost elements were materials handling labor and equipment maintenance. This activity also received a share of inspection and defective materials costs. An overhead rate ($19.42) was derived by dividing the total allocated costs ($303,000) by the number of loads (15,600).

The number of loads was estimated through a six-step process:

a. $\dfrac{\text{part weight} \times \text{annual volume}}{\text{runs/year for that part}} = \text{weight/run}$

b. $\dfrac{\text{weight/run}}{\text{pounds/load}} = \text{loads/run}$

(average of 2000 lb per transport container)

c. loads/run + 0.5, then round result to nearest full integer (a calculation to correct for incomplete loads)

d. multiply result in (c) by number of runs of that part/year = number of loads/year moved away from machines

e. loads/year × 2 (movement to and from machine) = total number of loads/year for that part

f. repeat process for all part numbers, and add number of loads/part to obtain total number of loads per year

6. *Parts Administration* overhead was incurred just by having a part number in the de-

partment's repertoire. It included the cost of establishing and maintaining records and systems documentation and a share of salaries in process engineering, industrial engineering, supervision, and materials control. The sum of $999,000 in overhead, when distributed among the 2,050 parts in the system, generated a head tax of $487 per part number.

7. *General and Administrative* overhead was attributed to the entire factory, not to a particular manufacturing process or activity. It included a large share of taxes, utilities, and depreciation, as well as smaller shares of salaries such as accounting, reliability, and manufacturing engineering. The $998,000 of general and administrative (G&A) overhead was prorated to products on the basis of their value added: the sum of direct labor plus the other six overhead activity costs for each part. The value-added sum became the denominator for determining the G&A rate to be applied to the part.