ABC Puts Accountants on Design Team at HP

"Bottom-up" involvement by engineers and production makes cost system effective.

BY C. MIKE MERZ, CMA, AND ARLENE HARDY

Lybrand Gold Medal Winner, 1992-93.

Engineers in a major circuit board assembly department of Hewlett-Packard (HP) have something to tinker with besides machinery. They can tinker with their "own" activity-based costing (ABC) system, continually thinking of ways to improve it.

In 1989 HP implemented an ABC system at the Boise Surface Mount Center (BSMC) in Idaho. The ABC system was integrated fully into the company's formal accounting system so that cost information in all internal and external reports now contains costs using ABC. Design engineers, customer service engineers, the production team, and the accounting staff routinely use ABC to measure historical costs, value inventory, assess financial results, and forecast future performance.

The ABC system has evolved over the four years since it was implemented—thanks in part to the engineers' tinkering. In addition to the obvious technical changes that ABC brought to the cost accounting system, it also changed the role of the department's accountants dramatically, essentially making them a part of the product design team.[1]

The technical aspects of ABC have been discussed much in the last few years, but actual experience using ABC over an extended period of time seldom has been reported. The unique aspects of how HP has been using ABC are well worth describing.

Authors Mike Merz and Arlene Hardy (l.) discuss a circuit board with Ken Schrader, service manager, and Ron Ray, production section manager.

CURRENT STATUS

Since January 1993 the ABC system has been fully operational within the BSMC. All cost data pertaining to circuit boards that have been produced, that are being designed for production, or that are being bid on in the process of getting new business come from the ABC cost system. All data are entered into the company's general ledger system so that the ABC system is completely on-line.

It is significant that the ABC system has been completely operational and on-line for four years because some recent articles imply that ABC analysis should be done "off-line" while the traditional cost system continues to report cost data. The fact that operational people within the department routinely gather and analyze activity data differs markedly from H. Thomas Johnson's recent observation that "activity information is usually compiled and monitored by central staff personnel or outside consultants."[2] The BSMC's use of ABC as a completely operational accounting system to provide all data for cost analysis and reporting represents an advanced application of ABC.

MANUFACTURING ENVIRONMENT

The Boise Surface Mount Center manufactures about 50 different electronic circuit boards for internal customers within HP. With surface mount technology, patches of a semiliquid solder are placed on the surface of a circuit board, and electronic components are placed on the solder patches. Then the board goes through an oven to melt the solder to form a strong mechanical bond and a reliable electronic circuit. The process is highly automated, with computer-controlled "pick-and-place" machines that can select more than 100 different components each minute from the correct reel and place each one on the surface of the board within a tolerance of four-thousandths of an inch. Production volumes for each board vary from a few hundred per month to several thousand. Annual production costs exceed $100 million.

The BSMC operates as a form of cost center that charges out its manufacturing costs to its internal customers, each of which is independent of the BSMC in the organization structure. The BSMC has no "captive" customers! About 700 employees work directly in the BSMC, including production workers and their supervisors, engineers, and material procurement personnel. In the circuit board industry, total volume sometimes is cited as the total number of placements—the number of individual electronic components attached to all boards manufactured. The BSMC makes hundreds of millions of placements annually, so it is a relatively large producer although not as large as several of the industry giants.

Because circuit boards have become a commodity product and because the life cycles of both the product and manufacturing technology are short, the BSMC has to compete in a very dynamic business environment. To get and keep business, the BSMC must compete for orders with other circuit board manufacturers within HP and with outside vendors, based on schedule, quality, and cost. Efforts to get new business require continual interaction with customers to help them design new boards that can be produced efficiently, to prepare cost bids, and to start up production of new boards. Production volumes fluctuate as older boards phase out of production and new boards are introduced. As technology continues to evolve, new equipment is inserted into the production line. The manufacturing environment changes so rapidly that if a few weeks elapse between your visits to the factory, the production line may look completely different next time.

This environment conforms closely to the conditions for which ABC is recommended:

- Products are very diverse,
- Overhead costs are relatively high and for some products are higher than the direct costs,
- Production volumes vary significantly among products, and
- Operating managers believe that the old system that applied all overhead as a percent of direct material costs did not give meaningful product costs.

EVOLUTION OF ABC SYSTEM

To date, the cost pool and driver system has evolved so it uses 10 different cost pools and drivers, as shown in Table 1. The composition of the cost pools and selection of the most appropriate drivers resulted from an intense analysis of the production process and cost behavior patterns by the accounting, production, and engineering staffs, similar to the process followed by other companies.[3]

Costs are assigned to products in two stages almost exactly as recommended in the ABC literature. First, all of the direct and indirect costs associated with an activity, such as material procurement and handling, are collected into a separate cost pool. Then the volume of activities selected as the driver are accumulated, in this case the total number of unique parts on each board. Dividing the cost pool dollars by the total number of unique parts yields the overhead application rate, say $7.50 per unique part. If a board had 500 total parts but only 100 unique parts, it would be charged $750 for material procurement overhead during the six-month budget cycle. This amount is the total amount charged—if the customer ordered 2,000 of that particular board during the six months, the effective unit cost would be $.375

TABLE 1 / COST POOLS & DRIVERS

COST POOLS	DRIVERS
1. Panel operations	Percent of a whole panel; if one panel contains four individual boards, then each board is charged 25% of the panel rate.
2. Small component placement	Number of "small" components placed on the board's surface.
3. Medium component placement	Number of "medium" size components placed on the board's surface.
4. Large component placement	Number of "large" components placed on the board's surface.
5. "Through-hole component insertion"	Number of components with wires that are inserted through holes on the board.
6. Hand load component placement	Minutes required to place all components that must be hand loaded rather than automatically placed on the board.
7. Material procurement & handling	Number of unique parts in the board.
8. Scheduling	Number of scheduling hours during a six-month period.
9. Assembly setup	Number of minutes of setup time during a six-month period.
10. Test & rework	Number of "yielded" minutes of test and rework time for each board.

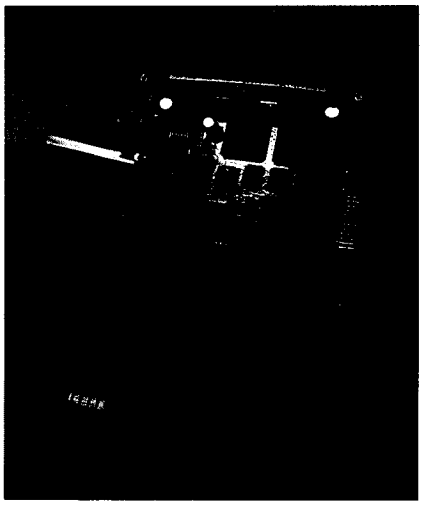
of material procurement and handling. As with most cost systems, each cost driver application rate is predetermined during the budget cycle, and an adjustment for any over- or under-applied overhead in each cost pool is made at the end of the accounting period.

The ABC system is in a state of continuous evolution. As engineers and production people gain experience about how a certain cost driver works or whether overhead costs have been distributed to the appropriate cost pool, they keep coming back to accounting to request changes in the cost system to make it reflect perceived cost behavior patterns. Of the 10 cost drivers currently being used, only three have not been changed in some way during the four years that ABC has been in place. A major benefit of implementing ABC was that engineering and production now feel a sense of ownership over the cost system as a result of the ongoing effort of working together with accounting to identify the appropriate cost pools and their drivers. Another benefit is that the accounting staff must work closely with production and engineering to make sure that costs are assigned to the correct pool and to maintain accurate counts of driver activities.

The BSMC operates as a form of cost center that bills its customers for the standard cost to manufacture their product. Customers receive detailed bills that show how the manufacturing overhead component of their board has been computed using the cost driver system. The manufacturing cost of a board includes only two components—direct material and manufacturing overhead. Because direct labor is such a small percent of total cost, it is included in manufacturing overhead.[4] As mentioned earlier, all manufacturing costs and activity data are collected and recorded using the ABC system. All formal and informal reports, analyses, and forecasts use ABC information.

ACCOUNTANTS INVOLVED IN DECISION PROCESS

Implementing an ABC system dramatically changed the role of the accounting staff in product decisions. Accountants now provide important inputs into product design and development decisions. Under the prior cost system, all overhead was applied as a percent of direct material cost, and it was difficult to understand how changing a board's design would change manufacturing costs. Also, designers had little motivation to optimize the board for efficient production. With ABC, however, the cost system attempts to mirror the manufacturing process, so that engineers and production managers easily can see how design changes will affect costs.



The circuit board produced by BSMC for HP's Coyote Disc Drive resting upon a completed disc drive.

Two cases in which the accounting staff influenced product design illustrate the important role played by the accountants. In the rush to introduce new products to the market, the circuit boards in the new product sometimes are released for production before the engineers have time to optimize the design for production. If the product is successful, the board design is modified—"rolled over"—later to simplify manufacturing.

During 1991, one particular board produced in high volumes was expensive to manufacture because several components had to be hand loaded rather than placed on the board automatically by a machine. Although the board was scheduled to be rolled over in six months to a design that was easier to produce, the accounting staff worked with engineering and production to prepare an analysis showing the customer how much costs could be reduced by rolling over the board's design sooner. Recognizing that they could save millions of dollars by acting sooner, the customer rapidly changed the board's design.

During the design phase of another new product, the design engineers realized that the cost to manufacture one of the circuit boards in that product was going to be so high that it would preclude introducing the product at the target price. The BSMC accounting staff was asked for help. Armed with their ABC system loaded into a personal computer, the accountants helped the engineers perform a "what-if" analysis. If four small components were substituted for the one large component, how would cost be affected? If the two components that would have to be hand loaded could be replaced with components that could be placed on the board automatically, how would cost be affected? By trying lots of combinations of different designs, the engineers and accountants were able to lower the board's cost to an acceptable level.

The BSMC's customers seem to like the transparent cost reports from BSMC that show clearly how costs are computed. The general perception in the BSMC is that the ABC system has helped significantly in getting new business.

EFFECT ON PRODUCT COSTS

Prior to adopting ABC, the BSMC applied all overhead as a percent of direct material cost. To measure the effect that ABC had on product costs, and the resulting amounts that customers were billed, the boards that BSMC was producing during late 1991 were "costed" both ways: (1) all overhead applied as a percent of direct material costs, using an ad hoc analysis, and (2) with the ABC system currently used by the BSMC. Such comparisons are not made routinely—ABC has become a way of life within the BSMC.

Table 2 and the bar chart in Figure 1 show the distribution of percentage changes in product costs for all boards that were being manufactured. They also show that the use of ABC increased the total cost of a lot more products than it decreased. The old method for applying overhead was as a percent of material costs. Products with low material costs had low amounts of applied overhead. ABC caused dramatic increases for some of these products.

One board that would have cost about $5 if overhead were applied as a percent of material had a reported total cost of about $25 with ABC—an increase of 400%. Some boards with high material costs received much less applied overhead with ABC even though the percentage change did not appear as dramatic. For example, one board with high material costs would have had $123 of overhead applied as a per-

TABLE 2 / % CHANGE IN TOTAL MANUFACTURING COSTS: EFFECT OF ABC

Percent Change Caused by Activity-Based Costing	Number of Products
> + 100%	1
+ 50% to + 100%	5
+ 20% to + 50%	6
+ 5% to + 20%	23
- 5% to + 5%	13
- 20% to - 5%	9
Total	57

Note: This table shows the percentage change resulting from ABC. For example, if a product would have a total cost of $100 using a single overhead rate based on direct material costs but a total cost of $129 with ABC, then the percentage change would be plus 29%.

cent of material cost but only $45 with ABC. The percent change in total product costs for that board, however, was only about minus 12%. Either cost system would apply, of course, the same amount of total overhead to all the products manufactured.

During a recent six-month forecast and budget cycle, the ABC system resulted in shifting millions of dollars of costs between customers and products and thus had a dramatic impact on pricing and product design decisions.

ABC COSTS NOT 'RELEVANT'

As customers learned to use costs reported by the ABC system to make product design decisions, an unanticipated side effect of the new cost system became apparent. For making decisions, the ABC costs were relevant to the customer but not relevant to the BSMC as the manufacturer. For example, one customer figured out a way to reduce her board's cost by placing two boards on each preprinted panel that goes through the assembly line rather than just one. The effect was that instead of one whole panel operations charge of about $18 for each board, the same charge now was spread over two boards, so the total board cost to the customer was reduced by $9.

From the BSMC's standpoint, however, the actual manufacturing costs did not decline nearly that much because excess capacity existed in panel operations, and no specific cost reduction in labor or other overhead resulted from the design change to that one board. So even though customers can treat costs determined from the ABC system as relevant to their decisions, the same cost is not necessarily relevant to decisions by the manufacturer, BSMC.

ENGINEERS TINKER WITH COST SYSTEM

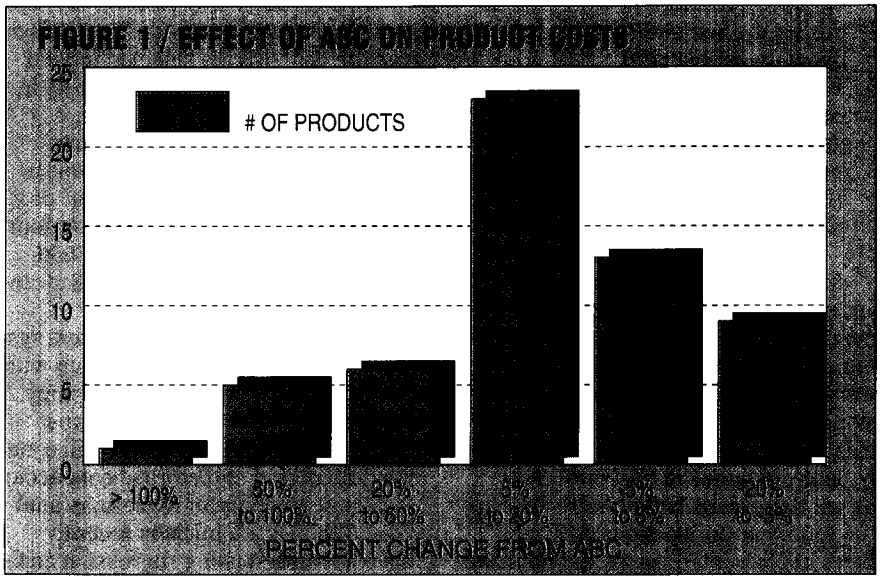
Both the production engineering and the production staff participated in defining each cost pool and its appropriate driver for the ABC system. Although the accountants gather data and administer the cost system, the production and engineering people now feel that they own the system. The well-known propensity of engineers to tinker mentioned earlier has had an unanticipated side effect. An almost daily dialogue goes on among production, engineering, and the accountants about how the ABC cost system could be improved to reflect product costs more accurately.

The engineers have instigated a major revision to the cost system that will be implemented this year. After a lot of analysis, discussion, and physical observation of both the production line and cost behavior, management concluded that cycle time is the most appropriate cost driver for most of the production line operations. The first five cost pools shown in Table 1 that now are allocated with a cost driver measured in physical volumes of components placed on a board will be allocated instead with a cost driver measured in minutes or seconds of cycle time required to complete the placements. One of the anticipated benefits of using cycle time as a cost driver is that the total standard cycle time for all boards that go through a certain operation can be compared with the total actual cycle time to complete that operation during a given time period. This comparison will provide an independent check on the accuracy of the standard cycle times for each operation for each board.

Using cycle time as a driver will require a new set of decision rules. With the current drivers, designers know it costs about $.02 to place a small component on a board or $.15 to place a large component. To help designers make trade-off decisions, new decision rules in terms of dollars of cycle time per placement must be developed.

The HP experience with ABC indicates that a cost system should be in a continual state of involvement for three reasons: (1) As actual experience is gained with the initial ABC model, desirable changes in the way cost pools and cost drivers have been defined become apparent, (2) the cost system must accommodate changes in manufacturing technology, and (3) the cost system must accommodate new products that frequently force changes in the way the production line operates. Thus, having a consultant perform a one-time study and then install an ABC system to be operated by a company's accountants does not seem appropriate in a dynamic environment. Our experience indicates that an effective ABC system must have continual, "bottom-up" involvement by accountants, engineers, and production people. That an ABC system must evolve continually and not be considered static has not been discussed much in previous writing about ABC.

FIGURE 1 / EFFECT OF ABC ON PRODUCT COSTS



STABILITY OF COST POOLS

To test the statistical validity of the cost drivers, we ran a series of simple, linear regressions between the overhead dollars in the cost pools and the cost driver volumes. The linear regression model looks for a fixed cost component (the "Y intercept") and a variable cost component (the "X coefficient"). Applying overhead with a cost driver makes the implicit assumption that the volume of a cost driver is the independent variable X and the overhead dollars in the cost pool are the dependent variable Y. If this assumption is valid, then a good statistical relationship should exist between volume and overhead cost. Five regressions were performed:

1. Material procurement and handling overhead vs. the number of distinct parts purchased, the cost driver.
2. All overhead related to automatic component placement vs. the number of components placed with the automatic machines. Because the definition of automatic placement cost pools had changed several times, several cost pools and drivers had to be combined to have sufficient data points for a regression.
3. Test and rework overhead vs. the number of minutes yielded test time, the cost driver.
4. Through-hole insertion overhead vs. the number of through-hole placements, the cost driver. Through-hole insertion is the older technology in which components have individual wires that are inserted automatically through holes in the circuit board. This technology is being phased out rapidly, and the volume of through-hole insertions during the last budget cycle had declined to almost zero.
5. Total department overhead vs. total component placements. This regression tested the relation between the combined overhead of all 10 cost pools and total component placements.

Actual data were available for fiscal years 1990, 1991, and 1992. Because overhead rates are set for each six-month budget cycle, six data points were available for the regressions—three years with two budget cycles per year. As mentioned previously, many changes in cost pool and driver definitions had occurred during the four-year period since ABC had been implemented, so we did not have sufficient data to run regressions on all the cost pools.

Regression results are shown in Table 3, "R squares," the squared correlation coefficients for each regression. The R squared measures the proportion of change in the dependent variable explained by changes in the independent variable. Thus, the R squared of .914 for the regression of material handling overhead vs. the number of distinct parts indicates that 91.3% of the change in overhead can be explained by changes in the number of distinct parts. The table also lists the range in cost driver volumes that occurred over the three-year period to give a feeling for whether volumes remained in a relevant range. While no firm definition of the relevant range seems to exist, a rule of thumb is that fixed and variable cost relations remain stable only within a volume range of plus or minus about 20%.

We are reasonably pleased that the regression analyses tended to confirm that the cost drivers selected indeed are correlated with overhead costs in their cost pool. Our experience, though, suggests that such regressions have very limited usefulness in selecting cost drivers for an ABC cost system, for several reasons. After four years of working with ABC, we had barely enough data points to run meaningful regressions.

The main criticism of older cost systems is that they failed to keep up with changing manufacturing technology. An effective ABC system also must change over time, and rarely will a stable time period of historical data occur to permit meaningful regression analyses. While academicians recently have advocated using regression analysis to help select cost drivers,[5] we believe that relying on the judgment of engineers and production people familiar with technical processes is the only practical way to define cost pools and select drivers.

TABLE 3 REGRESSION ANALYSIS OF SELECTED COST POOLS

REGRESSION	R SQUARED	VOLUME RANGE* (+ or -)
1. Material procurement overhead vs. number of distinct parts.	.914	51.2%
2. All automatic placement overhead vs. number of automatic placements.	.923	84.5%
3. Test overhead vs. yield test time in minutes.	.098	19.3%
4. Through-hole overhead vs. number of through-hole placements.	.631	96.7%
5. Total department overhead vs. total number of components placed.	.946	40.4%

*The volume range was computed around the volume mid-point. For example, if the volume varied from 40 to 120 million placements, 80 million would be the mid-point, and the range would be plus or minus 50% [(120 - 80) ÷ 80].

PRICING TO CHARGE FOR VOLUME VARIANCES

The BSMC recently developed a unique method for charging production volume variances to its customers. To avoid having to pass variances along to customers, the BSMC has been defined as a form of cost center called a "performance center," which will charge customers only for standard manufacturing costs. Any variances from standard will be absorbed by the department. The operating goal is to just break even, meaning that the net variance for a budget period will be zero. This system eliminates the argument that when it operated as a pure cost center, the BSMC had no motivation to control costs.

Manufacturing overhead rates are very sensitive to changes in production volume, however, and manufacturing overhead constitutes a very high percent of total product cost. Significant volume variances can occur if actual volumes differ from the planned volumes used to set overhead rates. To charge customers for any volume variance they cause, the BSMC has adopted a volume discount or premium system. Overhead rates are set for each six-month budget cycle based on the volume forecasts for each customer. If a customer's orders exceed the forecast by a certain percent, that customer receives a volume discount approximately equal to the favorable volume

variance resulting from spreading the total overhead over a larger volume base. Conversely, if a customer's actual orders fall below the forecast, they are charged a higher amount. Two volume ranges for price discounts and premiums were established as shown in Figure 2.

Because the price premium for being under forecast is higher than the price discount for being over forecast, customers are motivated to avoid overly optimistic forecasts. Customers have responded favorably to this new system because it permits them to predict exactly what their costs will be. The BSMC has not had enough experience yet to tell how the volume discount or premium system will work in the long run.

NO AUDIT PROBLEMS

The ABC system has been audited four times since it was implemented in 1989—twice by HP's internal auditors and twice by its external auditors. Both auditing groups were familiar with ABC and were able to understand quickly the BSMC's system, which uses ABC costs to value inventory and cost of goods sold. In addition to their usual tests of the accounting records, the auditors verified unique aspects of the cost system. They verified that cost drivers could be measured accurately because accountants typically do not record physical measures such as the number of electronic components placed on circuit boards or the number of setup minutes. The auditors also verified that cost drivers were reevaluated adequately every six months during the budget cycle.

All the audits went smoothly. The ABC system is well documented, and a good audit trail is maintained, so the auditors got satisfactory answers to all their questions. The ABC system passed both internal and external audits with no problems.

HOW MUCH DOES ABC COST?

Managers usually assume that an ABC system with multiple cost drivers will cost more to administer and maintain than a traditional cost system with only one or two cost drivers. We tried to identify the additional accounting costs, if any, required to implement and maintain the BSMC's ABC system. During the study and implementation phase, a cost manager and financial analyst worked with production, engineering, and materials procurement personnel. After implementation, the BSMC rapidly doubled in capacity as production volumes grew. Even though more accounting support was required, there was no apparent way to determine the specific impact that ABC may have had. Because it has to justify all its costs to customers, the BSMC's cost system must be more complex than if all costs were passed on to a single department or product line, but it is not certain what additional costs, if any, are attributable to ABC. A casual comparison showed that the size of the accounting staff that supports the BSMC was about the same as the size of the accounting staff that supports a similar manufacturing department still using a traditional cost system.

What did become apparent, though, was how ABC changed what the accountants did. Accountants in departments with traditional cost systems seem to spend more time trying to understand why production costs do not make sense and dealing with frustrated production managers who do not believe production cost reports. The accountants who support the departments using ABC spend much more time helping production to manage costs. Another division of HP that uses ABC experienced similar results.[6]

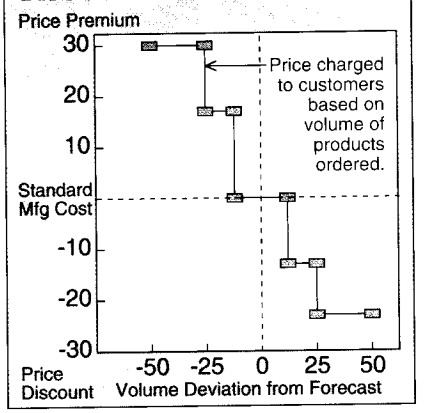
THE OVERALL RESULTS

The Boise Surface Mount Center at Hewlett-Packard's Boise site by now has had more than four years of operating experience with its ABC system. The BSMC took the rather bold step of integrating ABC fully into its computerized financial and cost reporting systems, unlike many companies that do ABC analyses "off-line" while maintaining a traditional cost system for financial reporting.

One aspect of using ABC that has not been described in previous articles is that the system must evolve continually. As the BSMC gained experience with the original model and as manufacturing technology changed, desirable changes in definitions of cost pools and cost drivers became apparent. Most of the cost pools and cost drivers have been modified in some way since 1989 when the ABC system was implemented.

Because the ABC system now mirrors the manufacturing process, the engineers and production staff believe the cost data produced by the accounting system. Engineering and production regularly ask accounting to help find the product design combination that will optimize costs.

FIGURE 2 / VOLUME DISCOUNTS & PREMIUMS



The accountants now participate in product design decisions. They help engineering and production understand how manufacturing costs behave. They produce cost bids customers understand and that help the department get new business. In addition to producing good cost information, the ABC system makes the professional lives of the accountants more rewarding. ■

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[1]In this article, the term accountant is used in the generic sense; actually, Hewlett-Packard distinguishes between various job classifications within the accounting function such as "accountant" and "financial analyst."

[2]H. Thomas Johnson, "It's Time to Stop Overselling Activity-Based Costing," MANAGEMENT ACCOUNTING, September 1992, p. 32.

[3]Robin Cooper, "Implementing an Activity Based Cost System," *Journal of Cost Management*, Winter 1990, pp. 69-77.

[4]R. Hunt, L. Garret, and C.M. Merz, "Direct Labor Cost Not Always Relevant at HP," MANAGEMENT ACCOUNTING, February 1985, pp. 58-62.

[5]Harold P. Roth and A. Faye Borthick, "Are You Distorting Costs by Violating ABC Assumptions?" MANAGEMENT ACCOUNTING, November 1991, pp. 39-42; Adel M. Novin, "How to Find the Right Bases and Rates," MANAGEMENT ACCOUNTING, March 1992, pp. 40-43.

[6]D. Berlant, R. Browning, and G. Foster, "How Hewlett-Packard Gets Numbers It Can Trust," *Harvard Business Review*, January-February 1990, pp. 178-183.