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NONMARINE INDUSTRY COST ESTIMATING AND COST CONTROL FINDINGS REPORT

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16. Abstract

Use of product-oriented cost estimating and cost control in nonmarine industries is assessed related to the expected business use of these approaches in ship design and shipbuilding. Companies observed were Trane Company, Caterpillar, Inc., and Boeing Company (Space & Defense). In all cases, the cost estimating and cost control approaches were process based systems in which similar products used similar processes. Cost control approaches for product manufacturing have changed from labor-oriented control to volume product throughput controls usually attributed to Activity Based Costing (ABC) principles. The parallels with foreign shipbuilding companies are very high. Foreign shipbuilding use of process and interim product knowledge for high level and detail production control has been consistently documented as a major driver in lowering both product cycle and product cost. Further, increased levels of process automation are also reported in foreign shipbuilding, especially in the fitting and welding of hull structures.
Parallels seem to indicate that cost estimating and control approaches in nonmarine industries, which draw on product and process knowledge as their major driver, may also be appropriate in U.S. shipbuilding.

Key indicators of these approaches include:
- flattened organizations;
- traditionally indirect functions reporting directly production cost centers;
- increased production automation with the requisite decrease in direct labor cost and increase in indirect support cost.

17. Key Words
Ship design, shipbuilding, activity based costing, ABC, cost estimating, cost control, product cost, product cycle, labor-oriented, volume throughput, product oriented

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CONTENTS

1. EXECUTIVE SUMMARY

In assessing the use of product-oriented cost estimating and cost control in nonmarine industries, this task has identified that a major issue is to determine the expected business use of the envisioned cost estimating and control approach. Companies observed were Trane Company, Caterpillar, Inc., and the Boeing Company (Space & Defense Division).

The systems observed were noted to be either for internal use at Caterpillar and Trane or for both internal and customer requirements at Boeing Space & Defense. In all cases, the cost estimating and cost control approaches were process-based systems in which similar products used similar processes. The major observed difference in approach occurred at Boeing where the product development was currently in a prototype phase with strong project management procurement control from the DOD customer.

All companies indicated that their cost-control approaches for product manufacturing had changed from labor-oriented control to volume product throughput controls. Direct product labor was reduced to the point that it no longer was the most effective measure of performance or cost control. While direct labor cost is still an important cost constituent, the cost of labor is no longer used to allocate other portions of total cost. Activity-based costing approaches are used to allocate indirect costs and, product throughput within individual processes was seen to provide a more accurate and lower cost approach to cost control. Key indicators of these approaches include:

- flattened organizations;
- traditionally direct functions reporting directly production cost centers;
- increased production automation with the requisite decrease in direct labor cost and increase in indirect support cost.

Specifics of the management implementation of new cost estimating and control approaches varied due to the individual company's product, business plan, competition, legacy cost systems, and customer. However, in all cases, the approach was based on a thorough understanding of the delivered product, the interim or subproducts, and the processes through which the interim products pass. Processes include all added-value steps required for the life cycle of the delivered products.

The parallels with foreign shipbuilding companies are very high. Foreign shipbuilding use of process and interim product knowledge for both high level and detail level production control has been consistently documented as a major driver in lowering both product cycle and product cost. Further, increased levels of process automation are also reported in foreign shipbuilding, especially in the fitting and welding of hull structures.

These parallels seem to indicate that cost estimating and control approaches in nonmarine industries, which draw on product and process knowledge as their major driver, may also be appropriate in U.S. shipbuilding. However, major unresolved issues of business planning or strategy remain in the use of these approaches.

2. BACKGROUND

Product-oriented, work-definition approaches in foreign shipbuilding have been observed and documented, primarily in Japan, since the mid 1970s. These approaches appear to have significantly enabled reduced product cycles and reduced product cost. These approaches have been available to U.S. shipbuilders who have failed to keep pace with the productivity levels of foreign shipbuilders. Part of the difference is thought to be related to U.S. Navy procurement practice and requirements, which remain ship-systems based rather than interim-product based.

This task was intended to assess the use of similar product-oriented approaches in domestic nonmarine industries. The assessment was to observe and report any effective business strategies that would allow adoption of effective cost-estimating and cost-control approaches more easily between U.S. Navy and U.S. shipbuilders.

3. OBJECTIVE

The objective of this activity was to study the relevant use of product-oriented cost estimating and cost control by nonmarine companies that design and manufacture products of similar complexity or scale to ships, and to report on approaches that may be of interest to the Navy or to shipbuilders in the implementation of product-oriented cost estimating and cost control.

4. APPROACH

The approach of the study was to:

- Identify at least three (3) suitable nonmarine companies that are using product-oriented or activity-based costing methods.[1]
- Obtain and study information related to their operations and cost approaches.
- Develop a set of questions appropriate for each company's situation that investigates the relevant issues of the objective.
- Synthesize the findings of all visits into a summary report indicating important concepts concerning costing approaches that should be considered in ship acquisition and construction.
- Provide immediate input to the project manager on items that appear to be novel and of significant importance to cost approaches for ships.

4.1. INDUSTRY SELECTION

Company Selection Criteria

The objective of the study dictated that the specific companies selected for detailed review and visits would; (1) manufacture and assemble complex and large scale commercial products, and (2) have in place advanced cost estimating and/or management control systems.

These criteria were logically established to assure that there was direct relevance to shipbuilding products and to assure that only companies using competitive approaches to cost issues would be considered.

4.1.1. LITERATURE SEARCH AND INFORMATION SOURCES

Literature Searches

The literature searches conducted in support of the Product-Oriented Design and Construction (PODAC) Cost Modeling Project were done to identify potential companies that met the criteria identified above. This information is available from PODAC Cost

[1]Appendix A includes a list of the foundation reference material related to activity based costing (ABC).

Model Development - Phase I Final Report.[2] These literature searches had been conducted through the University of Michigan library system, including the library at the Department of Naval Architecture and Marine Engineering and the NSRP library system at UMTRI, and the Society of Manufacturing Engineers library system. Literature search abstracts totaled more than 400 pages and only selected citations are included in Appendix A of the PODAC report. Pat Cahill is currently on staff with UMTRI-MSD and assisted Mark Spicknall in the literature search for this task. Very few of these articles identify specific companies that meet the criteria identified above.

Also, as part of this task, a keyword literature search was conducted using sources and databases available at the University of Michigan Kresge Business School library and at the Navy's Best Manufacturing Practices office. Copies of these abstracts are also included in Appendix A.

Two articles identified highlight companies that meet the criteria identified above. The first article[3] (Appendix B) addresses Trane's development, implementation, and use of an activity based costing and accounting system. Trane is a producer of large scale heating and air conditioning components and systems for commercial and military use. The article reviews the costing processes at one of Trane's equipment manufacturing plants where the activities, processes, and problems encountered have some direct parallels to the shipbuilding environment.

The second article[4] (Appendix C) reviews the history of the development and implementation of an activity based costing system used by Caterpillar to estimate and control the costs of manufacturing heavy construction equipment. Although the scale of production in terms of product size does not exactly match that of shipbuilding, the basic premises of group technology and work center-oriented manufacturing and assembly are employed. The article explains how the cost estimating and cost control functions are integrated into a single Cost Information System, or CIS. The CIS is part of a larger Computer Integrated Manufacturing (CIM) environment, which allows Caterpillar to access and update cost information at every stage of its design and production process.

Other Sources of Information

In addition to literature searches, several other sources of information were utilized. Michigan Business School professors with expertise in managerial accounting and cost estimating were consulted independently and asked to identify companies meeting the required criteria. Dr. James Noel, Assistant Professor of Accounting, voluntarily coordinated this effort. Again, Caterpillar and Trane were continually mentioned as two manufacturing companies that were widely known to have implemented advanced costing and accounting methods and systems. The Business School professors attempted to identify a domestic manufacturer of large scale machine tools that had implemented advanced costing and accounting methods and systems, thinking that this industry would be close to shipbuilding in complexity, scale, and scope. However, they were unsuccessful in uncovering any domestic manufacturers involved in these activities.

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[2] by Howard M. Bunch, Patrick D. Cahill, Alan Behning, and Jeffrey Kappel, The University of Michigan, January 1995, Appendix A - Relevant Literature Review.
[3] Clements, Ronald B. and Spoeda, Charlene W., "Trane's SOUP Accounting," Management Accounting, June 1992, p: 46-52.
[4] Jones, Lou F., "Product Costing at Caterpillar," Management Accounting, February 1991, p: 34-42.

Relevant Harvard Business School case studies were reviewed to identify companies that met the required criteria. While this effort identified many manufacturing companies that have implemented advanced costing and accounting methods and systems, none of these companies manufactured and assembled products at the scale and scope considered adequate for relevance to this effort. A list of the case studies reviewed is included in Appendix D.

NAVSEA's Advances Through Commonality (ATC) program material identified Boeing as a major implementor of product-oriented design and construction, and, potentially, costing. Contact was made with Boeing Defense and Space Division, which expressed an interest and a willingness to participate in the project. There is significant similarity between the group technology-based production processes used at Boeing and those used in the shipbuilding industry.

Navy sources involved with the Mid-Term Sealift Technology Development Program suggested that Caterpillar and General Dynamics, Fort Worth, might be companies worth visiting. Currently the General Dynamics Fort Worth Division builds F-16 fighter aircraft with very little or no commercial work going on.

Based on the combined literature searches and other information sources available, Boeing, Caterpillar, and Trane were identified as companies that most closely met the selection criteria for the task.

4.1.2. DIRECT CONTACT, QUESTIONNAIRE, AND DISCUSSIONS

After selecting the three target companies, Boeing, Caterpillar, and Trane, points of contact were identified and phone conversations initiated to assess their suitability as site evaluation candidates, and to determine their willingness to participate. In conjunction with the telephone contacts, a questionnaire (Appendix E) was developed to help focus the data-gathering effort and alert the selected companies as to the type of information that was being sought for the project.

Mr. Harv Martin, the comptroller at Trane's Pueblo, Colorodo manufacturing facility, was identified as the point of contact for more information on Trane's SOUP (System Of Utter Practicality) accounting system. Once initial contact was established, the questionnaire was faxed to Mr. Martin along with a visit request. Mr. Martin responded several days later that he could not support a visit on the dates requested. In addition, he declined to answer the questionnaire stating that he felt the questions were too detailed and would be delving into proprietary and confidential information. However, he was willing to clarify some relevant issues verbally.

Regarding accounting for government and commercial products within the same facility, Mr. Martin stated that their products were priced to the customer as end products only, requiring no in-process accounting or differentiation among customers within their cost management system. He further stated that whatever was necessary to put their products on a certified or qualified pricing list for the government was handled outside of the product manufacturing arena, and that he was not familiar with the specifics. In reference to estimating the cost of new products, Mr. Martin stated that products were estimated primarily on the basis of material content, as labor cost is such a small percentage of end cost that it is not considered. Indirect costs are allocated to products on an activity basis. Variations of their products are also costed based on material content. Customers specify particular performance attributes, and Trane determines the component changes necessary to deliver that product with the cost differential based on the material costs. As described in detail in appendix B, this plant supplies millions of product variants.

Contact with Caterpillar was somewhat more successful than with Trane. Mr. Lou Jones, the author of the article reviewed, was identified as the point of contact in Caterpillar's Peoria facility. Mr. Jones was immediately open to the suggestion of a site visit. In fact, Caterpillar has had so many calls as a result of his article that they have a standard presentation prepared. Although he declined to answer the questionnaire in specifics, he felt that the visit would be comprehensive enough to cover, at least in general, all of the issues of concern to this project.

Contact with Boeing, which also has a standard presentation, was through Mr. Joe Lewis and Mr. Rick Fichera of the Boeing Defense & Space Group. Their initial reaction to the UMTRI questionnaire was that many of the issues addressed in the questionnaire were ones that they were still trying to solve within their own organization. However, they were still open to a site visit to discuss the issues in further detail and provide some additional insight as to how Boeing does business.

4.2 SITE VISITS

Two site visits were conducted based on the initial discussions described above. These were at Caterpillar on March 14, 1995 and at Boeing on March 15, 1995. Appendix F contains the agenda for each visit, the persons contacted, and the trip report of Howard M. Bunch, who accompanied Richard C. Moore on the visits. Also included in Appendix G is a copy of the presentation on Shipyard Estimating Methods used to introduce the participating company personnel to cost estimating and control as practiced in U.S. shipbuilding companies. This material helped establish a common understanding of cost estimating and control issues and has fostered effective communications.

All companies selected for detail study were highly successful commercial producers of internationally competitive products. All had been under intensive competitive pressure, which forced extensive changes in management thinking to remain profitable and viable in their industry. Caterpillar had lost significant market share to Komatsu of Japan, was not cost competitive in many product segments, and had lost touch with customer requirements. Figure 1 provides a brief overview of the changes Caterpillar initiated following its "wake-up call" in the mid 1980s. Boeing has undergone significant change following commercial competition from Airbus, and also due to customers' needs for lower operating cost and purchase price. Defense and space spending cutbacks have forced similar rationalization of its Space & Defense business. Trane's competitive pressures were not as well identified due to the lack of direct questioning and presentations. However, Trane bases its customer satisfaction on delivering a full spectrum of 60 million distinct products within four product lines, each within six to eight size ranges. All of these product configurations are manufactured in a single plant on a single lot order basis, and all are competitively priced.

Cost estimating and control in these companies is a part of a wider management approach to significant reductions in product cycle, product cost, and associated cost of business normally considered beyond the scope of product and process improvements in domestic shipyards. These companies saw that to remain viable their entire approach to every aspect of business had to be reexamined. Automation of many processes had led to low levels of direct labor cost relative to total cost. Indirect cost, outside the traditional control of line production management, had become a large part of total cost, and many internal products of indirect functions (such as drawings, purchase orders, cost data, accounting records, etc.) directly affected product delivery and quality without appropriate consideration in the production process.

Reengineering At Caterpillar

Business Issue	*Action*	*Timeframe*
✓ Customer Focus	Reorganized Marketing	1983...
✓ Manufacturing & Logistics	Plant With A Future (PWAF)	1987-94
✓ Product Development	Shortened & Streamlined Process	1989...
✓ Strategy & Decision Making	Reorganized Company...Profit Centers/Service Centers	1990...
✓ Performance Measurements	Threw Out The Old... Developed New	1990-91
✓ Business Support Processes	"ON DEMAND, NO ERROR" (BHAG)	1993...

FIGURE 1

All of the companies considered in this task have directly involved production management in new forms of cost estimating and cost control. These new forms are based on wider utilization of human resources coupled with throughput based control systems. These changes have required intensive employee education and training with management involvement to fully understand the impact of the changes and totally incorporate the changes into the operation of the entire organization. Generally, these changes have led to fewer total employees and the elimination of all but essential tasks. Many management systems have been adapted to these changes and now perform similar functions in a far different environment. For example, manufacturing resorces planning (MRP) was formerly used for material and process task definition only and has now integrated this information into a total cost information system. Detailed work instructions are developed to provide worker required information, but work control does not include detail labor cost tracking.

Specific observations concerning each visit are provided in the following sections.

4.2.1. CATERPILLAR INC.

The discussions at Caterpillar were hosted and led by Mr. Lou Jones. Following an introductory presentation describing Caterpillar's recent business environment and the interest of U.S. shipbuilding in cost estimating and control, Mr. Bob Polizzi provided a detailed discussion concerning cost management. This presentation is provided in detail in Appendix F. Specific slides are used in this section to fully describe important concepts.

Cost management focuses on internal management needs, not on external needs. Where defense procurement occurs, special requirements for product costing are obtained directly from the cost management system and summarized by the sales force to meet DOD requirements. Cost management functions supported by Caterpillar's computer systems are listed in Figure 2. In this slide, the largest area of support is *analyze design, process, and sourcing decisions*. This area supports Caterpillar's integrated product and process development (IPPD) approaches, and five separate cost/profit trade-off at each stage of product development from *a single cost management system* (as opposed to 50 different systems at GM). Product percent cost split is 50/30/20 (material/labor/overhead). This is compared to Japanese competitors, where material is 85 percent due to supplier involvement arrangements.

Figure 3 is very important as it identifies that the basis of cost allocation is *planned production volume*. All expenses, summed department, material purchases, and plant overhead are allocated by planned product throughput during the period. Figure 4 shows the specifics of business plan cost allocation to product costs. The entire company has adopted a single view of "normal plant cost methodology" (see Figure 5). This approach provides a set of product/process data, which is consistent with the accumulation of cost shown in Figure 6 (see Figures 7, 7a, 7b, 8, and 9 for additional examples of this accumulation approach, which is consistent with Activity Based Costing (ABC)). Each plant is able to make internal decisions about its specific "drivers" for some types of allocation, such as general overhead, within the company methodology (see Figure 10). These decisions are made with support from the Headquarters Cost Management Staff. The *full overhead rate* (applied to Normal Plant Cost - Figure 6) is said to be 5-10 percent.

Cost Management

- Measure how well we do against targets and competitors
- Provide price setting bases
- Measure margins
- Analyze design, process, and sourcing decisions
- Provide cost trends
- Measure impact of corrective actions
- Measure impact of strategic decisions
- Measure productivity and overall cost effectiveness
- Measure complexity and cost drivers
- Identify and analyze nonvalue added activities
- Top tier measurement

target based on price and competitive analysis.

five reviews (cost/profit at each stage.)
- co-located cross-discipline teams
- complete process/product trade-off

GM → 50 different cost systems
- needed continuity.

→ need to assure lowest cost of total product)

largest area of val.

FIGURE 2

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FIGURE 3

PLANT BUSINESS PLAN

FOR A PLANNED PRODUCTION VOLUME

DEPARTMENTS BUSINESS PLANS — DIRECT MATERIAL PURCHASES — PLANT OVERHEAD

- Labor Costs
  - Number of Employees
  - Wages and Fringes
- Department Overhead Costs
  - Indirect Material & Expense

- Freight
- Utilities
- Depreciation
- Taxes
- Etc.

cost rates based on budgets (not actuals). {6 months ahead.}

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FROM BUSINESS PLAN TO PRODUCT COSTS

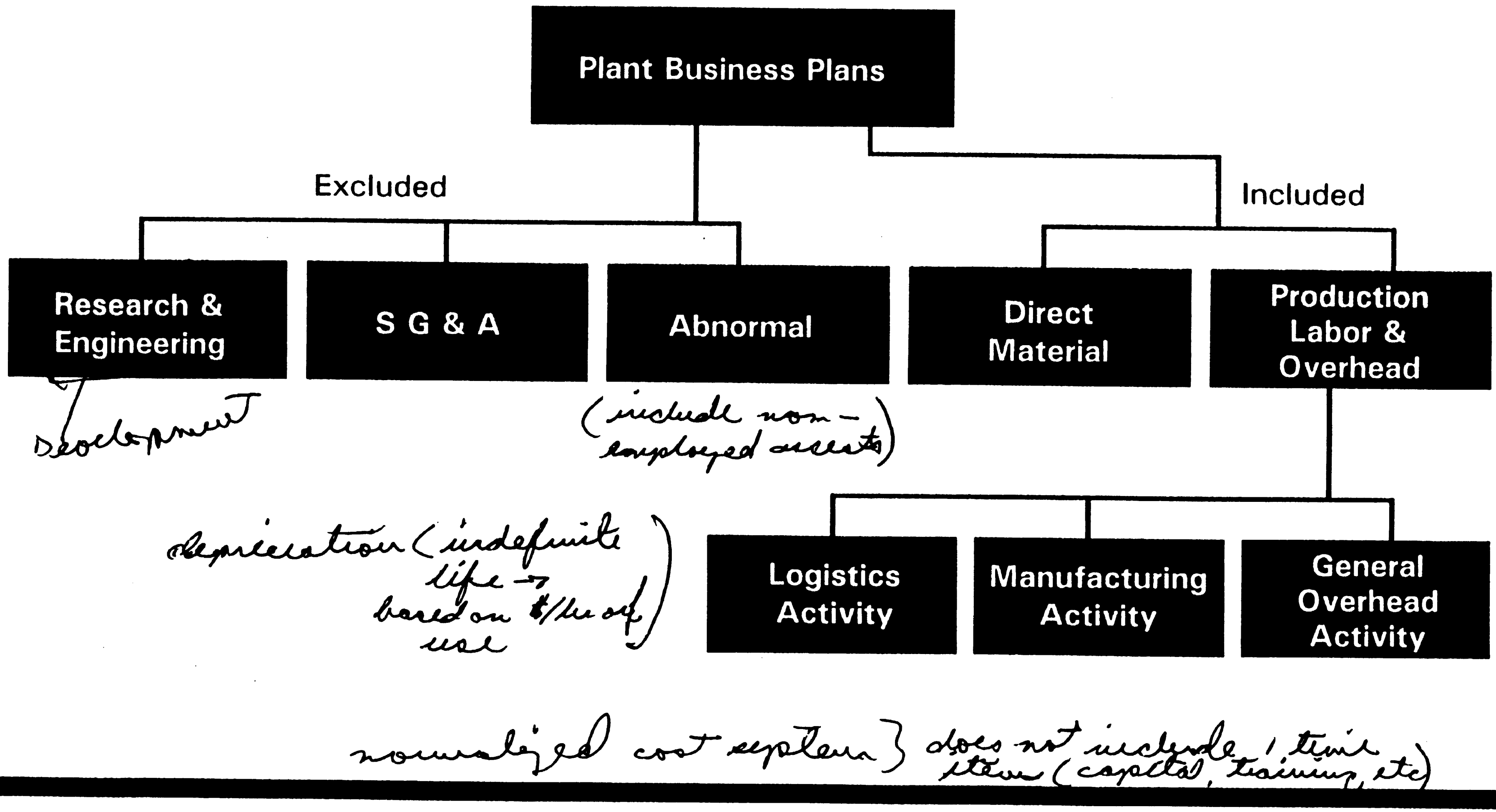

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FIGURE 4

Normal Plant Cost Methodology

(3 year business plan)

(7 year trend analysis vs current year) (old 2 + 5 future (vol. 3))

- Includes costs of current products at normalized production volumes.
- Excludes the effect of short-term changes in operating levels and start-up conditions.
- Not to be defined as costs incurred under ideal conditions.

Examples of Abnormal Costs:

1. Start-up costs related to the introduction of new products and new processes or systems.
2. Expenses related to short-term operating conditions (e.g. production levels, strike pulls).
3. Major rearrangements/infrequent plant repair (e.g. PWAF, resurface parking lot).
4. Manufacturing inefficiencies that are short-term (< 1 yr) and identifiable by section or cell (e.g. PWAF start-up).
5. Unallocated floorspace.
6. Surplus equipment.

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FIGURE 5

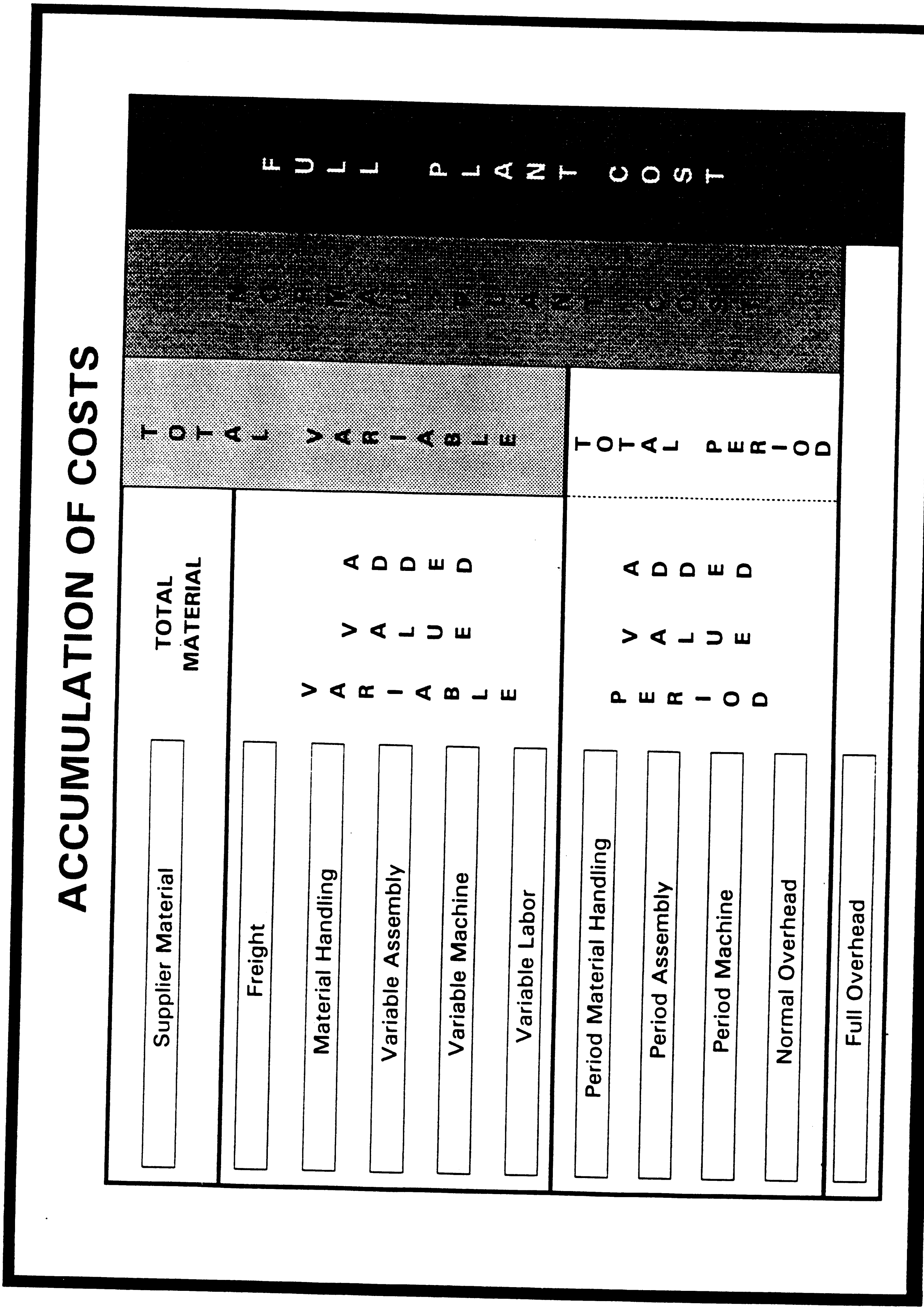
ACCUMULATION OF COSTS
FULL PLANT COST
NORMAL PLANT COST
TOTAL VARIABLE
TOTAL PERIOD
TOTAL MATERIAL
VARIABLE VALUE ADDED
PERIOD VALUE ADDED
Supplier Material
Freight
Material Handling
Variable Assembly
Variable Machine
Variable Labor
Period Material Handling
Period Assembly
Period Machine
Normal Overhead
Full Overhead

FIGURE 6

FIGURE 7

Caterpillar Cost Methodology
Rates by Machine

- rates updated (every 6 months)
- inputs updated monthly.

Variable Labor	*Variable Machine*	*Period Machine*
Direct Labor	Material Handling	Depreciation (original cost)
Fringes	Perishable Tools	Building (occupancy)
Performance Percent	Support Labor	Durable Tools
	Supplies	Planning
	Spoilage & Rework	Machine Repair (3 year history)
	Inspection/Quality	Mfg. Departl Burden (above foreman → to manuf. mgr.
	Power/Fuel	
	Unabsorbed Direct Labor	
(Drivers) Activity Base		
Labor and Set-Up Hours	Machine Run Hours	Machine Run and Set-Up Hours

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CATERPILLAR COST METHODOLOGY
RATES BY MACHINE

VARIABLE MACHINE

ACTIVITY BASE: MACHINE RUN HOURS

MATERIAL HANDLING

INTRAPLANT MATERAL HANDLING (0015/1015)

PERISHABLE TOOLING

PERISHABLE TOOLING (0055)
DISBURSING TOOLS (0062)
GRINDING TOOLS (0071)
TOTAL LABOR & FRINGES
PERISHABLE TOOLING (1055)
GRINDING TOOLS (1071)

SUPPORT LABOR

FIRST LINE SUPERVISION WAGES PLUS FRINGES
FACTORY CLEANING DEPT.
CLERICAL AND FOLLOW–UP (0012)
MATERIAL CLEANING (0016)
HOUSEKEEPING (0020)
OPERATIONS NOT ON BASE (0025)
FRINGES ON ABOVE HOURLY LABOR

SUPPLIES

PAINT/RUST PROOF (2242)
CLEANING MATERIAL (2244)
GAS & OIL (2245)
WELD/CUTTING GAS (2276)
WELD ROD (2289)
MISC. SUPPLIES (1087)

SPOILAGE AND REWORK

SALVAGING DEFECTIVE LABOR (0073/1073)
SPOILAGE DUE TO LABOR (2240)

INSPECTION/QUALITY

INSPECTING (0013) & FRINGES
LABOR & FRINGES FOR INSPECTION DEPARTMENT

POWER/FUEL

UNABSORBED DIRECT LABOR
(FOR CELLS)

FIGURE 7a

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CATERPILLAR COST METHODOLOGY
RATES BY MACHINE

PERIOD MACHINE

ACTIVITY BASE: MACHINE RUN AND SET-UP HOURS

FIGURE 7b

DEPRECIATION

COST DEPRECIATION ON MACHINE TOOLS
& SUPPORT EQUIPMENT

OCCUPANCY

BUILDING EXPENSES (INCL. DEPRECIATION)
BASED UPON FLOORSPACE ALLOCATED
TO THE MACHINE

DURABLE TOOLING

DEPRECIATION ON DURABLE TOOLS
TOOL ROOM AND TOOL DESIGN:
TOTAL DEPARTMENTAL EXPENSES
OCCUPANCY COST FOR FLOORSPACE
DEPRECIATION ON TOOL ROOM M&E
REPAIRS TO DURABLE TOOLS (0026/1026)
REPLACEMENT DURABLE TOOLS (0040/1040)

FRINGES ON ABOVE HOURLY LABOR

PLANNING

PLANNING DEPARTMENT LABOR & FRINGES
(INCLUDING WORK STANDARDS)

MACHINE REPAIR

REPAIRS-MACH TOOLS (0067/1067)
MAINT.-MACH TOOLS (0029/1029)
EQUIPMENT REPAIRS (0066/1066)

FRINGES ON ABOVE HOURLY LABOR

OTHER PERIOD MACHINE

PROVING NEW MACHINE TOOLS (0028/1028)
REARRANGING FACILITIES (0033/1033)
INSTRUCTING (0039/1039)
REPAIR & REPLACEMENT OF INSPECTION
EQUIPMENT (0041/0042/1041/1042)
OTHER SPECIAL ORDERS (0094/1094)
OTHER INDIRECT LABOR (0090)

FRINGES ON ABOVE HOURLY LABOR

RENTALS OF VARIOUS EQUIPMENT

323-15.B

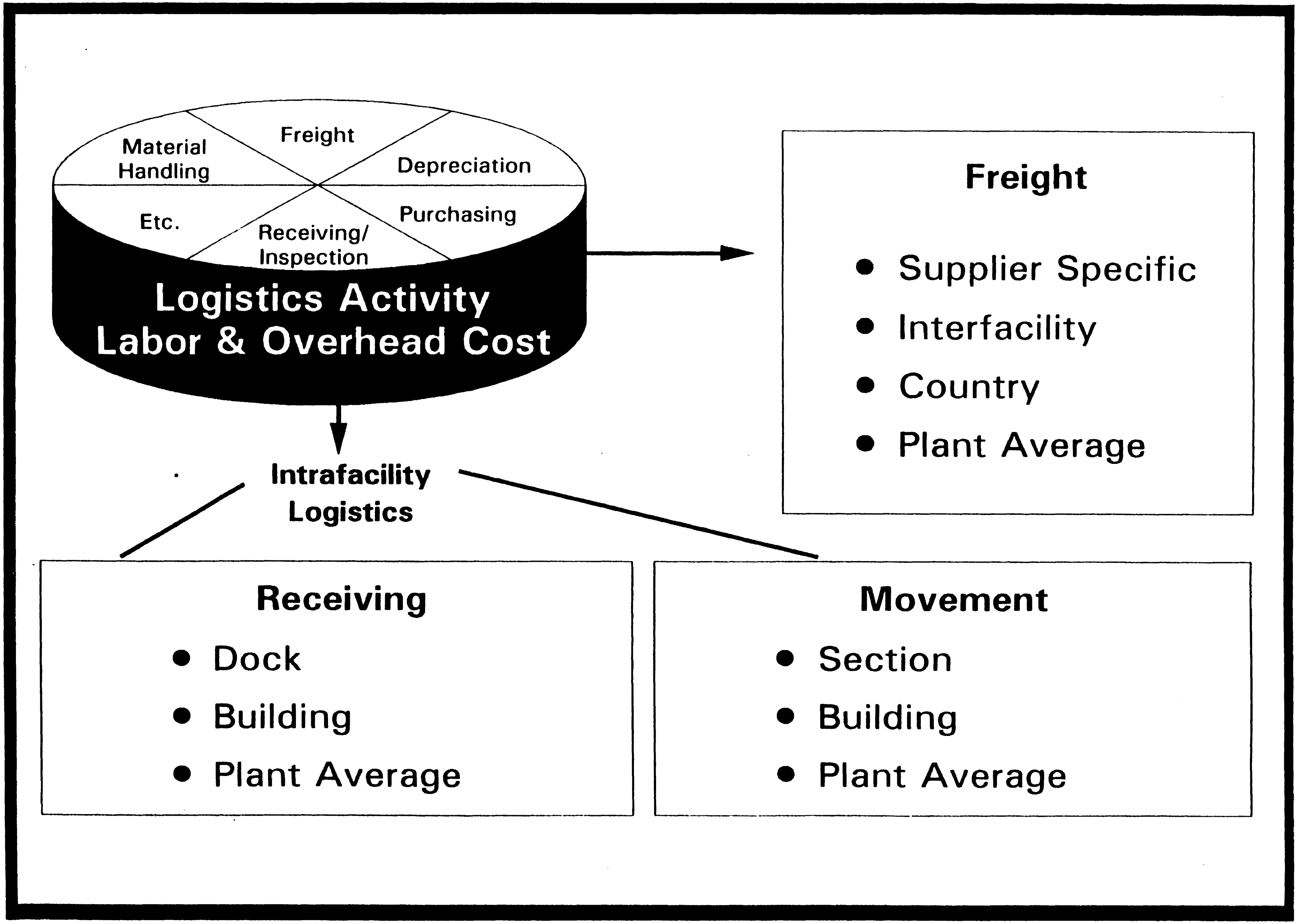

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FIGURE 8

GENERAL OVERHEAD ACTIVITY

Expenses Not Directly Associated with Logistics or Manufacturing that Apply to the Whole Plant in General

Period Only

- Accounting
- Employee Relations
- Labor Relations
- Plant Administration
- Engineering Maintenance
- Medical Services
- Scheduling and Inventory Control
- Information Services

Cost Base

- A Percentage of The Total of All The Other Costs

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FIGURE 9

Allocating General Overhead Expenses To Product Groups or Building

5-10% of material/labor/machine

General Overhead Expense	*Aurora by Product Group*	*Joliet by Building*
Personnel/Medical/Benefits	Variable Labor	Total Headcount
Labor Relations	Variable Labor	Hourly Headcount
Training	Variable Labor	Actual History
Information Services	Unique Part Numbers	Info Services Reports/Usage
Engineering Maintenance	PAC2	PAC2
Business Analysis	Surveys	Surveys
Capital & Indirect Purchasing	Surveys	Indirect Tool Items by Commodity, Open POs
Product Group General Admin	Specific	Specific
Requirements/Releasing	Unique Part Numbers	Commodity Spec/# of Releases
Quality Support	Surveys	Number of Warranty $ and Time Allocation
RSSM	Extended Material $	RSSMs by Commodity
Depreciation	Depr $ by Product Group	Period Machine Floorspace
External Purchase Services	Similar Plant Expenses	Lower Tier Reporting
Period Building	Depr $ by Product Group	Period Machine Floorspace
Other Minor Expenses	% of General Overhead by Product	Lower Tier Reporting

323-19a

FIGURE 10

FIGURE 11

GUIDELINES FOR DISTRIBUTING DEPARTMENTAL EXPENSES TO BURDEN POOLS

Acct #	Description	Mfg Gen'l.	Plant Engr., Plant Prot., Bldg. Maint.	Tool Room, Tool Design, Mach. Repair	Tools & Supplies, Disbursing & Grinding	Planning, Work Standards	Machine Shops Exc. Cleaning	Assembly, Test, Paint Ship
0001	Direct Labor				Variable Labor			VA
0002	Special Direct Labor				" "			VA
0003	R. Orders				" "			VA
0004	Install. of Attach. & Box				Variable Assembly			
0010/1010	Special Order-Def. Prod.				S. G. & A.			
0011/1011	Eng. Orders-Towmotor				Engineering			
0012	Clerical & Stock Follow-Up	PL	P Bldg	PMB	VMB	PMB	VM	VA
0013	Inspecting	PL	P Bldg	PMB	VMB	PMB	VMB	VA
0014/1014	Product Eval. Testing				Period Assembly			
0015	Intraplant Matl. Handling	PL	P Bldg	PMB	VMB	PMB	VM	VA
0016/1016	Material Cleaning	PL	P Bldg	PMB	VMB	PMB	VM	VA
0017	Interplant Matl. Handling				Variable Material			VA
0018	Plant Protection				Period Building			
0019/1019	Capital Add'ns - Canada				General Burden			
0020	Housekeeping	PL	P Bldg	PMB	VMB	PMB	VM	VA
0021/1021	Forge Shop Dies				Forge Shop Variable			
0022/1022	Repairs & Maint. Vehicles	PL	P Bldg	PMB	PMB	PMB	PM	PA
0023/1023	Capital Add'ns. - Burlington				General Burden			
0024/1024	Eng. Orders - Decatur				Engineering			
0025	Operations Not on Base Time	PL	P Bldg	PMB	VMB	PMB	VM	VA
0026/1026	Repairs & Maint. D. Tool				Period Machine Burden			PA
0027/1027	Capital Add'ns - Davenport				General Burden			
0028/1028	Proving New Machines				Period Machine Burden			PA
0029/1029	Maint. of Machine Tools & Equip.	PL	P Bldg	PMB	PMB	PMB	PMB	PA
0030/1030	Capital Add'ns - Aurora				General Burden			
0031/1031	Capital Add'ns - G.O.				General Burden			
0032	Altering Product for Shipping				Period Asssembly			
0033/1033	Rearranging Facilities	PL	P Bldg	PMB	PMB	PMB	PMB	PA
0034/1034	Experimental - Qualifying				Engineering			
0035/1035	Eng. Orders - Solar				Engineering			

323-24

Bill of activities (chart of accounts) about 50 pages

Bills of activities are standard company-wide, available to all employees, and used to support plant and cell cost management decisions and cost understanding. A bill of activities consists of 50 pages and is the equivalent of a typical business "chart of accounts" (see Figure 11).

The cost information system (see Figure 12), developed and used to support the cost management approach, draws heavily on legacy management systems used at Caterpillar. These include engineered work standards to machine operation level, engineered bills of material for MRP, and returned cost history. The legacy systems have been refined to regularly obtain and return data consistent with "normal plant cost methodology." MRP routing files are used to integrate operations-level detail labor estimates. Figures 13 through 16 provide an example of the summary of detail and presentation provided by the cost management system.

Summary: The cost management information system is a resource for decisions, and is not the decision maker. By itself, it does nothing and drives no processes automatically. It is accessed in every cost, process, and pricing decision made in Caterpillar. Due to the organization of plants, the information is available by process, or product and process with as much detail as required.

4.2.2. BOEING COMPANY - SPACE & DEFENSE GROUP

The visit to Boeing Space & Defense Group was conducted under a nondisclosure agreement. As such, no hard copies of the presentation materials were obtained. Additionally, the Commercial Aircraft counterparts were not available to the team, though Boeing may being willing to provide such contact.

GENERAL

Boeing Space & Defense has adopted a process-oriented approach to product development, product cycle, and product cost improvements. Processes are being analyzed, documented, and refined. The objective is to recognize process similarities and reduce the total number of different processes in use.

The reduction of the total number of different processes is directly related to the effort required to maintain each individual process. Personnel education and training, documentation, data organization, process interface issues, etc., are all examples of task efforts that are required for each individual process, and total cost of these efforts increases significantly as the total number of processes increase.

Product development at Boeing Space & Defense is being transitioned to exclusive use of integrated product teams (IPTs) and analysis integration teams (AITs), as had already been done in the Commercial Aircraft division for the 777 program. These two types of teams interact in a product-build team approach. The work is controlled through program execution plans (PEPs), which specify standard processes. The AITs and IPTs are multidisciplinary cross-functional teams. Boeing's approach fits the definition for concurrent engineering (CE) and DOD's term, "integrated product and process development" (IPPD). Boeing's experience with the CE/IPPD method has shown that process knowledge is the essential ingredient in team effective performance. PEPs contain task definitions, estimates of resources and schedules, performance metrics, etc., all of which heavily depend on process detail.

COMPONENTS OF COST INFORMATION SYSTEM

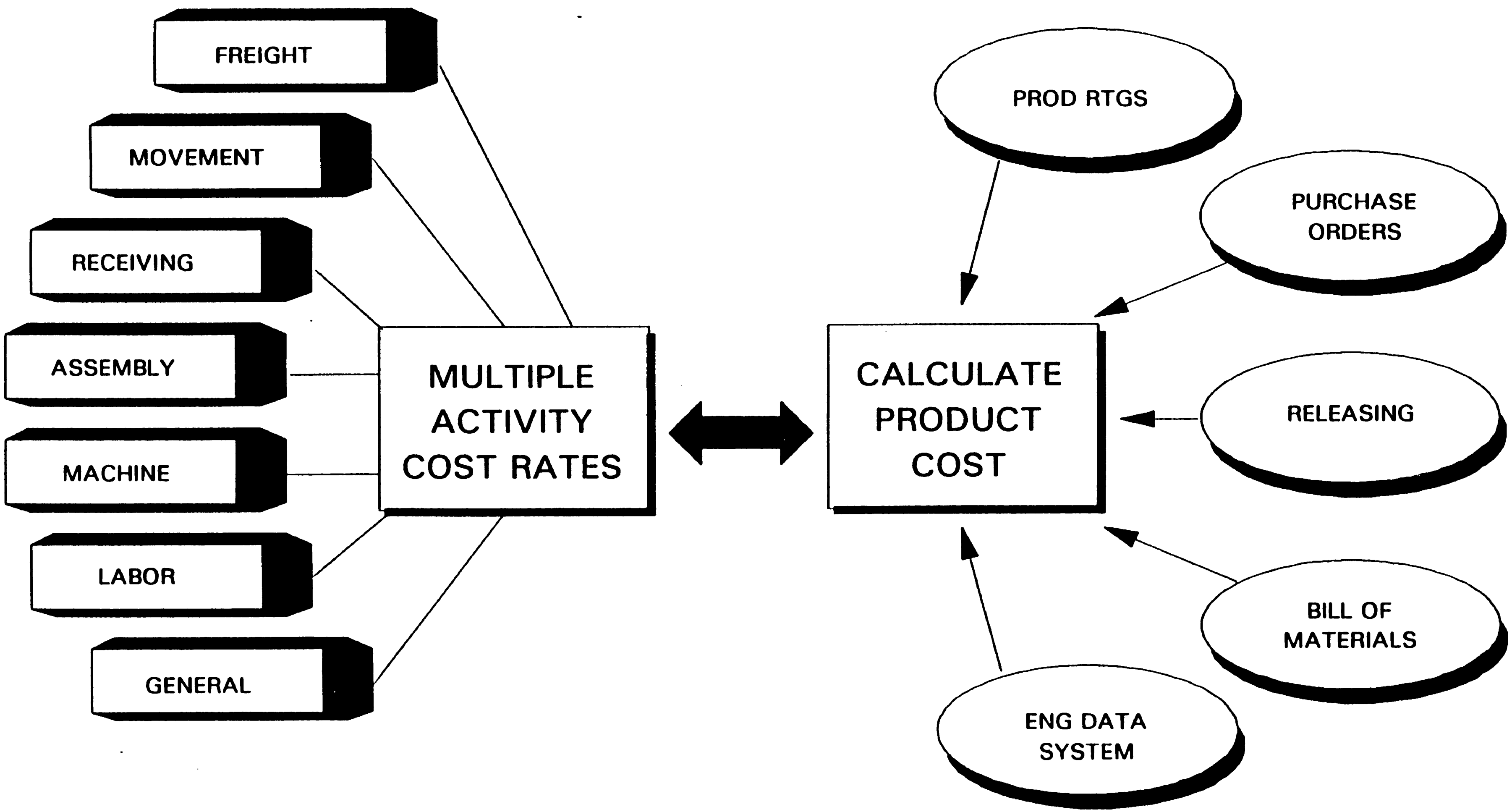

FIGURE 12

323 20

Calculating A Current Cost

Labor and Machine Costs

Part No. 1A1	Oper. No.	Mach. No.	Hours/ Piece	X	Rate	=	Operation Cost
Variable Labor	10	M3880	0.056		$43.085		$2.413
Variable Machine			0.050		26.221		1.311
Period Machine			0.056		79.415		4.447
Variable Labor	20	M6510	0.084		38.298		3.217
Variable Machine			0.040		23.307		0.932
Period Machine			0.084		70.591		5.930
Totals							
Variable Labor							$5.630
Variable Machine							2.243
Period Machine							10.377

Lot Size = 50 Pieces

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FIGURE 13

Calculating A Current Cost

Direct Material	Cost Per Pound	X	Rough Weight/ Piece	=	Direct Material Cost
0312-126-855 Bar	$0.160		20.0		$3.200

Direct material used is indicated on the production routing

Logistics	Rate	X	Rough Weight/	=	Logistics Cost
Freight	0.02454		20.0		$0.491
Variable Receiving & Storage	0.00386		20.0		0.077
Period Receiving & Storage	0.05443		20.0		1.089
Variable Material Movement	0.00416		80.0 *		0.333
Period Material Movement	0.00205		80.0 *		0.164

** Rough weight times number of moves (i.e. number of operations plus two)*
(coded for cells or conveyors)

General Overhead	Rate	X	Mfg. Cost	=	General Overhead Cost
General Overhead	0.11750		$23.604		$2.773

Adding the general overhead cost to the manufacturing cost provides the normal plant cost

FIGURE 14

323-7

Calculating A Current Cost

Cost Summary Sheet

Part No. 1A1	
Variable Costs	
Direct Material	
Labor	5.630
Machine	2.243
Logistics	
Freight	
Receiving & Storage	
Material Movement	
Total Variable Costs	
Period Costs	
Machine	10.377
Logistics	
Receiving & Storage	
Material Movement	
Total Period Costs	
Manufacturing Cost	
General Overhead	
Normal Plant Cost	

323-8

FIGURE 15

Calculating A Current Cost

Cost Summary Sheet

Part No. 1A1			
Variable Costs			
Direct Material	$3.200		
Labor	5.630		
Machine	2.243		
Logistics			
Freight	0.491		
Receiving & Storage	0.077		
Material Movement	0.333		
Total Variable Costs		$11.974	
Period Costs			
Machine	10.377		
Logistics			
Receiving & Storage	1.089		
Material Movement	0.164		
Total Period Costs		11.630	
Manufacturing Cost			$23.604
General Overhead			
Normal Plant Cost			

FIGURE 16

The CE or IPPD approach is being used to develop many military prototype aircraft and aircraft components. The PEPs define the IPPD product breakdown, which is mutually agreeable to both Boeing and the DOD customer. Boeing has learned that the selection of the product breakdown drives contract work breakdown structure (CWBS). Even though the CWBS form is defined by MIL STD 881A, the custom version of the CWBS accepted for these contracts fits Boeing's requirements in defining the IPTs needed to match its product and process characteristics and their build strategy.

COST ESTIMATING AND CONTROL

Cost estimating for Boeing Space & Defense is adapting to new CE and IPPD approaches. This function is also dealing with the reality that many of the components of the vehicle and processes to build the products have no production history. However, the DOD customer still requires supported cost estimates of both prototype and full production product proposals. Boeing Commercial Aircraft has had to address similar issues for the recent 777 program, but has had to support these estimates only internally for management review.

Boeing is using standardized processes as the basis for estimates in both commercial and defense businesses. Its approach to using standardized processes is to validate process performance (usually in terms of cost, schedule, resources, and quality), and describe the performance in terms of suitable metrics for a given product and product throughput. The validated processes can then be used as baseline references for new or modified products and processes. Suitable projection or modeling techniques are employed to account for the differences anticipated between a reference process and a new process. Each use of the new process is carefully monitored and documented to allow validation of the new process as quickly as possible.

The level of process documentation and review appears to be higher in the Space & Defense area than in Commercial Aircraft due to the significant differences in the number of major changes in vehicle design relating to composite materials, control systems, etc., for which Boeing has no production history other than product development prototype work. In Commercial Aircraft, product and process differences are not so great and there is a great deal of production volume to use in process validation.

For all these reasons, cost estimating and control is process oriented. Cost estimates are not considered valid unless the estimates are based on controllable processes. Customer confidence in cost proposals is built up through close coordination of process understanding and methods used to develop a modified process from a reference process.

Cost control methods used in Space & Defense are normal DOD program labor and material controls due to the stage of the product procurement process (currently in prototype development). In Commercial Aircraft, the Space & Defense personnel believe that cost is measured to budget and is controlled by the volume of similar units through a particular process in a time period. While this information could not be confirmed by direct questions, it seems that this approach is similar to Caterpillar and Trane for volume production. Boeing management indicated that employee involvement in process, and, therefore, cost control, is an imperative for success. Also, they stated that labor charging based cost control does not insure effective cost control if the process is not in control, and that processes that are in control can have effective cost control without detailed labor charging systems.

5. FINDINGS

5.1. USE OF ACTIVITY BASED COSTING

There is significant use of activity based costing approaches in nonmarine manufacturing. This use is directly correlated with enterprises engaged in competitive product development and distribution. The major drivers for use of activity based costing approaches include:

- variation in product type and/or production volume,
- high levels of capitalization and mechanization,
- high degree of product and interim product sales or out-sourcing,
- major cost improvement initiatives, and
- management sensitivity to need for continuous product and process improvement.

The major tenet of activity based costing approaches is the use of accurately allocated cost to drive effective decision making in both product and process-termed managerial accounting. Cost information is developed for this purpose from source data available throughout the enterprise's accounting system and presented according to "rules" that the enterprise has rationalized to fit its internal decision-making needs. Financial and operational cost information are developed from the same source data through appropriate "rules" governing their use. These two uses require different types of "rules," which are not interchangeable and lead to different information presentations.

An example of activity based costing, used in the manner described, is Caterpillar's data and rules for managerial accounting. Its current use of this method directly relates to the company's need to lower product prices while maintaining market share and profit margin.

5.2. USE OF IPPD APPROACHES FOR INNOVATIVE COST PROPOSALS

Both Caterpillar and Boeing have adopted IPPD or CE. Their product development efforts, therefore, require access to accurate cost information to support product design and production process issues and decisions. Caterpillar's cost management information system directly supports IPPD and CE requirements. Caterpillar's cost management information system also directly supports development of pricing proposals for commercial and federal sales. Boeing Space & Defense is developing process-based cost estimating techniques, which can be adapted to new product and process development. Boeing is working to assure that their DOD customers are aware of, and concur with, the approaches used to validate new product and process estimates.

One specific example of a comprehensive IPPD cost estimating tool is the Boeing composite part model, which ties process information to the computer design model in CATIA using an Oracle relational database. A prototype of the approach was developed on the Joint Advanced Strike Technology (JAST) program. Actual implementation of the estimating model for composites is a Boeing proprietary effort of about 20 man-years. The result will be a tool for both IPPD and cost proposal use.

5.3. BUSINESS APPROACH, COMPETITION AND CULTURE

All three companies considered in this task have adapted to remain competitive in the face of significant changes to their business environments. In all three cases, the common theme has been top-down led change, which is systemic rather than functionally oriented. Once the systemic approach or strategy was defined or created, needed change could be sought in functional areas such as cost estimating and control. Change included elimination of practices that had worked previously, but that presented barriers or impediments to reaching the new goals that the companies had determined were required for business success.

The driving force in changing the technology was rooted in the need for the business to be successful. Technology change usually has been accompanied or even preceded by cultural change, which has been led by dedicated executive managers convinced of the need to improve and redefine their approaches. Both Caterpillar and Boeing managers interviewed described this environment as driven by the pain of having to face the future as a significantly smaller and less viable (or nonviable) company if the program was not successfully adopted.

5.4. PARALLELS TO SHIPBUILDING BUSINESS

The size and complexity of products delivered by the companies studied in this task are not equal to a large ship, but have a similar scale. The characteristics of desired change (i.e., shorter product cycle times, lower total cost, higher customer satisfaction, etc.) are the recognized requirements for changes to bring U.S. shipbuilding into effective competition with foreign shipbuilders, and to necessary levels of performance for defense products.

Specific parallels for effective cost management and cost control between the companies studied and the observed effective shipbuilding approaches include the following:

- Increased degree of production automation leads to direct labor no longer being an effective measure or allocator of indirect cost.
- Increased degree of automation makes capital and facilities cost more important in each product and process decision.
- Product breakdown for manufacturing is identified during product design and each component is linked explicitly for manufacture using specific processes.
- Reduction in company organizational complexity (i.e. number of management levels, number of support functions, etc.) pushes cost control responsibility lower in the organization and closer to the individual process owner.
- Production capacity is governed by process capacity and not by total available labor.
- Direct production labor is a minor component of overall product cost.
- Indirect cost is a major cost and price driver and must be controlled and improved as much as material and direct labor.

6. RECOMMENDATIONS

The findings of this task indicate that there are significant systemic differences between these company's and U.S. shipbuilder's business plans and strategies relative to cost estimating and control. The use of cost estimating and cost control techniques observed through this task, while interesting, may be of no value to either the U.S. Navy or to U.S. shipbuilders as long as current business strategies within these two groups emphasize direct labor as the controlling resource and cost driver in ship acquisitions. The largely commercial view central to these companys' operating approaches indicates that they view product demand as a controllable portion of their business, which can be managed for both growth and product direction.

The strategies for implementation of cost estimating and cost control appear to be directly tied to continuous improvement in product cycle time, product cost, and product performance as viewed by the customer. The strategies for implementation of cost estimating and cost control are part of an environment established to meet business objectives and are not objectives unto themselves.

The following recommendations are made recognizing the state of U.S. shipbuilding business strategy. These recommendations assume that there could be value in further studying nonmarine industry approaches to cost estimating and cost control.

6.1. DEVELOPMENT OF ABC EXAMPLE FOR A NOTIONAL SHIPYARD

Apply the approaches observed at Caterpillar and documented by Trane to the Notional Shipyard developed by UMTRI-MSD in Phase 1 Midterm Sealift Research. The goal would be to provide an example of the operational differences between a shipyard operated under traditional cost allocation principals and one operated under ABC principals. The effect on overall price of a vessel could be determined using typical reported cost factor ranges available to NAVSEA 017 and a typical chart of accounts for a U.S. shipyard. The approach could be further validated using a receptive foreign shipbuilder as a project participant.

6.2. DEVELOPMENT OF COST ESTIMATES INVOLVING PROCESS CHANGE

Apply the approaches in cost estimating observed at Boeing Defense & Space to processes significantly modified from traditional shipbuilding practice. The goal would be to transfer, perhaps under nondisclosure agreement, the proprietary approaches being developed and implemented by Boeing Space & Defense to meet DOD customer requirements for validated cost estimates for new products and processes. U.S. shipbuilders and U.S. Navy cost estimators have been reluctant to move very far away from cost history in making cost estimates. Detailed understanding of Boeing's approach could provide new methods to quantify the risk of process improvement and provide effective estimates prior to process and product changes.

6.3 IDENTIFICATION OF IMPEDIMENTS TO ABC ADOPTION

There are many policies and statutes invoked in U.S. Navy program acquisition. These policies and statutes are based on different business objectives than on the policies that drive commercial companies. A recent study of U.S. Navy Laboratory Infrastructure Capabilities, performed by a joint government and nongovernment team, considered this topic for possible improvement of the long-term objective of the Naval Surface Warfare Center-Carderock Division. The study provided a more commercial business approach for the laboratories, and identified the policies and statutes that represented impediments to achieving the desired commercial business approach.

The goal of this work would be to specifically study impediments to effective implementation of ABC based on standard and validated processes. The study could use the results of 6.1 above to provide examples of alternative approaches for cost control and the data needed to support such an approach.

Appendix A

List of Foundation Reference Material for
Activity Based Costing

and

Keyword Literature Searches of Kresge Business School Library
and
Navy's Best Manufacturing Practices

List of Some Core References

Cooper, "The Two-Stage Procedure of Cost Accounting: Part One," *Journal of Cost Management*, Summer 1987.

Cooper, "When Should You Use Machine-Hour Costing?" *Journal of Cost Management*, Spring 1988.

Cooper, "The Rise of Activity-Based Costing - Part One: What Is an Activity-Based Cost System?" *Journal of Cost Management*, Summer 1988.

Cooper, "The Rise of Activity-Based Costing - Part Two: When Do I Need an Activity-Based Cost System?" *Journal of Cost Management*, Fall 1988.

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.

Cooper, "Implementing an Activity-Based Cost System," *Journal of Cost Management*, Spring 1990.

Cooper & Kaplan, The Design of Cost Management Systems, Prentice-Hall, Inc., 1991.

Hamel & Prahalad, "Strategic Intent," *Harvard Business Review*, May-June 1989. (Komatsu's attack on Caterpillar)

Kaplan, "Yesterday's Accounting Undermines Production," *Harvard Business Review*, July-August 1984.

Kaplan, "Flexible Budgeting in an Activity-Based Costing Framework," *Accounting Horizons*, Vol.8 No.2, June 1994.

Miller & Vollmann, "The Hidden Factory," *Harvard Business Review*, September-October 1985.

ess No: 00912911 ProQuest ABI/INFORM (R) Global Edition
le: Estimating and Costing for the Metal Manufacturing Industries
Authors: Mittal, Ravi O
Journal: Engineering Economist (EEC) ISSN: 0013-791X
Vol: 39 Iss: 1 Date: Fall 1994 p: 108-110
Subjects: Metalworking industry; Book reviews; Cost estimates; Estimating techniques
Codes: 9000 (Short Article); 3100 (Capital & debt management); 8660 (Metals & metalworking industries)

Abstract: A review of the book Estimating and Costing for the Metal Manfacturing Industries by Robert C. Creese, M. Adithan, and B. S. Pabla.

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Codes: 9000 (Short Article); 3100 (Capital & debt management); 8660 (Metals & metalworking industries)

Abstract: A review of the book Estimating and Costing for the Metal Manfacturing Industries by Robert C. Creese, M. Adithan, and B. S. Pabla.

cess No: 00907471 ProQuest ABI/INFORM (R) Global Edition
le: How 'the best' companies use MRP and just-in-time for successful manufacturing
Authors: Spencer, Michael S
Journal: Hospital Materiel Management Quarterly (HMM)
ISSN: 0192-2262
Vol: 16 Iss: 1 Date: Aug 1994 p: 27-34
Illus: References
Companies: Motorola Inc DUNS: 00-132-5463 Ticker: MOT
Trane Co
Verbatim Corp DUNS: 05-051-5022
Blue Bird Body Co DUNS: 00-327-9627
John Deere Waterloo Works

Subjects: Manycompanies; Case studies; Manufacturers; Just in time; Material requirements planning
Geo Places: US
Codes: 9190 (United States); 5330 (Inventory management); 9110 (Company specific); 8600 (Manufacturing industries)

Abstract: A study of production planning and control methods used in 6 leading companies found that a blending strategy is more effective than reliance on a single system. The blending of just-in-time (JIT) methods and materiel requirements planning (MRP) allowed companies to choose methods that best fit their needs. The 6 companies examined were: 1. the Motorola plant in Huntsville, Alabama, 2. the Carrier-Transicord plant in Athens, Georgia, 3. the John Deere plant in Waterloo, Iowa, 4. the Trane Inc. plant in Macon, Georgia, 5. the Blue Bird Bus Co. plant in Fort Valley, Georgia, and 6. the Verbatim Disk Inc. plant in Charlotte, North Carolina. The study of the companies was based on on-site interviews with top management in order to identify critical relationships and patterns between their use of MRP and JIT. For all 6 companies, there was no indication that JIT ever operated without MRP.

Access No: 00713534 ProQuest ABI/INFORM (R) Global Edition
Title: How to compete in your industry
Authors: Lockamy, Archie III
Journal: Production & Inventory Management Journal (PIM)
ISSN: 0897-8336
Vol: 34 Iss: 1 Date: First Quarter 1993 p: 1-5
Illus: Charts; References
Companies: Trane Co
Subjects: Appliance industry; Case studies; Performance evaluation; Quality control; Strategic planning; Corporate objectives; Organizational behavior
Geo Places: US
Codes: 9190 (United States); 8650 (Electrical, electronics, instrumentation industries); 9110 (Company specific); 5320 (Quality control); 2310 (Planning); 2500 (Organizational behavior)

Abstract: Agreement between organizational levels on a firm's strategic objectives is a prerequisite for manufacturing companies to successfully compete internationally. A multifunctional assessment approach is the most effective means of ensuring progress towards achieving established performance standards. To maintain effectiveness, the performance-measurement systems criteria, measures, and standards established on current strategic objectives must be dynamic and change with the internal and external environmental conditions of the business. Finally, firms must develop organizational cultures conducive to the development of interorganizational and multifunctional consistency on the strategic objectives. A case study of the self-contained systems of the Trane Corp. is used to illustrate the various strategic objectives on which manufacturing firms may compete, and to explore mechanisms of achieving consistency within a firm.

Access No: 00867384 ProQuest ABI/INFORM (R) Global Edition
Title: McDermott joins with rival
Authors: Anonymous
Journal: ENR (ENR) ISSN: 0891-9526
Vol: 232 Iss: 25 Date: Jun 20, 1994 p: 13-14
Illus: Charts
Companies: McDermott International Inc DUNS: 04-775-8503
Ticker:MDR
Offshore Pipelines Inc
Subjects: Construction companies; Acquisitions & mergers; Corporate profits
Geo Places: US
Codes: 9190 (United States); 9000 (Short Article); 8370 (Construction & related industries); 2330 (Acquisitions & mergers)

Abstract: McDermott International Inc.'s plan to merge its marine construction businesses with rival Offshore Pipelines Inc. may boost McDermott's financial prospects in what would otherwise be a difficult business environment, according to analyst Carey Callaghan of Lehman Brothers.

Access No: 00835384 ProQuest ABI/INFORM (R) Global Edition
Title: The top 500 design firms: Economic recovery taking hold but too late for 1993 billings
Authors: Tulacz, Gary J
Journal: ENR (ENR) ISSN: 0891-9526
Vol: 232 Iss: 14 Date: Apr 4, 1994 p: 34-39
Illus: Charts; Graphs
Subjects: Manycompanies; Ratings & rankings; Economic impact; Design engineering; Construction companies; Statistical data; Billings; Engineering firms
Geo Places: US
Codes: 9190 (United States); 8370 (Construction & related industries); 1110 (Economic conditions & forecasts); 9140 (Statistical data); 3200 (Credit management)

Abstract: The US economy is on the upswing and the construction market gradually is pulling out of the recession. Executives of leading US design firms generally are happy with business in 1993 and are optimistic about the near future. However, ENR's top 500 US design firms as a group had \$31.74 billion in design billings in 1993, a decline of almost 6.5% over \$33.9 billion in 1992. A factor in the decline of design billings for ENR's top 500 is the increasing owner demand for construction management at-risk and design-build

delivery systems. Top 500 design billings include traditional engineering and architectural design, studies, plans, inspection, and testing related to project construction. As in past years, ENR's top 500 design firms were most active in the petroleum/industrial process market, which accounted for $8.5 billion (27%) of their total fees. Hazardous waste work was once again the 2nd leading source of billings at $5.77 billion (18%), followed by transportation at $4.17 billion (13%), and general building at $3.96 billion (13%).

Access No: 00827590 ProQuest ABI/INFORM (R) Global Edition
Title: Contracts let for southern U.S. pipeline project
Authors: Anonymous
Journal: Oil & Gas Journal (OGJ) ISSN: 0030-1388
Vol: 92 Iss: 9 Date: Feb 28, 1994 p: 30
Companies: Florida Gas Transmission Co DUNS: 00-692-4518
Subjects: Construction contracts; Construction companies; Natural gas industry; Manycompanies; Pipelines
Geo Places: US
Codes: 9190 (United States); 9000 (Short Article); 8510 (Petroleum industry); 8370 (Construction & related industries)

·tract: Florida Gas Transmission Co. (FGT) has chosen contractors for its Phase III interstate pipeline expansion and let contracts worth a combined $320 million. Companies chosen to lay FGT's Phase III pipelines are: 1. H. C. Price Co., 2. Murphy Bros. Inc., 3. Latex Construction Co., 4. W. H. C. Inc., 5. Ranger Plant Construction Co. Inc., 6. Bluewater Constructors Inc., and 7. Piute Contractors Inc.

Access No: 00831151 ProQuest ABI/INFORM (R) Global Edition
Title: The top 10 questions to ask about a major construction project
Authors: Nicolay, John R
Journal: Trustee (TST) ISSN: 0041-3674
Vol: 47 Iss: 2 Date: Feb 1994 p: 16, 21
Subjects: Hospitals; Boards of trustees; Strategic planning; Building construction; Project management; Recommendations; Construction companies; Selection
Geo Places: US
Codes: 8320 (Health care industry); 2110 (Boards of directors); 2310 (Planning); 5100 (Facilities management); 9190 (United States)

Abstract: Drawing from experience on nearly 600 health care construction projects over more than 75 years, a list of the top 10

questions for trustees at health care facilities that are undertaking construction includes: 1. What criteria will be used to select the construction manager? 2. What do the construction manager's references say? 3. Are the construction manager and the architect-engineer going to be hired concurrently? 4. Does the hospital have someone on staff with experience on construction programs of similar size and complexity? 5. What is the financial history and strength of the construction firm under consideration? 6. How will the construction manager shield the hospital from the risks of construction? 7. How compatible is the culture of the construction management firm to that of the hospital? 8. What process will the construction manager put in place to establish a viable, effective partnership among the hospital, the architect-engineer, consultants, the construction manager, and trade contractors?

Access No: 00809714 ProQuest ABI/INFORM (R) Global Edition
Title: Baldwin Bridge: Breaking new ground and beating construction schedules
Authors: Robertson, Kathy
Journal: ENR (ENR) ISSN: 0891-9526
Date: Jan 24, 1994 p: 82-88
panies: Perini Building Co Inc
jects: Construction companies; Project management; Problem solving; Public works; Bridges; Case studies
Geo Places: US
Codes: 8370 (Construction & related industries); 9190 (United States); 9110 (Company specific)

Abstract: Perini Corp.'s solution to the challenges presented by the construction of the new Baldwin Bridge in Connecticut not only won the company the contract, but brought the project in well before the March 1994 completion date required in the Connecticut Department of Transportation specifications. The solution proposed by Perini and its joint venture partners, PCL Construction Group and O & G Industries, was to use an overhead gantry to place the precast bridge segments rather than work from the water with more conventional beam and winch construction. While use of a gantry is not unique to either building bridges or to segmental construction, Perini was the only company to translate that construction technology into a proposal for the Baldwin Bridge.

Access No: 00910479 ProQuest ABI/INFORM (R) Global Edition
Title: A preemptive strike on costs
Authors: Grogan, Tim
Journal: ENR (ENR) ISSN: 0891-9526

Vol: 233 Iss: 13 Date: Sep 26, 1994 p: 43
Illus: Graphs

Subjects: Construction industry; Cost engineering; Strategic planning; Suggestions

Places: US

Codes: 9190 (United States); 8370 (Construction & related industries); 2310 (Planning)

Abstract: Total Cost Management (TCM) preaches the use of cost engineering tools and methodology during the entire life cycle of a project, especially at its conception when future cost management crises can be most easily minimized. Traditionally, the role of the cost engineer was relegated to improving costs and schedule performance on a construction project. TCM seeks to expand this role by integrating cost engineering with all aspects of a project, including planning, estimating, and financial analysis. In order to manage cost before it occurs, TCM calls for 6 strategies: 1. life-cycle perspective of management situations, 2. familiarity with factors that affect cost, 3. ongoing awareness of the cost implications of events as they occur, 4. working knowledge of the tools available to manage cost, 5. timely action, and 6. an overall plan to implement life-cycle cost management.

Access No: 00874062 ProQuest ABI/INFORM (R) Global Edition

Title: Construction Specifications Institute's Masterformat: A tool for total cost management

Authors: Giammalvo, Paul D

Journal: Cost Engineering (ACO) ISSN: 0274-9696
Vol: 36 Iss: 7 Date: Jul 1994 p: 11-17
Illus: Charts; References

Subjects: Cost engineering; Systems integration; Standards; Organization development; Estimating techniques; Applications

Geo Places: US

Codes: 9190 (United States); 3100 (Capital & debt management); 5240 (Software & systems)

Abstract: With the proliferation of PC/Macintosh-based estimating, scheduling, and accounting software packages, there is a growing trend toward the integration of these packages to form a continuous feedback loop of information, from initial estimate to schedule of values to accounting, and finally back to updating or fine-tuning the estimating data. The management of this information is central to the vision of total cost management. In order to integrate the estimating, scheduling, and cost accounting functions, Construction Specifications Institute (CSI) Masterformat numbering system should be adopted. Using CSI coding as the basis for this system offers advantages, including: 1. It is recognized and accepted primarily in North America, but is gaining international acceptance. 2. It is the foundation of the project documents upon which bids are based. 3. Most of the major estimating databases are directly set up in, or at least cross-reference, CSI coding.

Access No: 00869014 ProQuest ABI/INFORM (R) Global Edition
Title: Building contractor estimating: British style
Authors: Law, Christopher
Journal: Cost Engineering (ACO) ISSN: 0274-9696
Vol: 36 Iss: 6 Date: Jun 1994 p: 23-28
Illus: Charts; Equations
Subjects: Cost engineering; Estimating techniques; Methods; Comparative analysis; Project management; Documentation; Construction contracts
Geo Places: UK
Codes: 9175 (Western Europe); 3100 (Capital & debt management); 8370 (Construction & related industries)

Abstract: Most of the estimating effort expended in the UK is geared toward the pricing of bills of quantities (BQ), which are detailed and accurate documents that list every item of work in a standardized format, with quantities measured using strictly adhered to measurement rules. They provide a vast data bank of information for every project. An overview is presented describing a BQ. It is suggested that the BQ method of preparing contract documentation warrants a serious examination by AACE International and associated professional organizations as an alternative to the generally ccepted norm of issuing a set of drawings and detailed specifications to arrive at a bid price.

Access No: 00916547 ProQuest ABI/INFORM (R) Global Edition
Title: Business modelling techniques
Authors: Corbitt, Terry
Journal: Management Services (MNS) ISSN: 0307-6768
Vol: 38 Iss: 5 Date: May 1994 p: 22-23
Subjects: Project management; Cost engineering; Decision making models; Software packages
Geo Places: UK
Codes: 9175 (Western Europe); 5240 (Software & systems); 2310 (Planning)

X other

Abstract: Developments in computer technology have made available hardware and programs that can assist and improve project management. Among the advantages of project management are better visibility of efforts and results, shorter project completion times, better customer relations, lower project costs, and improved coordination nd control of workers' efforts. For computerized project control to be successful, the following areas must be addressed: planning, monitoring, control, cost information, and communication. Computer-based project management packages are highly structured and usually require users to adapt their working practices to the

structure of the software. Among the features that should be available are ease of use, resource leveling, sort and report, and the ability to handle what if scenarios.

Access No: 00794944 ProQuest ABI/INFORM (R) Global Edition
Title: Conceptual and early design estimating techniques for building heating, ventilation, and air conditioning systems
Authors: Reynolds, Frederick M
Journal: Cost Engineering (ACO) ISSN: 0274-9696
Vol: 35 Iss: 11 Date: Nov 1993 p: 25-36
Illus: Charts; Graphs; Equations; References
Subjects: Cost engineering; Heating; Air conditioning; Estimating techniques; Guidelines; Project management; Building construction
Geo Places: US
Codes: 9190 (United States); 3100 (Capital & debt management); 8370 (Construction & related industries); 9150 (Guidelines)

Abstract: With the current economic conditions facing the US and most of the world, construction cost data is being demanded even more uickly, and even though estimators are given less design ınformation, greater accuracy than ever before is expected. Cost overruns are no longer acceptable or affordable, since these industries are being forced into a new era of accountability. Ultimately, this transition will result in more precise competition, better products and productivity, and hopefully, a cleaner environment. It is therefore critical to develop methods that enhance the accuracy of early construction costs so that they can stand on their own throughout the design process. Guidelines are presented that may help to remove some of the obstacles that confront all mechanical estimators.

Access No: 00636354 ProQuest ABI/INFORM (R) Global Edition
Title: Airport Maintenance Costs
Authors: Varela, Leopoldo
Journal: American Association of Cost Engineers Transactions (AEE)
ISSN: 0065-7158
Vol: 2 Date: 1992 p: M.1.1-M.1.5
Illus: Charts; References
›anies: Airports & Auxiliary Services-Mexico
Subjects: Airports; Maintenance costs; Cost engineering; Building construction; Case studies; Transportation terminals
Geo Places: Mexico
Codes: 8350 (Transportation industry); 3100 (Capital & debt

management); 9173 (Latin America); 9110 (Company specific)

Abstract: In Mexico, the Construction and Conservation Subbureau of Airports and Auxiliary Services (ASA) requires a system that permits planning and budgeting the conservation of buildings, facilities, and paved areas of its large disseminated airport network. ASA manages a total of 51 airports that had 35 million passengers and one million aircraft operations during 1989. Three types of evaluation missions to airports have been made - exhaustive, quick inspection visits, and monitoring. To determine the maintenance costs of the different elements and airports of the network, an investigation into various sources inside the subbureau was made. Some sources of documents consulted were construction bids, mission reports from the airports, and historical costs. Four methods were elaborated for the calculation of the conservation expenses for each airport and for the entire network: 1. the method of the survey, 2. physical dimensions (parameters), 3. correlation with operations, and 4. conservation managers consensus.

Access No: 00905780 ProQuest ABI/INFORM (R) Global Edition
Title: Project management using intelligent 3-D CAD
Authors: Dharwadkar, Parmanand V; Song, Bin; Gatton, Thomas M
Journal: American Association of Cost Engineers Transactions (AEE)
ISSN: 0065-7158
Date: 1994 p: CA2.1-CA2.6 Illus: Charts; References
Subjects: CAD; Expert systems; Object oriented programming; Construction; Cost estimates; Project management; Systems integration; Models
Geo Places: US
Codes: 9190 (United States); 8370 (Construction & related industries); 5240 (Software & systems); 9130 (Experimental/theoretical)

X other

Abstract: There is a clear need for an intelligent computer model to bridge the gap between various CAD, cost estimating, and scheduling applications. Using object-oriented relational models, integration of these stand-alone software programs is possible. Suggestions have been made for various types of intelligent CAD models and some systems have been developed to demonstrate the advantages of such types of systems. The existing systems such as PLANEX and OARPLAN have used CAD models to integrate drawing and scheduling information. An overview is presented of major research projects that have been developed pertaining to construction planning with the assistance of knowledge-based systems. In addition, a knowledge-based object-oriented 3-D CAD project model is described. This model may be used in a computer integrated construction system to assist project managers to plan and visualize the construction process.

Access No: 00905817 ProQuest ABI/INFORM (R) Global Edition
"itle: A parametric cost estimating system
.hors: Hollmann, John K
Journal: American Association of Cost Engineers Transactions (AEE)
ISSN: 0065-7158
Date: 1994 p: EST4.1-EST4.7 Illus: Charts; References
Companies: Eastman Kodak Co DUNS: 00-220-6183 Ticker: EK
Subjects: Construction industry; Building construction; Cost estimates; Estimating techniques; Data bases; Systems development; Case studies
Geo Places: US
Codes: 9190 (United States); 8370 (Construction & related industries); 3100 (Capital & debt management); 5240 (Software & systems); 9110 (Company specific)

Abstract: In pursuit of continuous improvement, cost estimators continue searching for more effective means to prepare building conceptual cost estimates for project budgets. Owners are asking questions about ranges, options, risks, and trade-offs - complex questions that the cost estimator is expected to answer quickly and for little expense. Parametric estimating, which includes a broad class of methods such as capacity factoring, equipment factoring, and cost modeling, has much to offer the owner in this regard. Eastman Kodak's capital estimating department has developed a cost estimating system for buildings that can answer those types of questions quickly with a tested accuracy range of -5% to 15% for total buildings and -15% to 30% for any building system. By combining elements of tandard square foot unit estimating with parametric techniques, the system can be used to quickly estimate the cost of most common buildings, yet it only has about 100 cost records in its database and resides on a small spreadsheet.

Access No: 00728864 ProQuest ABI/INFORM (R) Global Edition
Title: Intelligent cost/schedule estimation for modular construction
Authors: Murtaza, Mirza B; Fisher, Deborah J; Musgrove, John G
Journal: Cost Engineering (ACO) ISSN: 0274-9696
Vol: 35 Iss: 6 Date: Jun 1993 p: 19-25
Illus: Charts; References
Subjects: Modular; Construction; Project management; Cost estimates; Estimating techniques; Scheduling; Expert systems; Economic models; Economic impact
Codes: 8370 (Construction & related industries); 5240 (Software & systems); 1130 (Economic theory)

Abstract: Construction owners and engineers are often faced with decisions involving the choice between modular and traditional approaches to project design and construction. In addition to various qualitative factors that determine the feasibility of a modular approach, this decision is based on the economic impact of modularization. The technology of modularization, as well as the

Access No: 00775596 ProQuest ABI/INFORM (R) Global Edition
Title: Piping cost estimating expert system
Authors: Lopez, Pedro; Balderrama, Ana Maria
Journal: American Association of Cost Engineers Transactions (AEE)
ISSN: 0065-7158
Date: 1993 p: L.3.1-L.3.12 Illus: Charts; References
Subjects: Cost estimates; Data base management systems; Software packages; Construction costs; Project evaluation; Cost engineering
Geo Places: US
Codes: 5240 (Software & systems); 3100 (Capital & debt management); 9190 (United States); 8370 (Construction & related industries)

Abstract: One of the major difficulties in estimating piping costs is to evaluate the complexity of labor in prefabrication and construction activities. An expert computerized system (EXPERTUB) is presented, which through its detailed estimate module calculates all the accessories and pipe material costs, calculates the labor manhours for prefabrication, construction, and other related activities, and the total cost using unitary rate by manhours methodology, and through its parametric module calculates all the major parameters of labor and cost based on actual detailed calculations and calculates conceptual cost estimates of labor and material. The purpose of the EXPERTUB system, the system description, the input data, and the program output are examined. A detailed estimate module prototype of the EXPERTUB program has been developed in Lotus in order to test the different modules, comparing with actual detailed estimates. The next phase of the system development is to program the modules in DBASE.

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Access No: 00650687 ProQuest ABI/INFORM (R) Global Edition
Title: A Painless Approach to Construction Cost Estimating
Authors: Nason, Randall R
Journal: Security Management (SEM) ISSN: 0145-9406
Date: Nov 1992 p: 18A-20A Illus: Charts
Subjects: Security systems; Construction costs; Cost estimates; Goals; Guidelines
Codes: 5140 (Security management); 8370 (Construction & related industries); 9150 (Guidelines)

Abstract: A security professional must have a broad knowledge of system engineering, the design profession, and the construction industry to be proficient in preparing a construction cost estimate (CCE). A CCE can smooth the way for maintaining adequate funding by

providing a basis for project evaluation, project planning, and bid evaluation. Three basic components must be considered in developing a CCE: 1. labor, 2. materials, and 3. equipment. Additional project costs and costs of implementation are also factors. Preparation of the CCE can be broken down into the following steps: 1. Identify subtasks. 2. Establish a bill of materials. 3. Establish material prices. 4. Formulate work crew productivity. 5. Formulate required equipment rates. 6. Combine the cost estimate with the bill of materials.

Access No: 00628957 ProQuest ABI/INFORM (R) Global Edition
Title: Preliminary Estimating Models for Infrastructure Projects
Authors: Sanders, Steve R; Maxwell, Robert R; Glagola, Charles R
Journal: Cost Engineering (ACO) ISSN: 0274-9696
Vol: 34 Iss: 8 Date: Aug 1992 p: 7-13
Illus: Charts; Equations
Companies: Alabama Highway Department
Subjects: Studies; Heavy construction; Mathematical models; Regression analysis; Cost engineering; Cost estimates; Bids
Geo Places: US; Alabama
Codes: 9130 (Experimental/theoretical); 9190 (United States); 8370 (Construction & related industries)

Abstract: A methodology is presented for creating preliminary estimating models for heavy construction activities. Bridge widening projects are used as case studies to present the methodology and examine the adequacy of the resulting model. The proposed model is the result of a statistical analysis of past bids received by the Alabama Highway Department for bridge widening projects. It consists of 9 separate simple regression models, each of which predicts the cost of one of the selected work items, including old bridge removal, concrete pavement, steel reinforcement, and superstructure. The best available testing method was to use the model to estimate past projects and compare the results to the bids received. Each model was created using data from all bidders. However, the intent of the study is to predict the lowest bidder.

Access No: 00588088 ProQuest ABI/INFORM (R) Global Edition
Title: Estimators' Tasks and Computer-Aided Estimating Systems: A Survey of FCEC Member Companies
Authors: Oteifa, Sherif; Baldwin, Andrew
Journal: Construction Management & Economics (CMG) ISSN: 0144-6193
Vol: 9 Iss: 6 Date: Dec 1991 p: 543-552
Illus: Charts; Graphs; References
Subjects: Construction companies; Cost estimates; Surveys; CAE;

Civil engineering; Implications; Statistical data; Comparative analysis

Geo Places: UK

Codes: 5240 (Software & systems); 8370 (Construction & related industries); 9175 (Western Europe); 9140 (Statistical data)

Abstract: A survey of the members of the Federation of Civil Engineering Contractors (FCEC) confirms the importance of estimators' experience and expertise within the estimating and tendering process. Some 56% of the respondents surveyed currently use some form of computer-aided estimating (CAE). The benefits of these systems are limited primarily to the arithmetic functions relating to an estimator's tasks. The use of expert systems would appear to offer a route for improving existing computer-aided estimating systems. If progress in using computers for estimating and tendering for civil engineering works is to be achieved, new generations of computer systems should be designed to accommodate existing CAE structures.

Access No: 00735308 ProQuest ABI/INFORM (R) Global Edition

Title: Simultaneous estimation of cost drivers

Authors: Datar, Srikant M; Kekre, Sunder; Mukhopadhyay, Tridas; Srinivasan, Kannan

Journal: Accounting Review (ACR) ISSN: 0001-4826
Vol: 68 Iss: 3 Date: Jul 1993 p: 602-614
Illus: Charts; Equations; References

Subjects: Cost accounting; Manufacturing; Statistical data; Cost analysis; Simultaneous; Cost estimates

Geo Places: US

Codes: 9190 (United States); 8600 (Manufacturing industries); 4120 (Accounting policies & procedures); 9140 (Statistical data); 3100 (Capital & debt management)

Abstract: Managers frequently choose the amounts to expand in various activities simultaneously rather than sequentially. When managing quality, decisions to invest in different types of prevention activities are made jointly. A study was motivated by field observations at an automobile lamp manufacturing plant. Two observed effects were estimated: 1. the influence of lamp design on the consumption of overhead resources during manufacturing, and 2. the interdependence among supervision, maintenance, and scrap costs. In activity-based costing, simultaneous effects of costs are not estimated. In the study, interdependencies among activities were simultaneously estimated. Instead of supervision hours, maintenance hours, and physical scrap level, product and process design variables were used as cost drivers of supervision, maintenance, and scrap costs. This estimation procedure recognizes that maintenance costs affect supervision costs and vice versa and that both costs are affected by product and process design choices.

,ess No: 00664116 ProQuest ABI/INFORM (R) Global Edition
Title: A sequential block approach to the design of a cost estimation system
Authors: Downs, Kraig A; Trappey, Amy J C
Journal: Computers & Industrial Engineering (CIE) ISSN: 0360-8352
Vol: 23 Iss: 1-4 Date: Nov 1992 p: 423-426
Illus: References
Subjects: Cost engineering; Cost estimates; Manufacturing; Implementations
Codes: 3100 (Capital & debt management); 5240 (Software & systems)

Abstract: A sequential block approach is proposed for the design of a computerized cost estimation system. The system constructs cost estimates by defining each step of the production process as a block for a specific product. The sequence of blocks is then linked as a tree structure to represent the whole production process. The approach allows the user to obtain a cost estimate for each operation and material used and simultaneously to represent the process routing. The design of the system is illustrated using the estimation of the manufacturing cost of a typical plate-fin type automotive evaporator. The advantages of the sequential block approach to cost estimation include the following: 1. flexibility, 2. the ability to have varying degrees of completeness, 3. expansibility, 4. intuitive building of cost models, and 5. a wide)plication base.

Access No: 00595466 ProQuest ABI/INFORM (R) Global Edition
Title: An Integrated Cost Estimating System for Concurrent Engineering Environment * *
Authors: Wong, Julius P; Parsaei, Hamid R; Imam, Ibrahim N; Kamrani, Ali K
Journal: Computers & Industrial Engineering (CIE) ISSN: 0360-8352
Vol: 21 Iss: 1-4 Date: 1991 p: 589-593 Illus: Charts
Subjects: Product design; Manufacturing; Product development; Cost estimates; Estimating techniques; Prototypes; Systems development
Codes: 7500 (Product planning & development); 5240 (Software & systems)

Abstract: Concurrent engineering is the simultaneous design of a product and the processes required to produce it and support it. When implemented, concurrent engineering can help to reduce product 'evelopment cycle time for the introduction of high quality products . low cost. Often, the traditional cost estimating systems are utilized in the concurrent engineering environment. The traditional cost estimating systems are not structured for concurrent engineering. An integrated cost estimating system specifically designed for concurrent engineering (ICESCE) is designed to work in

the concurrent engineering environment and to enhance the power of concurrent engineering. The design of ICESCE consists of 4 modules: a database module, a central processing module, an interface module, and a utility module. The construction of a prototype of ICESCE is being initiated at the University of Louisville. The database management utilities will use relational database techniques and conform to structured query language standards.

Access No: 00748946 ProQuest ABI/INFORM (R) Global Edition
Title: York's hot prospects
Authors: Weinberg, Neil
Journal: Forbes (FBR) ISSN: 0015-6914
Vol: 152 Iss: 4 Date: Aug 16, 1993 p: 138
Companies: York International Corp DUNS: 11-851-6947
Subjects: Air conditioning; Manufacturers; Financial analysis; Stock prices
Geo Places: US
Codes: 8600 (Manufacturing industries); 9190 (United States); 3400 (Investment analysis); 9000 (Short Article)

Abstract: The potential of the stock of $2-billion York International Corp., a manufacturer of large home and commercial air conditioners, is discussed.

Access No: 00640338 ProQuest ABI/INFORM (R) Global Edition
Title: Quest for Quiet Room A/C
Authors: Remich, Norman C., Jr
Journal: Appliance Manufacturer (APL) ISSN: 0003-679X
Vol: 40 Iss: 9 Date: Sep 1992 p: 58, 61
Companies: Frigidaire Co
Carrier Corp DUNS: 00-131-7072
Subjects: Air conditioning; Manufacturers; Product design; Product testing; Noise; Standards; Innovations
Geo Places: US
Codes: 8600 (Manufacturing industries); 7500 (Product planning & development); 9190 (United States)

Abstract: Air conditioner (A/C) manufacturers are designing quiet into room air conditioners, with attention paid to materials, airflow treatment, compressors, and other noise-contributing elements. In addition, appliance makers are using sophisticated testing procedures to evaluate noise levels. Design and testing notwithstanding, one important ingredient in the process is missing: a uniform rating or sound standard that tells consumers in layman's language the best deal they are getting in a noise-free room air conditioner. Without a rating or sound standard system, manufacturers rely on such cliches

as super or ultra to convey quiet to the consumer. These cliches are promotional hype without a rating system to back them up. A far less tangible characteristic and, hence, not so easily solved as sound itself is the quality of sound. The low-profile design for rigidaire Co.'s Quiet One couples a polycarbonate cabinet with a compressor and fan motor outside of a bulkhead for quiet operating. Carrier Corp. uses a polypropylene cabinet for its Siesta model to help minimize noise.

Access No: 00594563 ProQuest ABI/INFORM (R) Global Edition
Title: Saudi Arabia: Selling Compressors in the Saudi Market
Authors: Anonymous
Journal: Middle East Executive Reports (MEE) ISSN: 0271-0498
Vol: 14 Iss: 12 Date: Dec 1991 p: 8, 17-18
Subjects: Air conditioning; Manufacturers; International trade; Exporters; Business conditions; Market potential; Earnings trends
Geo Places: Saudi Arabia
Codes: 1300 (International trade & foreign investment); 7000 (Marketing); 8600 (Manufacturing industries); 9178 (Middle East); 9180 (International)

tract: Extreme heat and humidity in the Western and Eastern rovinces and dry, hot weather in the Central Province have helped make Saudi Arabia the largest market for air-conditioning and refrigeration compressors in the Middle East. Imports of compressors plunged from $46.4 million in 1988 to $27.3 million in 1989 but moved up to an estimated $30.3 million in 1990. The Saudi market for compressors consists of 3 segments: 1. local manufacturers and assembly plants, which account for 60% of Saudi purchases of air-conditioning and refrigeration compressors, 2. operation and maintenance companies, which represent 25% of the Saudi market, and 3. spare parts dealers, which represent 15% of the market. Compressors are typically distributed through manufacturers of air-conditioning and refrigeration systems and by traders and wholesalers dealing in air-conditioning and refrigeration spare parts.

Access No: 00832503 ProQuest ABI/INFORM (R) Global Edition
Title: When and how to expand overseas
thors: O Hea, Paul
nal: Director (DRT) ISSN: 0012-3242
Vol: 47 Iss: 8 Date: Mar 1994 p: 44-46
Companies: Colt Group Ltd DUNS: 21-715-6769
Subjects: Strategic planning; Expansion; Market entry; Foreign investment; Requirements; Case studies; Manufacturers;

Ventilation
Geo Places: UK; Germany
Codes: 9175 (Western Europe); 2310 (Planning); 7000 (Marketing); 1300 (International trade & foreign investment); 9110 (Company specific); 8600 (Manufacturing industries)

Abstract: Companies that plan to do business in overseas markets, including those in the European Community, must address each as an individual market, understand their inherent tribal characteristics, and make allowances for them in their marketing strategies. There are key strategic questions that need to be addressed before making an investment in overseas manufacturing capacity. The decision of UK manufacturer Colt to begin manufacturing and marketing its products in Germany was made because conventional wisdom suggested it would be impossible to trade successfully in a foreign country without a local manufacturing capability. The situation is now different, with product distribution between countries substantially easier. If a company does manufacture on a local basis, the potential is unleashed for local management to adopt the company's products to suit their local requirements, which results in a disparate product portfolio. It is most important to put in place sound indigenous management whose first priority should be the effective marketing of services and products in the markets, rather than their manufacture.

Access No: 00661645 ProQuest ABI/INFORM (R) Global Edition
Title: Intelligent design passes IQ test
Authors: Beck, Paul E
Journal: Consulting-Specifying Engineer (CSE) ISSN: 0892-5046
Vol: 13 Iss: 1 Date: Jan 1993 p: 34-38
Illus: Charts; Diagrams
Companies: West Bend Mutual Insurance Co DUNS: 00-643-4245
Subjects: Building construction; Design engineering; Automation; Ventilation; Advantages; Energy management
Geo Places: US
Codes: 8370 (Construction & related industries); 5240 (Software & systems); 9000 (Short Article)

Abstract: West Bend Mutual Insurance Co.'s (West Bend, Wisconsin) new 150,000 square-foot headquarters building - winner of the 1992 Intellex Building for Excellence Award - boasts a wide array of integrated mechanical and electrical systems tied together through a sophisticated direct-digital-control automation system. At the heart of the building's design is a relatively new concept in air distribution known as environmentally responsive work stations (ERW). Building occupants in open-office areas can individually control temperatures and airflow within their spaces through vents and radiant heaters built into their furniture. The ERWs used at West Bend Mutual require air to be distributed via an under-floor plenum beneath a raised floor. The raised-floor scheme substantially reduced the number of variable-air-volume boxes and amount of the ductwork required. The building-automation system makes use of digital control to tie together heating, ventilating and air conditioning, security and fire-protection systems, and many of their

subcomponents.

Access No: 00606877 ProQuest ABI/INFORM (R) Global Edition
Title: 20th Century HVAC Meets 18th Century Aesthetic Requirements
Authors: Beck, Paul E
Journal: Consulting-Specifying Engineer (CSE) ISSN: 0892-5046
Vol: 11 Iss: 4 Date: Mid-Mar 1992 p: 16-20
Companies: Colonial Williamsburg Foundation
Subjects: Heating; Ventilation; Air conditioning; Innovations; History; Heat recovery systems; Building construction; Case studies
Geo Places: US
Codes: 5150 (Energy management); 9190 (United States); 9110 (Company specific); 8370 (Construction & related industries)

Abstract: Visitors to Colonial Williamsburg, Virginia, experience the buildings, crafts, lifestyle, and food of the 18th century with little or no indication of 20th-century heating, ventilating, and air-conditioning (HVAC) systems. Despite appearances, buildings within the 173-acre historic district incorporate a wide array of 'nnovative, energy-efficient mechanical and electrical technology. The Colonial Williamsburg Foundation has an 18-person, in-house staff of architects and engineers who work closely with outside consultants and sometimes handle design projects internally. A commitment to authenticity often presents design challenges for mechanical and electrical engineers. One of the biggest challenges facing engineers in renovating Shields Tavern was meeting the restaurant's 48.25-ton cooling load without using exposed cooling towers or condensers that would detract from the historic ambiance. The problem was solved by using 14 water-source heat pumps located throughout the facility.

Access No: 00794944 ProQuest ABI/INFORM (R) Global Edition
Title: Conceptual and early design estimating techniques for building heating, ventilation, and air conditioning systems
Authors: Reynolds, Frederick M
Journal: Cost Engineering (ACO) ISSN: 0274-9696
Vol: 35 Iss: 11 Date: Nov 1993 p: 25-36
Illus: Charts; Graphs; Equations; References
jects: Cost engineering; Heating; Air conditioning; Estimating techniques; Guidelines; Project management; Building construction
Geo Places: US
Codes: 9190 (United States); 3100 (Capital & debt management);

8370 (Construction & related industries); 9150
(Guidelines)

stract: With the current economic conditions facing the US and most of the world, construction cost data is being demanded even more quickly, and even though estimators are given less design information, greater accuracy than ever before is expected. Cost overruns are no longer acceptable or affordable, since these industries are being forced into a new era of accountability. Ultimately, this transition will result in more precise competition, better products and productivity, and hopefully, a cleaner environment. It is therefore critical to develop methods that enhance the accuracy of early construction costs so that they can stand on their own throughout the design process. Guidelines are presented that may help to remove some of the obstacles that confront all mechanical estimators.

Access No: 00921160 ProQuest ABI/INFORM (R) Global Edition
Title: How Carrier does it
Authors: Herrington, Mike
Journal: Across the Board (CBR) ISSN: 0147-1554
Vol: 31 Iss: 9 Date: Oct 1994 p: 36
panies: Carrier Corp DUNS: 00-131-7072
ubjects: Case studies; Appliance industry; Total quality; Awards & honors
Geo Places: US
Codes: 9000 (Short Article); 9190 (United States); 9110 (Company specific); 8650 (Electrical, electronics, instrumentation industries); 5320 (Quality control)

Abstract: Carrier Corp. has used the Malcolm Baldrige National Quality Award Criteria as the conerstone for awarding the in-house Willis H. Carrier Global Quality Award for several years. Carrier's development of its award is discussed.

Access No: 00722696 ProQuest ABI/INFORM (R) Global Edition
Title: Why carrier's hot about VA
Authors: Raia, Ernest
Journal: Purchasing (PRG) ISSN: 0033-4448
Vol: 114 Iss: 9 Date: Jun 3, 1993 p: 50-53
Illus: Charts; Diagrams
panies: Carrier Corp DUNS: 00-131-7072
Subjects: Purchasing; Cost control; Value analysis; Case studies; Implementations; Advantages; Heating; Machinery
Geo Places: US
Codes: 8670 (Machinery industry); 9190 (United States); 5120

(Purchasing); 9110 (Company specific)

Abstract: Carrier is the largest manufacturer of heating, ventilating, and air conditioning (HVAC) equipment in the world, with annual sales exceeding $4 billion. While Carrier can claim market leadership in all regions of the world, the competition is still fairly stiff with all the big-time players wanting a share of the $24-billion HVAC market. With strong downward pressure on prices throughout the 1980s, cost containment became a priority for purchasing. Allen Alexander, Carrier's vice president of corporate purchasing and logistics, began advertising for procurement specialists that had a bent for value analysis (VA), creating 6 new slots within corporate purchasing that would concentrate exclusively on reducing product costs. In 1992, the new group, led by VA expert Sung Cho, undertook a systematic review of Carrier's purchases, looking for projects with a high payback that could be implemented quickly and with minimal investment. Cost savings implemented by the VA group are discussed.

Access No: 00631212 ProQuest ABI/INFORM (R) Global Edition
Title: True Believers
Authors: Morgan, James P; Cayer, Shirley
Journal: Purchasing (PRG) ISSN: 0033-4448
Vol: 113 Iss: 2 Date: Aug 13, 1992 p: cover, 50-61
Illus: Charts; Graphs
Companies: Mazda Motors of America DUNS: 02-434-4848
Wang Laboratories Inc DUNS: 00-101-8167 Ticker: WANB
Black & Decker Corp DUNS: 00-131-7189 Ticker: BDK
American Cyanamid Co DUNS: 00-215-0001 Ticker: ACY
Carrier Corp DUNS: 00-131-7072
Subjects: Manycompanies; Purchasing; Suppliers; Partnerships; Initiatives; Quality control; Manyindustries
Geo Places: US
Codes: 5120 (Purchasing); 5320 (Quality control); 9190 (United States)

Abstract: Purchasing's 1992 survey on supplier partnering results in 2 conclusions: 1. A very large percentage of companies have made overtures toward the development of closer relationships with key suppiers. 2. Only about half of those companies saying they have programs aimed at improving supplier quality have anything in place that can conceivably be termed an aggressive program. A number of companies are dealing with specific aspects of the drive to develop world class supplier partners, including Mazda Motor Manufacturing, Black & Decker Corp., Carrier Corp., and Wang Laboratories. Supplier workshops are at the core of Mazda Motor's partnering relationships. The company uses them for a variety of purposes, including to educate new suppliers about systems and procedures and to keep suppliers posted on corporate movements. At Wang Laboratories Inc., the quality leadership process introduced to employees in February 1990, and to suppliers in April 1991, provides a perspective and an environment for continuous improvement.

Appendix B

Trane's SOUP Accounting

UMTRI The University of Michigan
Transportation Research Institute
2901 Baxter Road, Ann Arbor, Michigan 48109-2150

Marine Systems Division

September 15, 1995

Mr. Robert Randall
Management Accounting
10 Paragon Drive
Montvale, NJ 07645
Fax: (201) 573-0639

Dear Mr. Randall:

I am writing in regards to copyright release for two articles published in the Management Accounting magazine. The first is title "Product Costing at Caterpillar," published in the February 1991 issue, and the other is "Trane's SOUP accounting," published in the June 1992 issue.

We would like permission to copy the above mentioned articles to be used as appendices in one of our final reports, "Nonmarine Industry Cost Estimating and Cost Control Findings Report."

Please let me know as soon as possible if this will be acceptable. Thank you for your consideration.

Sincerely,

Roxanne Tuttle

Roxanne Tuttle
Research Secretary

PERMISSION GRANTED
Robert F. Randall DATE: 9-18-95
Assistant ~~Publisher~~ Director

$25.00 per article
$50.00 Total

Trane's SOUP Accounting

It's a system of utter practicality!

BY RONALD B. CLEMENTS AND CHARLENE W. SPOEDE, CMA

MRP II, JIT, CIM, TQC, TQM, SPC, ABC, and TCM[1] are just a few "cures" that are supposed to bring American manufacturers to "world-class" manufacturing status in the 1990s. Which "pill" or combination dose of pills is the real remedy, and how do we design a cost accounting system to support this new wave of alphabet soup solutions?

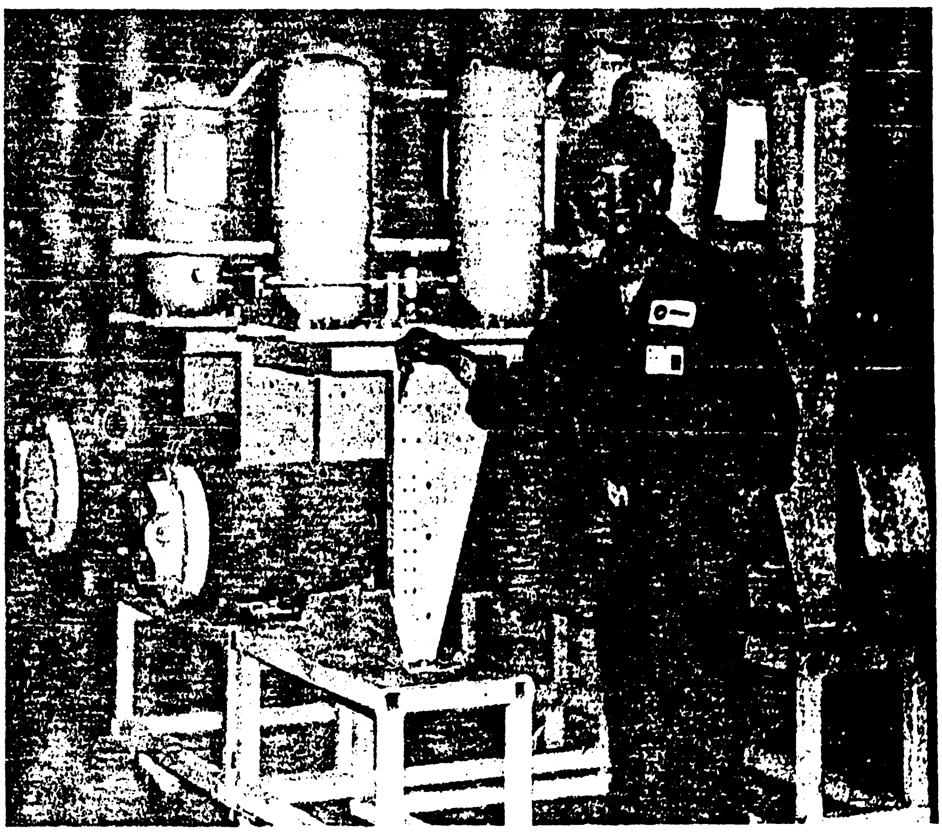
When faced with this dilemma at the Trane Co., we blended some of the new ideas with traditional approaches to create a cost accounting system for our business. Our system may not work for others. We learned through our experience that there is no recipe that will work for all companies, but our approach may provide a guide to how you can design your own system to meet your own goals with simplicity and low cost. The mechanics of our cost system may seem relatively easy when compared with the management decisions that are required to change and improve your business.

The Trane Co. is an operating sector of American Standard, a leading worldwide producer of air conditioning systems, bathroom/kitchen fixtures and fittings, and a major European manufacturer of commercial vehicle braking systems. Sales for 1991 were $3.6 billion. The Trane Co. plant in Pueblo, Colo., produces water chillers for commercial and industrial building air conditioning applications.

Trane business systems and manufacturing processes use ingredients from all of the alphabet soup solutions just mentioned. We are not dedicated to any single one because we have found we cannot totally ignore any of the approaches. Each concept has some advantages that can improve manufacturing processes dramatically. We refer to our new manufacturing efforts as demand flow manufacturing (DFM), a variation of just-in-time (JIT) to which we have added our own unique features. Because our manufacturing system uses many of the alphabet soup philosophies, we refer to our new accounting system, developed in tandem with new manufacturing procedures, as SOUP (system of utter practicality) accounting.

Any project of this magnitude requires the complete support of top management and the entire management team. Inasmuch as the cost system interacts with all other functional areas, cooperation, compromise, and willingness to consider new ways of doing things are required in order to make major changes. The common mission of "world-class manufacturer" must be shared by the entire leadership team, and company culture must be favorable to change.

As we wanted to move quickly, we decided to develop our new manufacturing procedures and our SOUP accounting system in a brand-new environment. Our objective was to start up a plant in Pueblo, Colo., using everything new—hu-



Trane employee shows one of the water chiller units, produced via demand flow manufacturing.

man resource philosophy, products, processes, technology, and business systems—at a new location with new people and a culture of continuous improvement. We wanted to give our ideas every opportunity to succeed.

Of course, whatever can be done in a new plant can be done in an existing facility also. The only differences are the priorities of what must be done and the additional time that may be required to convince all members of the team to embrace the ideas and help develop the new system. Priorities will vary based on the specifics of a particular manufacturing facility and are determined by spotlighting where the greatest benefits can be achieved. In an existing facility the major obstacle to change often is the attitude, "We have been doing fine," and "If it ain't broke, don't fix it." Unfortunately, a financial disaster often is required to create the survival environment where people are impelled to break old patterns of behavior.

Our Pueblo plant is designed to manufacture four distinct product lines, each in six to eight size ranges. Additionally, we produce four different subassemblies, also in six to eight size ranges, for affiliated plants. Our business is a custom sales order business in which we build each unit to a unique order based on the customer's selection of standard features and options from a large number of possible combinations. A potential customer could order one of 60 million distinct product configurations.

Our overall business philosophy is to deliver a quality product in minimum time while controlling work in process through the use of our DFM system, which pulls materials as needed similar to the way a JIT KANBAN system operates. This philosophy is supported by a quest for simplicity and lowest total cost. Our cost accounting system must complement and support this philosophy. Thus the expense to collect detailed cost information must be justified and truly must add value. In addition, the cost system to support this new business must support our external reporting requirements as defined by the Securities & Exchange Commission, the Internal Revenue Service, and generally accepted accounting principles.

POLICY DECISIONS

After much discussion, we decided to retain a standard cost system. Our preference for a standard cost system is driven by corporate policy and our tax conventions with the IRS but, more important, from our desire to monitor cost changes. Most of our product cost consists of materials. A standard cost system exposes material cost changes, especially material costs as a result of bill of material changes and part substitutions.

In addition, the use of conversion labor and overhead standards allows for easy unit-level conversion costing. The key considerations when developing conversion (labor and overhead) standards are:

1. Our guiding motto is "approximately right" or "close enough."
2. You don't need a significant amount of engineering input.
3. An annual review for each cost pool should be adequate.

In the past, considerable time and effort had been devoted to achieving *precise* labor and overhead costs. We decided that the time and resources devoted to achieving this previous degree of precision was not cost-benefit effective and, in fact, encouraged a misguided level of confidence in the final numbers. Although engineers traditionally have been used to develop overhead standards, you, as a financial manager, should have access to all the necessary information to determine the total costs of any pool, including direct costs and any allocation methodology. Once you have the total costs you need to decide only how many units will be pro-

OPERATING RULES FOR COST SYSTEM DESIGN

1. We will use a frozen standard cost system based on absorption accounting. Full absorption will be at 85% of capacity (corporate policy).

   [This met our need for consistency within the corporation and reporting to external entities. Also, it matched our preference for a standard cost system.]

2. All labor and overhead required to convert raw material into finished goods are defined as conversion cost and added only at major subassembly points or upon completion of the units.

   [We need to cost a completed unit as it ships out the door to relieve inventory and match costs with revenues, but we do not need a cost for each individual part or subassembly. At this point, most people ask the question, "What about service parts?" We decided to design the system as if we did not have service parts. Then we came back later and added the complexity needed, but only for the service parts, not all the parts in the system.]

3. There will be no detailed labor reporting because direct labor is less than 5% of product cost.

   [Our experience told us that the cost—people and computers—required to track actual labor would never pay for itself in the form of savings.]

4. Purchased parts will be issued by backflusing at major assembly points or for completed units. All plant materials are stored at point of use. There is no stockroom.

   [This reduces the material handling cost and eliminates the need for stockroom personnel, who add no value to the process.]

5. All low-cost items (nuts, bolts, screws, labels, and the like), which represent 76% of our part numbers but only 3% of the total cost of the product, will be carried on the bill of material as $.00 cost. These items are expensed to manufacturing overhead when received.

   [This means we don't review standards each year and we don't measure any purchase variation from standard. At the same time, we left these items on the bill of material so our MRP II system will plan them and they are available for service parts analysis. Because historically we had shown labor and material costs to four decimal points on the bill of material, this was one of the more controversial decisions we made.]

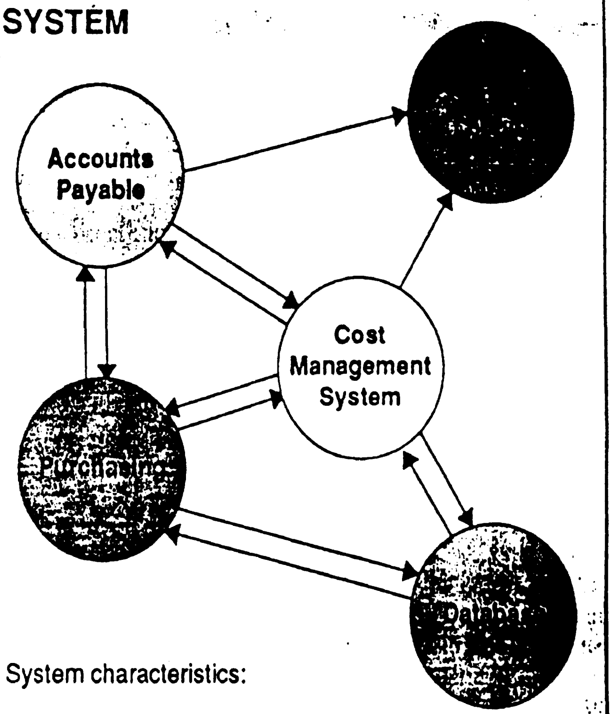
6. Conversion costs will be grouped by cost pools that bear a direct relationship to distinct processes within our plant. The number of cost pools will be minimal. ■

cessed through the cost center to absorb the cost and what "driver" within the cost center will be used as the base to allocate the costs to the units. Most of these choices are policy decisions.

Clearly the standards are not precise, and you expect some variation, so there is no need to update them constantly. We have found that, unless major changes occur, an annual review of the pools and the allocations within each cost pool are adequate to provide sufficiently accurate information for our financial statements. Rather than rely on unit variance information, most managers base overhead control decisions on total costs incurred.

Our business computer system included a prepackaged, integrated, closed-loop system. We decided that the mechanics of our cost system must operate within the capabilities of this software *without* program modification. The use of an integrated database software improved our ability to eliminate redundancy in our cost system. Transaction data needed to be entered into the system only once. In addition, we found we can eliminate 80% of the paper and transaction detail if we so desire. A model of our cost and management system structure is shown in the illustration in Figure 1.

FIGURE 1/CLOSED-LOOP BUSINESS SYSTEM



System characteristics:

1. Online purchase order, material receipt, and accounts payable match (quantity and prices).
2. No paper used between purchasing, receiving, and accounting.
3. Integrated for material standards, purchase price variation, inventory valuation, unvouchered liabilities, and voucher interface to the general ledger.

COST ACCOUNTING SYSTEM OBJECTIVES, PHILOSOPHY, AND IMPLEMENTATION

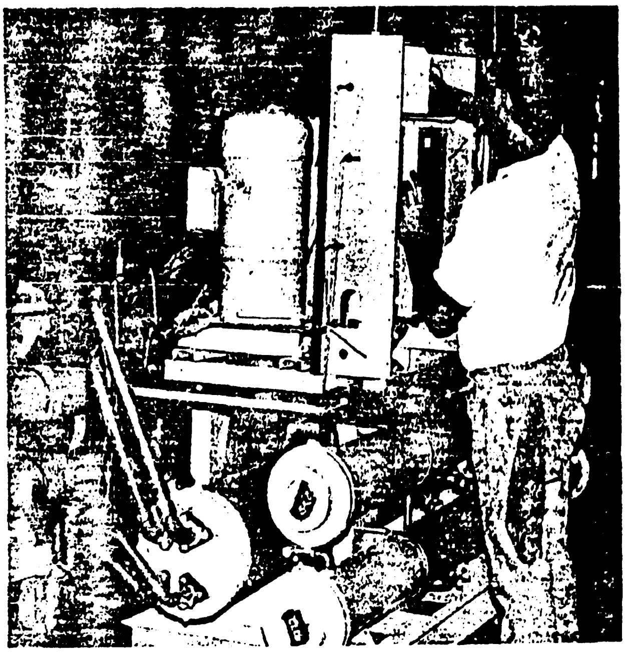
With this background, we set out to design a cost system with the following objectives and philosophy. Our major guidelines to achieving these objectives are keep it simple, and keep it low cost.

- The cost system is a subset of the business philosophy. It must fit and complement the business philosophy and reflect plant operating characteristics.
- The cost accounting system should be *simple*.
- The cost accounting system operation should be *low cost*.
- The system should eliminate artificial, unnecessary reporting steps.
- The system should *not* reward production for building inventory.
- Accounting exactness *does not equal* accurate product cost.
- Cost the unit but not each individual part.
- Eliminate detailed labor reporting—labor and overhead are combined into conversion cost.
- Apply conversion cost based on total product cycle time (or some other base you deem appropriate).
- The cost system must meet the external reporting requirements as set forth by the SEC and the IRS and must meet GAAP.

Based on these objectives, overall philosophy, and guidelines, we developed the detailed operating rules discussed in the sidebar on page 47. Once we had established these guidelines and rules, we proceeded with implementation. As you might expect, all rules and guidelines weren't fully developed at first. Some of them evolved over time as we got into more detail and understood the limits of our software and the limits of our bill of material structures.

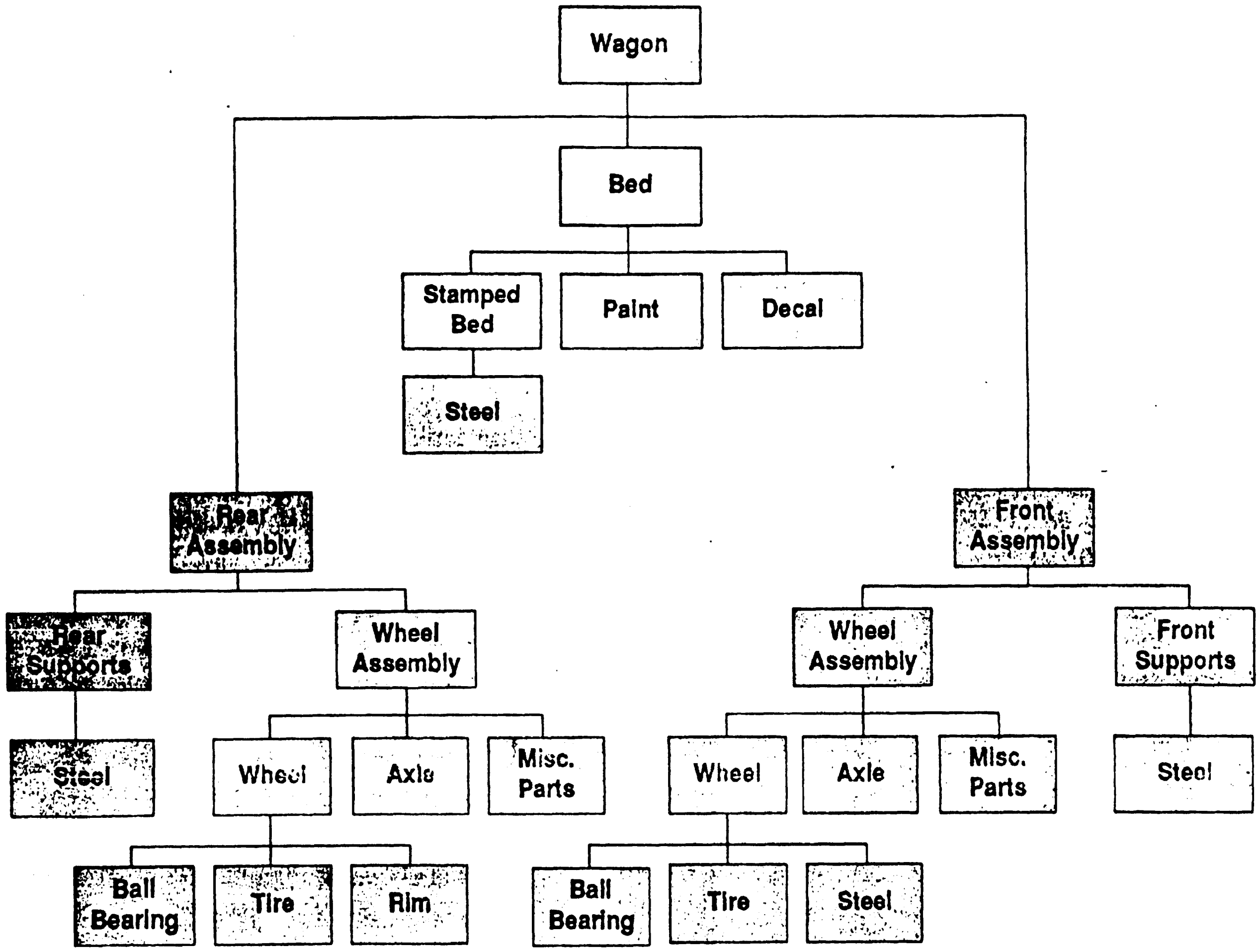
While we were developing the cost system, Trane's materials people were designing a bill of material that was modular and flat (four levels maximum). It had none of the traditional bill of material subassembly relationships. Look at Figures 2 and 3. Figure 2 portrays a traditional bill of materials for a wagon, while Figure 3 shows a "flattened" version.

With a traditional organization, Trane's bill of materials might have 10 to 12 levels, which are indicative of the number of levels of subassembly. Manufacturing, engineering,



Trane's production management uses no computerized shop floor control or labor reporting system. Employees work on individual units as a whole.

FIGURE 2/TRADITIONAL BILL OF MATERIALS



and finance no longer needed these relationships to be defined in the bill of material. Each functional area had determined independently and jointly that the expense of maintaining these traditional relationships in the bill of material did not provide any value to the business. Thus they were abandoned in favor of the modular BOM.

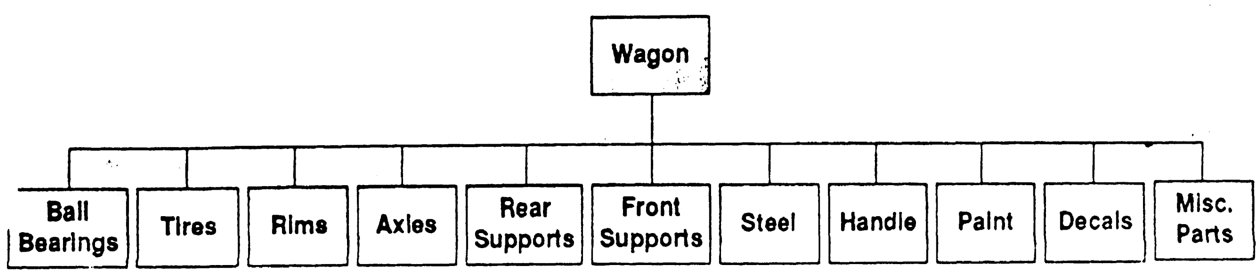
Many benefits resulted from designing a flat bill of materials. Business operations were simplified, and the ongoing cost of running the business was reduced. The new bill of materials design reduced the number of part numbers in the system, the number of engineering drawings, and the number of parts to cost.

Many times during the implementation process we found ourselves making decisions that could have added complexity to the system. We resisted these temptations as best we could. Any feature or option that might have been added to the system was left out if it didn't get a usage factor of 80% to 90%. For example, if a repetitive process applied to only 10% to 20% of our units, we did not attempt to track the cost of the double processing to the specific units. Also, we left out anything that we "might" need in the future because we felt we could always add features to the system, but we knew from experience that we would never take them out of the system.

COST POOLS

We defined the plant's conversion cost pools as illustrated by the plant layout in Figure 4. Our manufacturing plant is extremely capital intensive. Cost pools are differentiated mostly by capital intensity and are

FIGURE 3/FLAT BILL OF MATERIALS



broken down by distinct processes. Each cost pool represents the completion of a major assembly or the entire process to assemble a complete product..

Our efforts were simplified by three factors:

1. Our plant has very few assets that are used in multiple processes or products. Our assets are set up by process, and parts are not trucked throughout the plant.
2. We have been very aggressive to outsource as many "low tech" parts as possible, which simplifies our manufacturing plant and supports our demand flow philosophy.
3. Production management did not want or need any form of computerized shop floor control system or labor reporting system. Production flow is regulated by a series of KANBAN-type systems, is synchronized by the production master schedule, and operates based on a philosophy of one-piece flow. That is, the transfer batch between stations is one unit.

Unfortunately, a financial disaster often is required to create the survival environment where people are impelled to break old patterns of behavior.

The conversion cost pool is a grouping of costs that are representative of a distinct process in the plant. The costs included and the magnitude of these costs are illustrated by the Cost Conversion Pool–Widget (R) in Table 1. As you can see, there are some allocations (for example, from engineering) to the cost pool, but, for the most part, these costs are actual direct costs based on a representative sampling or an extrapolation of actual cost at a lower production volume base. Table 2 shows how the total costs from the Cost Conversion Pool–Widget (R) would be allocated to the different size ranges produced.

PERFORMANCE MEASURES

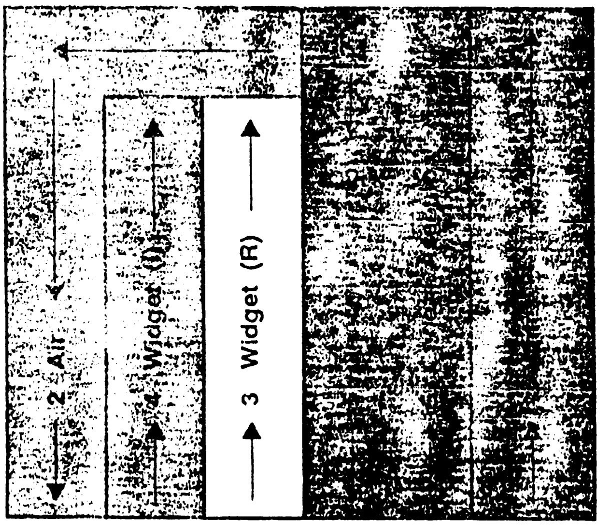
The issue of performance measures in our new environment created an additional challenge. We wanted to be careful not to put a series of measures in place in the organization that would lead to optimization of local areas to the detriment of the manufacturing system as a whole. Our criteria for performance measures were:

1. They should be few (five or fewer).
2. They must be understood clearly by all employees.
3. They should be calculated from readily available data.
4. If the measurement were a true global measure, the absolute number is not of primary importance. The trend rate and the rate of change are significant.

We finally settled on the following *six* measures:

1. *Sales Per Employee.* This measure is simple and is one to which all employees can relate. It emphasizes the output of the entire system versus some other measures that tend to emphasize local optimization rather than optimization of the entire system.
2. *Inventory Turnover.* This is a measure of the velocity of the system and a trend indicator for cash flow. It reflects the rate of conversion of purchased materials to cost of

FIGURE 4/PLANT LAYOUT AND COST CONVERSION POOLS



The arrows indicate flows.

The numbers 1 through 5 represent the total number of cost pools in the plant that reflect one cost pool for each product.

TABLE 1/COST CONVERSION POOL—WIDGET (R)

DETAILED COST ANALYSIS[1]

Cost Category	Basis	Annual Cost
Building	Square Foot (%)	$ 94,000
Depreciation		
Machining/ Assembly	Assets	517,000
General/Factory/ Maintenance	Square Foot (%)	23,000
Taxes	Capitalization	166,000
Labor and Benefits	Number of People	1,035,000
Engineering	Number of Engineers	371,000
Maintenance	Extrapolation[2]	45,000
Hard-to-Measure Materials, Supplies, Spoilage, Waste, Disposal, Other	Extrapolation[2]	559,000
Total		$ 2,810,000
Average conversion cost per widget		$ 2,810[3]

[1] Number of widgets produced 1,000
Capacity 1,175

[2] Based on an extrapolation of actual costs charged to the conversion cost pool.

[3] The total cost to produce 1,000 widgets is $2,810,000, or an average conversion cost of $2,810 per widget.

TABLE 2/WIDGET COSTING ANALYSIS[1,2]

UNIT MIX ANALYSIS

Size	% of Total	No. of Units Produced	Cycle Time Basis[3]	Total Cycle Time	Conversion Cost Per Unit
10	15%	150	100	15,000	$2,626
20	35%	350	100	35,000	$2,626
30	30%	300	110	33,000	$2,888
40	20%	200	120	24,000	$3,151
		1,000		107,000	$2,810 (average)

Total Cost $\frac{\$2{,}810{,}000}{107{,}000} = \$26.26$ (Each conversion allocation unit for 1,000 widgets is costed at $26.26 per widget.)

[1] Defined capacity of widgets is 1,175 per year.
[2] Costing policy is 85% of capacity.
[3] Cycle time reflects machine time plus line assembly time. Size 10 is the basis of the calculation, and size 40 takes 20% more machine and assembly time.

TRANE'S PLANT OPERATING CHARACTERISTICS

Overall Plant Philosophy
- Flat organization,
- Hold overhead to absolute minimum (lower cost/higher risk),
- Err on the side of simplicity (KISS),
- Challenge every assumption,
- The only constant is change.

Work Cells
- Equipment grouped by product not process,
- Limited supervision (50 to 1),
- Work cell leader rotates every 60 days,
- Only three labor grades throughout plant,
- Job rotation is a requirement for everyone,
- No shop floor labor reporting.

Reduce Work-in-Process
- Velocity driven, not batch driven,
- No repair stations,
- No inspectors.

Outsource Aggressively
- All sheet metal,
- Manufacture where you add value,
- Rings of defense.

Reduce/Streamline Material Handling
- Receive/ship at point of use (13 trucking doors),
- No central stockroom—materials stored at point of use,
- Cycle count regularly—top 50 dolloar items monthly.

Material Requirements Planning (DFM)
- MRP gets material to plant—DFM/MPS controls flow within plant,
- Shallow bill ofmaterial (four to five levels maximum),
- Bill of material accuracy goal equals 99%,
- Only one company bill of material,
- Sales order business (six to 10 orders a day),
- Standard options/features equal 60 million possible combinations.

Cycle Time
- Order processing, one to two days,
- Material planning, 30 to 50 days,
- Production, six to 16 days (25% to 50% of industry average),
- Widget manufacturing on continuous shift (seven days a week, 24 hours a day).

Production Management
- Master production schedule is bible (what to make—build parts to schedule),
- No computerized shop floor control (KANBAN type control),
- Flow manufacturing—tooling and fixtures—visual aids standardization (how to make),
- Minimum shop paper (no route sheets),
- No production control department/no industrial engineering department/no quality department/no timekeeping department,
- Visual shop floor control system (KANBAN style).

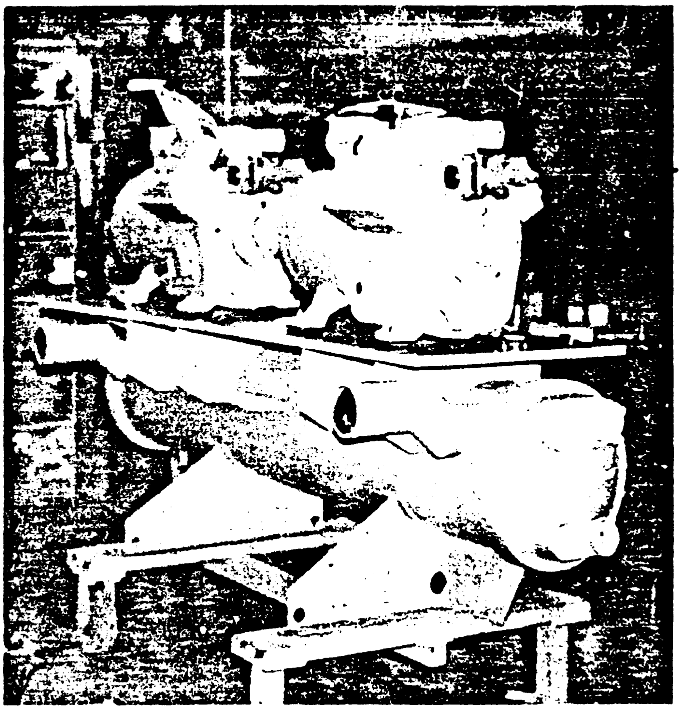
THE COST ACCOUNTING SYSTEM PROCESS

- Material, which is 70% of product cost, is backflushed at unit completion.
- Conversion cost (labor and overhead combined) is applied at unit completion.
- There is no labor reporting. Efficiency and rate variations are not tracked.
- Low-cost parts expensed to overhead:
  4% of BOM (bill of material) cost equals 76% of total BOM parts.
  96% of BOM cost equals 24% of total BOM parts.
- Work-in-process estimates are adjusted quarterly to reflect current production rate and manufacturing cycle time.
- Bill of material is modular, with a direct relationship between sales features and options, and reflects "pile of parts" concepts.

sales.

3. *Customer Services Costs as a Percent of Sales.* This is the cost of field service on shipped products during a 12-month warranty period.
4. *Manufacturing Cycle.* This measure tracks the time in days it takes to convert raw material and purchased parts into a finished product. (Order processing was not an issue as it already had been reduced to one to two days.)
5. *On-Time Shipping Percent.* The percentage of time we ship customers' orders when we say we will ship them is revealed by this measure.
6. *Return on Net Assets (RONA).* This is pretax income divided by the average net assets employed in the business.

These performance measures meet our requirements. Only RONA needed a significant amount of explanation to bring all of our employees up to speed on the various performance calculations and their meanings.



In Trane's SOUP accounting, the units (such as this water chiller) are costed, not the individual parts.

Any new cost system, no matter how simple or streamlined, should not compromise your audit or internal control requirements.

EFFICIENCY AND CONTROL

When you are developing a new cost system, you need to understand that the move toward simplicity and the reduction of accounting transaction detail does not mean a lack of control. In fact, we believe it is just the opposite. Our previous obsession with accounting exactness and direct labor reporting to the minute and to the nearest cent distracted us from what really was important. To retain the reporting of direct labor efficiencies or indirect labor ratios—or any other traditional form of labor reporting—will guarantee your DFM efforts will fail. These reporting mechanisms encourage your production organization to build parts that aren't needed or to build parts before they are needed. As you eliminate excess inventory and drive down the dollars of inventory in work in process, your traditional manufacturing efficiencies measures will get significantly worse in the initial stages of the implementation. Consequently, the first time you point out to the production organization that labor efficiency is declining, you will have torpedoed your entire DFM project. Also, any new cost system, no matter how simple or streamlined, should not compromise your audit or internal control requirements. It is just that these elements of your business are now viewed from a different perspective.

We believe you need to examine all of the techniques available in the alphabet soup library and apply only those techniques that fit your business goals and objectives. Trane's plant operating characteristics, as developed in response to the new techniques adopted, are summarized in the sidebar on page 51. Once plant operating characteristics have been defined, your cost system must be designed to provide the information required to support the manufacturing system. The sidebar also outlines a description of Trane's cost accounting process. Whatever you do, in designing manufacturing processes or in designing cost accounting systems, you cannot overemphasize the need for simplicity. ■

Ronald B. Clements is vice president and general manager of the Commercial Self Contained Business Unit of the Trane Co. in Macon, Ga. When he wrote this article, he was controller of the Water Chiller Business Unit in Pueblo, Colo., where he served as a member of an eight-person fast-track new-plant startup team with responsibility for all aspects of business development, including defining the business management/human resource philosophy, the plant operating characteristics, and the financial system. He holds a B.A. degree in accounting from Winona State University. He may be reached at (912) 781-6495.

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[1]For a refresher: MRP II is manufacturing resource planning, JIT is just-in-time, CIM is computer-integrated manufacturing, TQC is total quality control, TQM is total quality management, SPC is statistical process control, ABC is activity-based costing, and TCM is total cost management.

Is this article of interest to you? If so, circle appropriate number on Reader Service Card.	Yes	No
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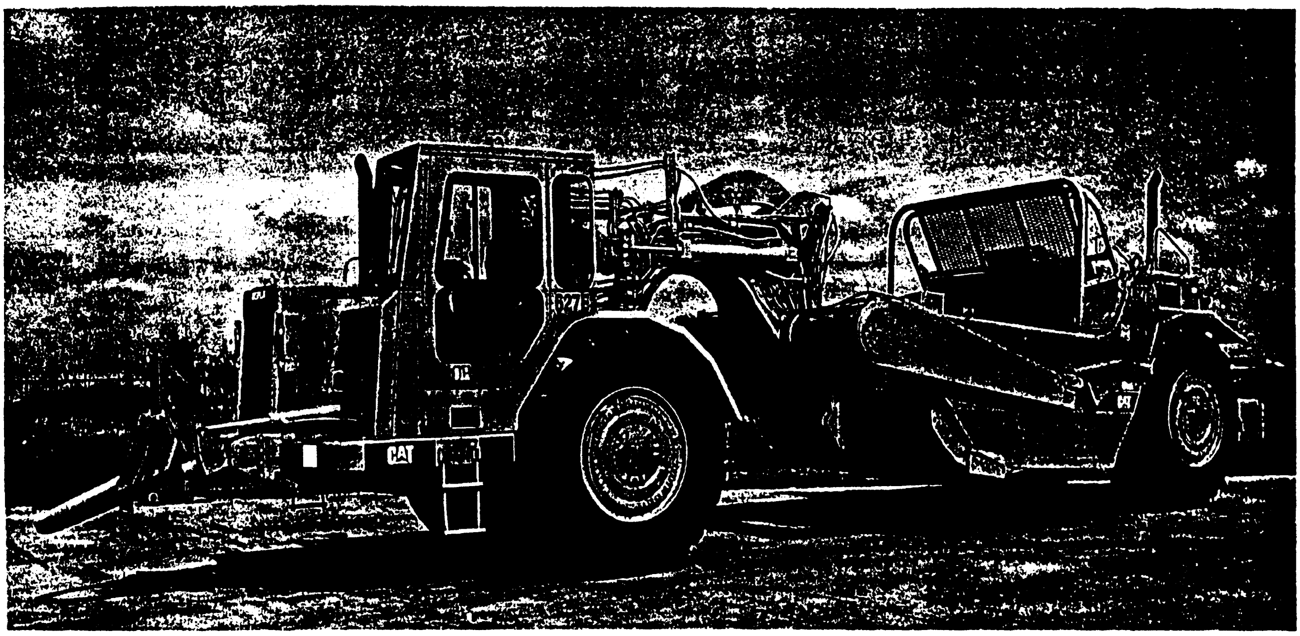
Appendix C

Product Costing at Caterpillar

PRODUCT COSTING AT CATERPILLAR

It's a vital link in an entire business process.



The scraper is one of Caterpillar's popular large, complex products.

BY LOU F. JONES

Certificate of Merit, 1989-90

Today's competitive environment makes it imperative for manufacturers competing globally to know their costs. They need to understand costs at several levels, the activities that are driving costs, the link between management decisions and subsequent costs incurred, and the areas where improvement opportunities lie. A topnotch costing system is one of the most powerful information tools a management team can have, especially if it provides a clear picture of the activities that are driving costs and the ways individual products and processes consume resources.

At Caterpillar we use costing in three distinct ways: standard costing, for inventory valuation; operational controls, for tracking and managing operating costs and other key operating characteristics; and product costing, for a variety of longer-term strategic decisions.

Standard costing is a bookkeeping activity for valuing inventory in the financial reporting cycle. The standard cost system has been kept simple, and we update standard costs only every five or six years, using variances to keep them updated to actual levels. (Remember—we use them for inventory valuation only, not cost management!) To update standard costs, we simply extract information from the product cost system data files and make necessary GAAP financial reporting adjustments.

Operational controls and product costing are cost management[1] tools. Our major efforts through the years have been in the development of and ongoing improvements to operational control and product costing systems.

Although our three cost systems have different missions, they are linked through a common database—the budget. The budget is "tapped into," and each system employs unique subroutines to format the information for its intended use. With operational control formats, the information is ordered so that actual material prices and operating costs can be compared to budget and targets. Our rolling budget process allows this report to recognize changes in product mix, volume, and other operations.

PRODUCT COSTING

Caterpillar's financial people long ago recognized the need for and potential competitive advantage of having the ability to cost products reliably. Caterpillar produces a variety of large, complex products (several kinds of heavy equipment, for example) at varying volume levels using many manufacturing processes and sources of supply. A simple cost system would not provide the level of accuracy required for sound cost management on these products.

Simple cost systems are accurate enough for assigning costs that are easily traceable to the production process, such as production material and direct labor, but they don't specifically assign costs such as machine tool energy consumption, setup, machine repair, perishable and durable tooling, and manufacturing support activities. Such systems also fail to recognize the product-by-product cost effects of volume, product and process complexity, product design, and the different values of capital assets used in the production process.

Simple systems are fine for valuing inventories, but if used for cost management they misstate the costs of manufactured products, especially at the part, component, major activity, and cost element level. Directionally accurate costs are needed at this level of detail if a cost system is to come alive as a powerful tool for internal cost management.

A good cost system mirrors the manufacturing process and related support activities and quantifies them product by product. The more complex and inconsistent these processes are the more difficult it is to assign costs to products accurately. Thus, the cost system becomes more complex as it attempts to compensate for the lack of simplicity of the manufacturing processes. The complexity of manufacturing operations "drives" the complexity of the cost system.

Conversely, as manufacturing operations are simplified, costing becomes simpler. When processes are simpler, repeatable, generate a consistent pattern of resource consumption, and produce consistent quality, then costing becomes easier. "Simple" cost systems are desirable, but "simplistic" systems in a complex manufacturing environment usually will generate misleading product cost information.

Such considerations led Caterpillar to develop a product costing system separate from its standard cost system. This managerial costing system is a variation of what is popularly called an "Activity-Based System."

We have a common system worldwide. As an international manufacturer, we must be assured of comparability when analyzing the cost of identical products produced at multiple loca-

CATERPILLAR'S ACCOUNTING VISIONARY

One of the most popular debates in accounting today is the appropriateness and usefulness of existing cost information. Critics point out that most cost accounting systems have not kept up with the changing business environment, yet there are some companies that have focused on continually improving the quality of cost information provided to management for strategic and tactical decision making.

One such company is Caterpillar Inc. For more than 40 years, Caterpillar has dedicated significant resources to providing good cost information to management and has continually updated its cost system to reflect the operating conditions in the factory. In the late 1940s, Caterpillar dismissed the relevance of a product costing method that many companies still rely on today: a single plantwide overhead rate based on direct labor. Caterpillar had found this method of overhead allocation inadequate, given the machine-intensive nature of its manufacturing processes. While direct labor and related overhead still represented a significant cost, depreciation, maintenance, utilities, tooling, and other machine-driven costs constituted a large share of factory overhead. To match these costs to products properly, the company implemented its MBU (Machine Burden Unit) System.

This system was significantly different from most companies' cost systems in at least three respects: (1) The MBU System classified factory overhead into two primary categories: *machine burden*, or overhead expense believed to vary with the machines used, and *man burden*, or overhead expense believed to vary with direct labor on a plantwide basis. (2) The different machines that were required to produce a variety of parts presented the need for separate machine rates (in terms of MBUs), which were calculated for several cost centers including assembly lines and large groups of like machines such as lathes and drills. (3) The MBU System, which was developed to provide product costs, operated independent of the existing standard cost system that was used for inventory valuation. This separation, which has continued to the present, laid the foundation for the development of a cost accounting function autonomous from financial accounting at Caterpillar.

This system was implemented under former CEO William H. Franklin while he was assistant controller. It emphasized the "allocation of overhead based on the plant activities causing the expenditure." Mr. Franklin fostered the development and use of accurate cost information until he retired as chairman of the board in 1975.

He said that good cost systems provided several benefits: "We were setting our parts prices much better. We found we were selling some parts way below cost. When we got [the parts] really costed right, some were [priced] way above cost... If you don't look out, you'll be wondering why you're not making any money on these parts or not getting any of the business. It costs quite a bit to have a good cost system. ...The investment in the system and in the people to support it ought to bring back more than its cost... I'm afraid most companies don't appreciate the value of what accounting can do for them."

In the August 1951 issue of the *NACA Bulletin*, Mr. Franklin published an article on "Allocation of Overhead Costs—a Short-Cut" in which he described Caterpillar's first attempt to cost products based on the specific activities and related costs that each consumed in the production process. When asked to discuss readers' responses, he said, "I don't think there was any reaction at all. I don't think I ever received a letter from anyone." When asked why so few companies took the lead in improving their cost systems, he replied, "I don't know why they didn't listen. Maybe I didn't make it plain." Anyone who knew Bill Franklin would disagree. ■

This sidebar was based on an interview by Stephen Soucy and Marcus Moore of Howell Management Corp. for a case study on Caterpillar Inc. Their research was sponsored by the Financial Executives Research Foundation and will be published later this year along with several studies of other leading companies' cost management practices.

tions. How could a company make good cost decisions if it had different cost systems from one location to another?

The objective of Caterpillar's cost system is to identify the activities consumed by products and through a logical, reliable, and consistent process assign the related costs properly to each.

In our factories, each machine tool, manufacturing cell, and assembly area has distinct owning and operating costs. As products pass through these areas they consume differing amounts of these costs. We establish specific cost rates for these areas and develop logical bases upon which the appropriate amounts of cost can be assigned to individual products as they move from area to area. These two concepts, specific costing rates and bases for applying them to products, are at the heart of Caterpillar's product cost system.

Our system is forward looking. The process begins with the business plan for the upcoming six months. The forecasted schedule of products and the resources to produce them are transformed into an operating budget. The budget is distributed into pools of costs as the initial step in establishing cost rates.

Specific costing rates and bases for applying them to products are at the heart of Caterpillar's product cost system.

Some costs are included in product cost pools, and some are not. Included are direct material, production labor, and all manufacturing-related overhead. Labor and overhead are further subdivided into logistics, manufacturing, and general overhead cost pools.

Excluded are:

- Research and development cost related to future products. Engineering related to current products is included in product costs.
- Parts distribution costs for warehousing and merchandising replacement parts.
- Selling, general, and administrative (S, G, & A) costs that do not support plant operations directly.
- Other costs of doing business such as interest, income taxes, warranty expenses, and abnormal costs.

Although excluded from unit-of-one product costs, these costs are *included* in profitability studies, investment analyses, and other analyses that require consideration of all "life-cycle" costs.


The multi-axis assembly platform in Gosselies, Belgium, which allows the assembler to position machine for ease of assembly.

NORMALIZING IS NECESSARY

The next step in Caterpillar's product costing system is called "normalizing." Normalizing smoothes the up-and-down effects that volume changes can have on unit period costs. Period costs exist for future levels as well as for today's level of business. We do not manage period costs to short-range volume swings, so if they aren't normalized, they could distort the inherent cost of products as volumes increase and decrease. Normalizing is accomplished by spreading period costs over long-term average volumes rather than current volume levels.

Another aspect of normalizing is the exclusion of abnormal costs such as start-up, learning curve, major factory rearrangements, and unusual levels of education and training. Normal costs are not "ideal" costs. These costs, such as desired efficiency, usual on-the-job training, and such, are treated as normal if they typify longer-term operations. Abnormal costs are not swept aside and forgotten, but they are quantified and kept in front of management.

Normalizing is necessary because most product decisions are long term and can involve product design, manufacturing process, logistics, capital investment, and supplier selection. At Caterpillar we are spending hundreds of millions of dollars on start-up to modernize our factories. Including these one-time-only expenses in cost rates would misstate the inherent costs of our products.

Obviously, normalized costs differ from actual costs incurred. When business is constant or growing and internal operations are relatively stable and to plan, actual and normal costs will be close. In a downturn, when operations are not stable, or if there are significant changes occurring in factory operations, actual and normalized costs can be quite different.

The cost analyst must stay attuned to the operations to normalize costs properly. If there are abnormal costs that aren't eventually managed out or that otherwise become normal to the operations, then they will be borne by the product. Therefore, the practice of normalizing requires close attention.

ASSET DEPRECIATION

Another important aspect of Caterpillar's costing approach is the specific assignment of depreciation to cost rates. Depreciation is assigned to cost rates based on usage and assumes an indefinite life for major productive assets. Basing depreciation on usage has the effect of removing the costs of unutilized machine capacities from current costs.

Setting cost rates involves taking normalized expenses from the budget and distributing them into variable and period cost pools for logistics, manufacturing, and general overhead activities.

TABLE 1

Variable	Expense Distribution	Cost Rate Base	Rate
Unformed—Wt. Base	$ 200,000	10,000,000 #	.0200/#
Casting/Forging—Wt. Base	360,000	12,000,000 #	.0300/#
Unformed—Moved	170,000	38,000,000 #	0045/#
Casting/Forging—Moved	250,000	50,000,000 #	.0050/#
Subtotal	980,000		
Purchased Finished	588,000	$21,000,000	.0280/$
Total	$ 1,568,000		
Period		*	
Unformed—Wt. Base	$ 72,000	12,000,000 #	.0060/#
Casting/Forging—Wt. Base	225,000	15,000,000 #	.0150/#
Unformed—Moved	43,000	43,000,000 #	.0010/#
Casting/Forging—Moved	56,000	56,000,000 #	.0010/#
Subtotal	396,000		
Purchased Finished	480,000	$24,000,000	.0200/$
Total	$ 876,000		

* Period rate bases are set on longer-term volume trends.

LOGISTICS ACTIVITY POOL

Caterpillar products are large and heavy. They are made from great amounts of plate steel (unformed material), castings, and forgings in addition to a wide variety of purchased components. It is costly to buy, transport, receive, and handle this material. Even when our factories are fully transformed into a just-in-time (JIT), synchronous flow mode of operation, logistics will be a major expense. Oversimplification in this area would greatly distort product costs.

Average monthly costs of logistics activities are assigned to five subpools. Costs of obtaining unformed material are grouped under "unformed weight base costs." Costs for moving the material to and from points of use in the factory are grouped under "unformed weight moved costs." In the same way, costs for castings and forgings are grouped into weight base and weight moved cost pools. Finally, the costs of buying, receiving, storing, and moving purchased finished material are grouped together.

Within the weight base cost pools are the activities on the shipping docks, in the receiving areas, and in the storage areas. The weight moved cost pools are for the intraplant handling of material as it moves through the production process.

The variable pools for these rates include costs such as freight on production material, material cleaning, receiving inspection, material handling labor, and fuel and electricity for operating material handling equipment.

Period cost pools include purchasing personnel, specific depreciation and maintenance on material handling equipment, utilities, insurance, property taxes, maintenance, and clerical support.

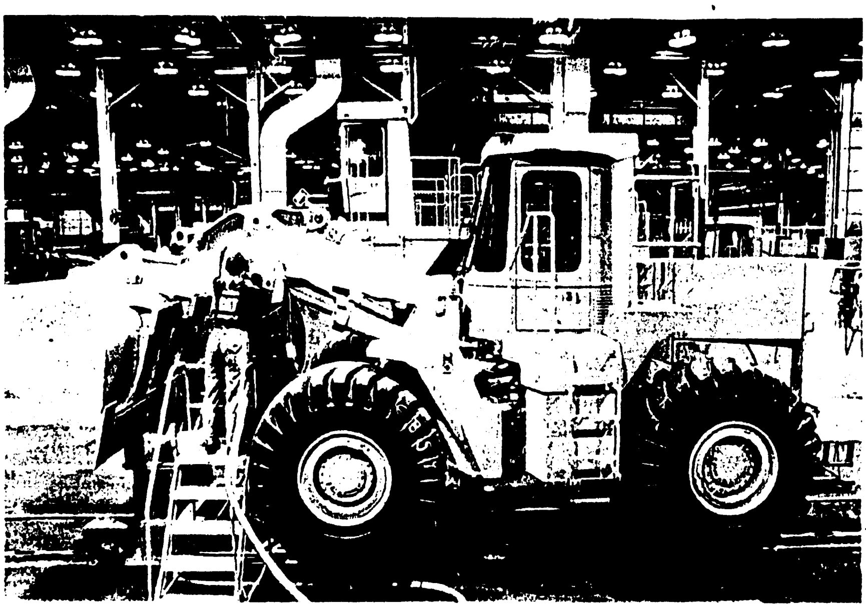
For unformed material, castings, and forgings the various expenses are distributed to the appropriate logistics cost pools and aggregated. Rates based on product weight are calculated using the poundage of material that will be used to produce product in the upcoming period. For weight moved, the poundage is multiplied by the number of times the material moves in the production process.

For purchased finished parts—those ready to be assembled into the product upon receipt—the rate is based on material prices. We do not have weights for all of these parts in our data files, but we are in the process of establishing a weight database for these items so we can improve this area. We believe weight is a good basis for assigning logistics costs to our products. Table 1 illustrates the rate calculations (not real numbers).

MANUFACTURING ACTIVITY POOL

In the manufacturing activity pools are costs associated with operating machines, manufacturing cells, work stations, assembly, test, painting, and shipping areas. Expenses are categorized on a period and variable basis and are assigned to individual cost centers by specific cost element.

Establishing the manufacturing activity rates is the most challenging aspect of our cost system. Typically, a Caterpillar factory has hundreds of cost centers for which rates are set. The logistics cost rates and the many manufacturing cost center rates are the unique elements that set Caterpillar's system apart from simple cost systems.



Wheel loader assembly process in Aurora, Illinois.

"Mini-budgets" of estimated expenses are prepared for each cost center. In each machining and fabricating area are three rates: a variable man rate, a variable machine rate, and a period machine rate. To aid in the rate-setting process for each area, cost information is entered on appropriately formatted data sheets. Ultimately it is entered into the computerized cost system for use in product costing.

The variable man rate is simple. It contains the pay rate and fringe benefits of the direct labor worker. No other expense is assigned to a product based on direct labor hours.

The variable machine rate includes costs related to operating the machine. Perishable tooling expense includes not only the tools—such as drills, taps, and cutting tools—but also a portion of the costs of operating the tool crib and grinding reusable tools. Power expense is based on the energy consumed while the machine is running. Other consumables, such as gas, propane, shot peening, cleaning materials, and weld flux, and the costs of handling them are included. Spoilage and rework, quality auditing, first-line supervision salaries, and other variable support costs complete this rate.

The period machine rate contains the depreciation for the specific machine or machines and other equipment in each cost center. Also included in this rate are the costs related to building occupancy, which are treated as a rental charge. These costs are assigned based on the floor space occupied by the cost center and include the depreciation on the building, heat and lights, plant security, and building maintenance and repair costs. The durable tool element includes the depreciation and expenses related to dies, jigs, and fixtures and the costs for storing and maintaining them. The repairs to machines, tooling, and equipment and related supervisory and management costs are based on machine repair and maintenance records. Planning expenses are based on the salaries of the industrial engineers who support each area. Other period machine expenses and period labor complete this rate.

The man rate is based on the direct man hour. The variable and period machine rates are based on the machine hour. The calculations in Table 2 illustrate the rate calculations (not real numbers).

TABLE 2

VARIABLE MAN RATE

Machine or Cell Area No.	M25
Machine Class	D8R (Drill)
Section No.	100
Operator Class	A500
Top Rate of Classification	$15.00
Fringe Benefits (Vacation, Holiday, etc.)	8.00
	23.00
Efficiency Factor	92%
Rate Per Man Hour	$25.00

PERIOD MACHINE RATE

Depreciation	$30.00
Occupancy Cost	8.00
Durable Tooling	7.00
Machine Repair	4.00
Process Planning	6.00
Other Period Machine Expense	3.00
Period Labor	2.00
*Rate Per Machine Hour	$60.00

VARIABLE MACHINE RATE

Perishable Tooling	$10.00
Energy Consumption	3.00
Indirect Material:	
Gas/Propane	N/A
Shot Peening	N/A
Cleaning Material	.50
Weld Flux	N/A
Material Handling	N/A
Spoilage and Rework	.50
Quality Auditing	2.00
Supervision	3.00
Other Variable Labor Support	1.00
Rate Per Machine Hour	$20.00

*Period rate base set on longer-term volume trends.

ASSEMBLY ACTIVITY POOL

The other manufacturing activity center rates are set for product assembly. Rates are set for each of the assembly areas and the related test, paint, and shipping areas. The attribution of costs involves a process similar to that used for man and machine rates. Variable and period rates are set based on average monthly expenses for each area and related support activities.

Variable rates include the costs of assemblers, test people, painters, and shipping personnel. Other costs are for clerical support, quality assurance, housekeeping, factory accounting, handling of products, tooling, indirect material and expenses, power, gas, supervision, and other support costs.

The period rate takes in specific depreciation on productive assets, occupancy costs, training, tool and equipment repair, and other supervisory and management costs.

Expenses are distributed to the assembly, test, paint, and shipping areas, and rates are set for each. The bases for determining the rates are the average monthly hours to assemble, test, paint, and ship product in each area in the upcoming period. Table 3 illustrates assembly area calculations (not real numbers).

Costs traceable to the production process are assigned to logistics and manufacturing activities. Assigning these costs properly involves extensive data gathering, functional surveys, and ongoing interaction with factory and support personnel. A good cost system must be flexible enough to accommodate changes in the operating environment. Support activities migrate as products mature, new products come on stream, and manufacturing processes stabilize. The consumption of these activities by products will change over time, and cost rates must be adjusted accordingly.

TABLE 3

Variable	Expense Distribution	Assembly Hours	Rate Per Hour
Assembly Line A	$ 500,000	10,000	$50.00
B	300,000	5,000	60.00
C	800,000	20,000	40.00
D	700,000	10,000	70.00
Total	$ 2,300,000		
Period			
Assembly Line A	$ 240,000	12,000	20.00
B	180,000	6,000	30.00
C	600,000	24,000	25.00
D	480,000	12,000	40.00
Total	$ 1,500,000		

* Period rate bases are set on longer-term volume trends.

GENERAL OVERHEAD

Many cost elements such as direct labor, energy, machine depreciation, and maintenance can be identified reliably and assigned specifically. Others require more effort. The further removed an activity is from identification with a specific manufacturing process the more difficult it is to assign costs reliably. At the far end of this spectrum are costs that are so general in nature that it is difficult to identify with a product on any reliable or consistent basis. These costs go into general overhead activity pools and include some of the period expenses for accounting, employee relations, labor relations, plant administration, medical services, scheduling, and inventory control. Two rates are established—one for in-house manufactured parts and one for purchased finished material. These pools of cost are small in relationship to the total.

These costs are assigned to products based on a percentage of the total of all other costs, including production material. Parts costing the most will absorb a larger portion of general overhead. Table 4 illustrates these calculations (not real numbers). (We are currently developing methods to make general burden costs more product specific.) The logistics, manufacturing, and general overhead cost rates are updated every six months based on the latest budget.

The entire organization must "own" the cost system and be involved in keeping the databases accurate and up to date.

OTHER KEY INPUT

That's the cost rate side—but product costing requires other key information. Our system uses several other data files to provide all the ingredients that are necessary for costing:

- *The Purchase Order File*—Provides the direct material price based on the latest purchase order.
- *The Station List File*—Provides descriptive data about the product by part number, such as source of supply, rough weight, quantity per piece, and parent part number.
- *Production Routing File (work order)*—Provides man and machine time by operation, machine numbers, setup times (if any), lot size indicator, and other key information. A separate file contains the product assembly, test, paint, and ship times.
- *Requirements File*—Provides the production requirements (quantities) for all products, attachments, replacement parts, and interplant material to be produced.
- *Product Structure*—Level-by-level bill of material.

It is vital that the entire organization "own" the cost system and be involved in keeping the databases accurate and up to date. A good cost system is more than an accounting responsibility. These files are updated monthly.

TABLE 4
GENERAL OVERHEAD

	Worked Material	Purchased Finished
Overhead Expense	$2,000,000	$1,800,000
Total Material, Logistics, and Manufacturing Cost Base	20,000,000	24,000,000
Rate Per $	.1000	.0750

COSTING THE PRODUCT

To understand the costing of an individual part is to understand product costing at Caterpillar. Table 5 explains the process, using part number 1A1 housing made from an iron casting as an example.

The table shows how the 1A1 casting goes through the production process, drawing costs to it as it moves toward completion. The appropriate rates assigned costs based on how the product consumed activities along the way and assigned the costs to each operation.

In this example, the logistics costs were significant, which is typical of the handling costs on large components. Also there was a wide variation in the costs of operating the various machines used to produce the part. These differences in resource consumption illustrate why simplistic cost systems that don't recognize such differences will distort product costs.

The cost system has the capability to take 1A1 costs and the costs of all other parts, components, and assemblies and roll them up to produce the total cost of a complete salable product. The system uses a level-by-level bill of material to accomplish this rollup.

HOW COST INFORMATION IS USED

A standard cost system accumulates and reports costs for products as they move through the production process. The need for this information is driven by the financial

The shuttle transporting prime product between assembly stations in the Gosselies, Belgium, facility.

reporting cycle. To satisfy this need, the day-to-day stream of manufacturing events activates the standard cost system.

Our managerial cost system has no such repetitive driver. It is "activated" by requests for cost information on specific parts, products, and processes. In this regard it is a "database in waiting"—a computerized cost consultant. It is used only when its services are requested. If no questions are asked, the system sits there, like the lonely Maytag repairman, waiting for a call. But be assured, unlike the situation of the Maytag man, the phone is always ringing.

Caterpillar's system is called the "Cost Information System" or CIS. A variety of product cost and descriptive data are available on-line as printed output or in user files. In each of these applications the user can select the information desired, from the cost of an individual machining operation to one part to any level up to and including a complete product.

The system also includes an "estimated cost" module for use in estimating new product costs. This system soon will be augmented by another costing tool called "predictive costing," which will provide the design and industrial engineers with quick turnaround on the estimated costs of various design and processing alternatives. It is crucial that product cost estimates be provided at the earliest stages of product development. Most of a product's cost is locked in during the development phase, so it is vital that cost targets are attained. The "pay me later" rendition of cost management is expensive and disruptive.

Cost information from Caterpillar's system is used by individuals and teams for strategic purposes such as product development, component and piece part design decisions, sourcing decisions, quality and cost improvement analyses, investment justification studies, pricing analyses, competitive cost analyses, manufacturability, and manufacturing process alternatives.

OTHER CONSIDERATIONS

Any costing system, regardless of its quality, provides a "formula cost." If from a good system, this cost can be very useful for cost management. But cost systems, as any other management tool, have limitations, and the formula approach is not appropriate for all cost management issues.

"Unit of one" costs, for example, ignore economic factors such as inflation; time value of money; currency fluctuations; S,G,&A; R&D; parts distribution costs; new capital investment requirements; working capital; and income taxes. Other methods of analysis are needed.

Finally, cost systems are tools—no more, no less. Even the finest cannot assure cost management success. To be successful, a company must first have a cost management philosophy that is brought to life through a well-conceived, clearly understood cost management strategy. And, the entire organization must be involved. Additionally, the management accountants must understand the company's products, processes, engineering systems, suppliers, customers, and competitors—and be part of the team. If these things aren't in place, a cost system can't compensate for the lack of them.

A cost system is just one part of the equation. If the other elements are in place, then the cost management process becomes a powerful force for improvement and for competitive advantage. ■

TABLE 5

Part number 1A1 housing made from an iron casting.

Material Cost				$ 500.00
Variable Weight Base Logistics (.0300 x 1,000 lbs.)				$ 30.00
Variable Man:				
Operation	**Man Hrs. Per Piece**	**Rate Per Hour**	**Cost Per Piece**	
5 Mill	.52	$23.00	$12.00	
10 Drill	.27	22.00	6.00	
15 Turn	.34	24.00	8.20	
20 Bore	.42	28.00	11.80	
25 Clean	.10	20.00	2.00	$ 40.00
Variable Machine:				
Operation	**Mach Hrs. Per Piece**	**Rate Per Hour**	**Cost Per Piece**	
5 Mill	.50	$16.00	$8.00	
10 Drill	.25	30.00	7.50	
15 Turn	.30	25.00	7.50	
20 Bore	.40	20.00	8.00	
25 Clean	.10	10.00	1.00	$ 32.00
Material Cost				

Note: Variable man hours include a proration of setup times based on average lot sizes. Variable machine hours do not include setup because machine-related expenses are consumed only when the machine is running.

Variable Weight Moved Logistics: (Moves are one from receiving area to the manufacturing cell, five between machining operations, one to the checkout area, and one to the next cell or assembly area.) 8 Moves X 1,000 lbs. = (8,000 lbs. X .0050)				$ 40.00
Total Variable Costs				$ 642.00
Period Weight Base Logistics (.0150 X 1,000 lbs.)				$ 15.00
Period Machine:				
Operation	**Mach Hrs. Per Piece**	**Rate Per Hour**	**Cost Per Piece**	
5 Mill	.52	$61.50	$32.00	
10 Drill	.27	37.00	10.00	
15 Turn	.34	88.25	30.00	
20 Bore	.42	95.25	40.00	
25 Clean	.10	30.00	3.00	$ 115.00
Material Cost				
Period Weight Moved Logistics: 8 Moves X 1,000 lbs. = (8,000 lbs. X .0010)				$ 8.00
Total Manufacturing Related Period Costs				$ 138.00
Total Manufactured Costs (Variable & Period)				780.00
General Overhead @ 10%				78.00
Total Plant Cost				$ 858.00

Lou Jones is business measurements and systems manager for Caterpillar Inc. He is a member of the Central Illinois Chapter, through which this article was submitted.

[1]Throughout this article I have used the expression "cost management" for descriptive purposes because it is a commonly used term. But cost management and companion terms such as cost reduction, cost control, and cost containment have onerous implications for an organization and do not squarely address the issue. What really needs to be managed are the key business processes across the entire value chain. When they are managed well, then effective use of costs and assets is a natural consequence. For example, manufacturing is a major business process. When this process is simplified through programs such as JIT and flow manufacturing, then cost benefits follow.

Appendix D

List of Case Studies Reviewed

Harvard Case Studies reviewed related to cost accounting and estimating:

9-190-085, Bridgeton Industries, Automotive Components and Fabrication Plant, fuel tanks, manifolds, doors, exhaust systems, oil pans.

9-189-084, Seligram, Inc. Electronic Testing Center.

9-187-048, Mueller-Lehmkuhl GmbH, German producer of apparel fasteners.

9-187-107, -108, John Deere Component Works.

9-187-194, American Bank.

9-190-002, Kanthal, Swedish producer of electric heating products and bimetals for thermostats, circuit breakers, and household appliances.

9-188-142, -143 , Tektronics - Portable Instruments Division, oscilloscopes.

9-187-098, Polysar Limited, Canadian chemical company.

9-189-096, HCC Industries, producer of hermetically sealed electronic devices and microelectronic packages.

9-189-083, Digital Communications, Encoder Devices Division.

9-194-032, Ford Motor Company, Romeo Engine Plant.

9-184-047, Chemical Bank.

9-189-146, Metabo GmbH & Co. KG, manufacturer of power hand tools.

9-186-302, Fisher Technologies, manufacturer of experimental vanes and foils for turbines.

9-186-050, -051, Schrader Bellows, manufacturer of pneumatic and fluid power components.

9-193-031, Euclid Engineering, engineering, design, and rapid prototyping for automotive industry.

Appendix E

Direct Contact, Questionnaire, and Discussions

UNIVERSITY OF MICHIGAN TRANSPORTATION RESEARCH INSTITUTE (UMTRI)
MARINE SYSTEMS DIVISION
2901 Baxter Road
Ann Arbor, MI 48109

FAX COVER SHEET

DATE:	March 2, 1995	**TIME:**	2:05 PM
TO:	Rick Fichera The Boeing Company	**PHONE:** **FAX:**	206-773-3485 206-773-3787
FROM:	Patrick Cahill UMTRI/MSD	**PHONE:** **FAX:**	313-763-2465 313-936-1081
RE:	Richard Moore's March 16 Visit		

Number of pages including cover sheet: 4

Message

Per our phone conversation yesterday, find attached a list of questions that we developed to support our benchmarking study. Many of them may be answered by the presentations that you have prepared. Some may be more specific than you intended to get. I have marked the ones the will probably be addressed. I hope this aids you in your preparations. Feel free to call if you have any questions.

Cost Estimating and Control System Benchmarking

Boeing Defense & Space Group

Customer Base

1. Is your customer base commercial, government or both? Do you have different products for the different customers, or different versions of the same product? What are the percentage breakdowns? Possibly covered in Session 1 9:00 am

2. Are your prices set at the product level with no variation between customers, or are they negotiated per customer on a volume or other basis? Is this driven by financial concerns, marketing issues or some other factor or factors?
Possibly covered in Session 1 9:00 am

Product Development

3. How much customer input goes into new product development? Do you design a product to market to customers, or market your product capability to customers and then design to their specifications?

4. What percentage of your product development effort is spent on the development of "all new" products versus products that are incremental evolution of existing products? How often is an "all new" product developed?

5. To what degree, generally, do your "all new" products utilize existing standard components and subassemblies? May be covered in 10:15 session

6. How are product design alternatives compared relative to cost?
   Are absolute cost estimates developed for each alternative, or is a comparative analysis done based on the relative "producibility" of specific product attributes? Or is another approach used?

7. Do in-process design changes (change orders) occur or are products built to an end spec and sold as designed and built by your company?

Estimating Direct Labor

May be covered in 2:30 session

8. During product development, how are direct labor costs estimated?
   For evolutionary products?
   For "all new" products?

9. Are there direct labor cost standards (cost or labor hours per product attribute, example- 0.3 labor hours per of pipe piece assembled) available for existing production

processes? Do the standards have material attribute driven variations (i.e. size and thickness of pipe) within each process?

10. How were existing direct labor cost standards, if any, developed, or where did they come from?

11. How are direct labor cost standards developed for anticipated future production processes?

12. Are direct labor cost standards applied automatically to a computer-based product model based on attributes of the product, or are standards applied through some manual analysis and manipulation of data?

13. How did the process of estimating direct labor costs evolve in your organization? What were the forces affecting the development of this estimating process.

14. Are direct material cost estimates developed and applied during product development, and, if so, how are they developed and applied?

Estimating Indirect Costs may be covered in 2:30 session

15. If absolute cost estimates are generated during product development, do they include an estimated allocation of indirect costs to the product? If an absolute cost estimate does not include an estimated allocation of indirect costs, is some effort made to identify how different design attributes might effect indirect product costs? How?

16. If absolute cost estimates are not generated and only an attribute-based comparative producibility analysis of design attributes is done, does this comparative analysis take into account the potential effects of design attribute on indirect product costs? How?

17. If absolute cost estimates are generated during product development that include an estimated allocation of indirect costs to products, how are indirect costs allocated to products? What indirect cost pools have you defined and why, and what cost drivers have you defined to allocate costs between indirect functions, cost pools, and products?

18. Are indirect cost pools used in day to day cost management practices which are affected by market fluctuations, or are the cost pool estimates normalized and used more for strategic decision making?

19. Do you feel that accurate estimates of anticipated production volume are required to make indirect cost allocation estimates meaningful? Why or why not? For which indirect cost functions or pools?

Capacity Questions

20. Do you consider your operation, for cost estimating and control purposes, to be:
    a. one-off type production
    b. multiple lot production of a small number of significantly different products
    c. multiple lot production of a large number of different products
    d. large scale production line style multiple lot production
    e. something different?

21. Are 100% of capacity costs (direct and indirect) charged to products regardless of whether future product volumes are expected to utilize full production capacity? Why or why not?

22. How much would you normally expect actual production volume over the life of a new product to vary from initial estimates of volume?

Cost Collection Questions Maybe covered in 2:30 session

23. What type of cost collection scheme or job order numbering system, if any, is used for charging and accumulating direct labor hours? How is it tied to organization, system and production processes within engineering, planning, production, quality assurance, accuracy control and logistics support?

24. Does the job order numbering system tie into collection of indirect costs?

25. What type of system is used to identify material and equipment procurement, warehousing and handling costs?

26. What physical method, if any, is used to log hours? Timecards, timesheets, bar codes, mag stripe badges etc.? How does it relate to the job order numbering system?

27. What type of cost data, if any, is submitted to the customer? What form is it in both physically (paper, disk etc.) and structurally (data elements)?

28. How are return costs fed back into the cost estimating system?

Agenda for University of Michigan Visit to Boeing Defense & Space Group
Wednesday March 15, 1995

Sent to: *Henry Schwartz* · *Frank Ralchiek* · *Terry Donlin* · *Joe Lewis* · *Dick Moore* · *Carolyn Thomas*

MORNING

Time	Topic	Discussion Leader	Location
7:45	**Introductions** *Introduce participants, and establish the objectives of the day's session*	Joe Lewis and Dick Moore	Process Room (Building 18-26.2) ↓
8:00	**Shipbuilding Overview** *A description of the business challenges facing the shipbuilding industry, and the specific objectives of the study being conducted by the University of Michigan's Marine Systems Division*	Dick Moore	
9:15	**Integrated Product Team Implementation** *A description of the Integrated Product Team (IPT) approach used by Boeing, and discussion of the challenges encountered implementing IPTs on development and production programs*	Terry Donlin	
10:00	**Engineering / Operations Process Coordination** *An overview of the work underway to integrate and standardize key Engineering and Operations processes. Discussion of the challenges faced in delivering and implementing processes across programs. Also, a walk through of the Process Integration Room.*	Terry Donlin	
10:30	**Quantifying Savings Resulting From Process and Tool Improvements** *A description of an approach for pricing future business considering process improvements, using a single trade study as an example*	Steve Otrosa	
11:15	**Discussion**	All	

Agenda for University of Michigan Visit to Boeing Defense & Space Group
Wednesday March 15, 1995

AFTERNOON

11:30	**Lunch (catered)**		Estimating Conference Room (Building 18-05.1)
12:30	**Dick Moore discussions with Frank Ratchiek (agenda to be set by Dick)**	Dick Moore and Frank Ratchiek	TBD
1:45	**Use of Historical Data** *Work underway to build an expanded set of historical cost and product characteristics data, using a framework tied to technical processes*	Rick Fichera	Estimating Conference Room (Building 18-05.1) ↓
2:30	**Affordability and Cost Trade Example** *An overview of current work with ARPA and others to design and prototype a low cost ASTOVL fighter aircraft*	Mike Delabarre	↓
3:15	**Use of Models (Commercial and Boeing Composite Cost Model)** *Tools to help teams understand the cost impact of alternative configurations and conduct tradeoffs*	Steve Otrosa ~~Est~~ Ken Vergowe	↓
4:00	**Wrap Up Discussions**	All	↓

Cost Estimating and Control System Benchmarking Questions
Caterpillar

Customer Base

1. Is your customer base commercial, government or both? Do you have different products for the different customers, or different versions of the same product? What are the percentage breakdowns?

2. Are your prices set at the product level with no variation between customers, or are they negotiated per customer on a volume or other basis? Is this driven by financial concerns, marketing issues or some other factor or factors?

Product Development

3. How much customer input goes into new product development? Do you design a product to market to customers, or market your product capability to customers and then design to their specifications?

4. What percentage of your product development effort is spent on the development of "all new" products versus products that are incremental evolution of existing products? How often is an "all new" product developed?

5. To what degree, generally, do your "all new" products utilize existing standard components and subassemblies?

unit of - - one - (CE & prediction)

6. How are product design alternatives compared relative to cost?
   Are absolute cost estimates developed for each alternative, or is a comparative analysis done based on the relative "producibility" of specific product attributes? Or is another approach used?

7. Do in-process design changes (change orders) occur or are products built to an end spec and sold as designed and built by your company?

Estimating Direct Labor

8. During product development, how are direct labor costs estimated?
   For evolutionary products?
   For "all new" products?

An estimated cost module and a predictive costing tool have been added to the Cost Information System. Details are unknown.

9. Are there direct labor cost standards (cost or labor hours per product attribute, example- 0.3 labor hours per of pipe piece assembled) available for existing production processes? Do the standards have material attribute driven variations (i.e. size and thickness of pipe) within each process?

The only place direct labor comes into play is in the Manufacturing Activity pool. It is a variable man rate based on the classification of a worker in a particular manufacturing cell. The rate contains the pay rate and fringe benefits for the worker. Costs are alllocated to the products based on the hours spent working on the product within that particular cell. It wuld appear that return cost collection establishes the standards to use for different products.

10. How were existing direct labor cost standards, if any, developed, or where did they come from?

11. How are direct labor cost standards developed for anticipated future production processes?

12. Are direct labor cost standards applied automatically to a computer-based product model based on attributes of the product, or are standards applied through some manual analysis and manipulation of data?

13. How did the process of estimating direct labor costs evolve in your organization? What were the forces affecting the development of this estimating process.

In the 1940's former CEO William Franklin recognized that product costing with a single plantwide overhead rate based on direct labor was erroneous. He implemented the Machine Burden Unit system, which evolved into the Cost Information System

14. Are direct material cost estimates developed and applied during product development, and, if so, how are they developed and applied?

Direct material prices are obtained from the Purchase Order File, which provides the price based on the latest purchase order.

Estimating Indirect Costs

15. If absolute cost estimates are generated during product development, do they include an estimated allocation of indirect costs to the product? If an absolute cost estimate does not include an estimated allocation of indirect costs, is some effort made to identify how different design attributes might effect indirect product costs? How?

16. If absolute cost estimates are not generated and only an attribute-based comparative producibility analysis of design attributes is done, does this comparative analysis take into account the potential effects of design attribute on indirect product costs? How?

17. If absolute cost estimates are generated during product development that include an estimated allocation of indirect costs to products, how are indirect costs allocated to products? What indirect cost pools have you defined and why, and what cost drivers have you defined to allocate costs between indirect functions, cost pools, and products?

18. Are indirect cost pools used in day to day cost management practices which are affected by market fluctuations, or are the cost pool estimates normalized and used more for strategic decision making?

Period costs are normalized by spreading them over long term average volumes.

19. Do you feel that accurate estimates of anticipated production volume are required to make indirect cost allocation estimates meaningful? Why or why not? For which indirect cost functions or pools?

Capacity Questions

20. Do you consider your operation, for cost estimating and control purposes, to be:
    a. one-off type production
    b. multiple lot production of a small number of significantly different products
    c. multiple lot production of a large number of different products
    d. large scale production line style multiple lot production
    e. something different?

21. Are 100% of capacity costs (direct and indirect) charged to products regardless of whether future product volumes are expected to utilize full production capacity? Why or why not?

22. How much would you normally expect actual production volume over the life of a new product to vary from initial estimates of volume?

Cost Collection Questions

23. What type of cost collection scheme or job order numbering system, if any, is used for charging and accumulating direct labor hours? How is it tied to organization, system and production processes within engineering, planning, production, quality assurance, accuracy control and logistics support?

24. Does the job order numbering system tie into collection of indirect costs?

25. What type of system is used to identify material and equipment procurement, warehousing and handling costs?

26. What physical method, if any, is used to log hours? Timecards, timesheets, bar codes, mag stripe badges etc.? How does it relate to the job order numbering system?

27. What type of cost data, if any, is submitted to the customer? What form is it in both physically (paper, disk etc.) and structurally (data elements)?

28. How are return costs fed back into the cost estimating system?

UNIVERSITY OF MICHIGAN TRANSPORTATION RESEARCH INSTITUTE (UMTRI)
MARINE SYSTEMS DIVISION
2901 Baxter Road
Ann Arbor, MI 48109

FAX COVER SHEET

DATE:	March 2, 1995	**TIME:**	3:18 PM
TO:	Harv Martin Trane	**PHONE:** **FAX:**	719-585-3811 719-585-3896
FROM:	Patrick Cahill UMTRI/MSD	**PHONE:** **FAX:**	313-763-2465 313-936-1081
RE:	UMTRI Cost Estimating Benchmarking Study		

Number of pages including cover sheet: 4

Message

Per our phone conversation earlier, find attached a list of questions that we developed to support our benchmarking study.

UMTRI is under contract to the U.S. Navy to evaluate the cost estimating and control systems used in industries other than shipbuilding as part of a Product Oriented Design and Construction (PODAC) Cost Model development project. The study involves "benchmarking" the systems used in at least three non-shipbuilding industrial manufacturing facilities. Our preliminary research led us to select Caterpillar, Boeing and Trane as a diverse cross section of world class, commercially competitive manufacturers who have successfully implemented innovative cost control and estimating systems.

Mr. Richard Moore, the head of the UMTRI Marine Systems Division, will be making site visits to Caterpillar's Peoria, IL facility on March 14, and Boeing's Everett, WA plant on March 16. If it is at all possible, he is very interested in seeing first-hand how Trane has implemented their cost control system at the Pueblo facility and could work in a visit on either March 15 or 17.

If a site visit is not possible, we would greatly appreciate it if you could take a few minutes of your time and respond to the questions provided. If you require some form of non-disclosure agreement we will be happy to comply.

I can be reached at the number listed above if you have any questions, comments or suggestions. Mr. Moore will be back in the office tomorrow morning and can be reached at the same number if you would like to speak with him.

Thank you for your time and consideration.

Phone Conversation Record

DATE:	March 6, 1995
TIME:	4:20 PM
UMTRI Employee:	Patrick Cahill
Person ~~Called~~/Calling:	Harv Martin
Company:	Trane
Phone Number:	719-585-2811
Fax Number:	719-585-3896

Subject: Cost estimating benchmarking trip

Notes

Mr. Martin called in response to the fax sent last week with our questions and a request for a visit on March 15 or 17. He declined the visit request, stating that he was too busy during that time period and could not support the visit.

He further declined to answer the questions sent, stating that were fairly detailed and that answers would be delving into proprietary and confidential information. He suggested a review of the article on the SOUP accounting method, and offered to clarify anything mentioned in the article.

I asked for clarification on how they account for government versus commercial products. Mr. Martin stated that since their products were priced with a final, deliverable price and there was no in-process accounting to the customer required, they did not have to differentiate between customers in their cost management system. He further stated that whatever was necessary to put their products on a certified or qualified pricing list for the government was handled outside of the product manufacturing arena, and that he was not familiar with the specifics.

In reference to estimating new products, Mr. Martin stated that products were estimated primarily on the basis of material content; labor is such a small percentage of end cost that it is not considered. Indirect costs are allocated to the products based on large scale pools that are averaged out over the number of units delivered during a given time frame. Variations of their products are also costed based on material content. Customers specify particular performance attributes and Trane determines the component changes necessary to deliver that product with the cost differential based on the material costs.

Appendix F

Trip Report of Howard M. Bunch

Dated March 1995

TRIP REPORT
VISIT TO CATERPILLAR CORPORATION AND TO THE BOEING COMPANY
MARCH, 1995

BY

HOWARD M. BUNCH, BUNCH & ASSOCIATES

I. INTRODUCTION

This document is a report of a trip to Caterpillar Corporation (Caterpillar), Peoria, IL, and to The Boeing Company Defense and Space Group (Boeing), Seattle, WA, by Howard M. Bunch, Bunch & Associates(B&A). He was accompanied on the trip by Richard C. Moore, University of Michigan Transportation Research Institute (UMTRI). Complete addresses for both persons are found in Appendix "A".

There is first a general description of the trip: the schedule, and the objectives. This is followed by a description of events that occurred at Caterpillar. Then there is a section describing the events at Boeing. The final section reexamines the trip on the basis of four topics: activity based costing; use of integrated product/process design (IPPD) for innovative cost proposals; the business approach, competition, and culture; and parallels to the shipbuilding business.

A. Sponsorship

The trip was authorized by Delivery Order 0001[Mod 1] (Product-Oriented Cost Tool Development) under Contract NOO140-94-D-BC08 between the Naval Regional Contracting Center and Designers and Planners, Inc.

B. Schedule

The trip and the interviews occured during the period March 13-16, 1995.

Caterpillar personnel were interviewed on March 14, 1995.

Boeing personnel were interviewed on March 15, 1995.

Preparation of the trip report occurred during the period March 25-April 7, 1995.

C. Contacts

Appendix "A" gives the names and addresses of persons with whom meaningful contact occurred during the trip.

II. CATERPILLAR

A. Interviews

The movement to become a "world-class", competitive manufacturer was initiated in the early 1980s. It resulted from recognition that foreign competitors, especially Komatsu of Japan, was putting comparable products into the U.S. at a much cheaper cost. The company concluded, as the result of investigations conducted at the beginning of the restructuring process, that it was too functionally organized, and was too bureauacratic. It was concluded that the fundamental concept that must be followed was a "customer-driven delivery system." The entire company must develop a thorough understanding of customer needs, and respond as a total unit to those needs.

The first process to get underway was "customer focus," which was directed to reorganizing marketing; it started in 1983.

In 1987 "manufacturing and logistics" was initiated, with a focus on moving future-directed technologies into the enterprise. The project continued through 1994.

In 1989 the focus began to center on shortening the development process of new product development and introduction. There is continuing emphasis on this area of focus.

The company began a series of "reengineering initiatives" that have continued to the present. The first, "Strategy and Decision Making," was to develop a plan to reorganize the company into profit centers. It got underway in 1990

Performance measurement systems were given priority, starting during the 1990-91 period.

In 1993 the focus started on the business support processes. The goal was to respond to a request on demand, and to have zero errors in the system. To accomplish this "ON DEMAND, NO ERROR" there will be specific consideration given to the following"

- order fulfillment
- employee profiles
- recycling
- payroll processing
- accounts payable
- procurement
- financial reporting
- budgeting/forecasting
- one button product cost

The cost management services group was responsible for the "one button product cost" effort. They worked with the business units to understand their cost management needs; the technique was to sign partnership agreements tailored to the specific needs of each of the units.

In all of the initiatives, the actions were driven from top management. The overall system is shown in Figure 1, "Creating a High Velocity Caterpillar," which is the initial slide in a presentation given to visitors concerning the enterprise reengineering taking place at the company.

Insert Figure 1 about here.
slide 387-4 from Caterpillar briefing slides

The company has developed a series of games as management training tools. There is a business analysis game, that is focused on cash flow training. The second is an accountabilities game that is focused on accountability training. The third is the cost connection game which concentrates on cost control and management. The cost connection game is linked to the other two, and to management training programs in business strategy.

Appendix B.1 contains the "overheads" that were shown during the background briefing that related to the history of cost management at Catepillar.

B. Cost Modeling

The cost modeling concept is derived from the product life cycle; and cost management focuses on internal management needs of the business rather than on financial accounting external requirements. Appendix B.2 is a handout that was received that described the cost management system, and how it ultimately leads to the cost models utilized by the company. Appendix B.3 is a copy of a paper[1] that describes the costing system used at the company. Both the paper and the interviews were consistent in that the company has developed a product costing system that is a modified version of activity based costing. Each machine tool, manufacturing cell, and assembly area has distinct owning and operating costs. As products pass through these areas they consume different amounts of these costs. The concepts of

[1] "Product Costing at Caterpillar," Management Accounting, February, 1991.

specific costing rates and bases are applying the rates to individual products are the heart of the company's costing model.

III. BOEING COMPANY

A. Interviews

The discussion opened with an overview of Boeing's approach to cost control. "Boeing is trying to design a system where the the handshake between system design and production is seamless."[2] The company is building cost estimating systems on the basis of process analysis.

The company has reorganized into a product-oriented structure (versus a functional structure). They find that this structure improves the competitive position; it flattens the organization, thereby reducing layers of management; it brings to bear the maximum skills of more people; the people with the most knowledge are doing the work, and are more involved in the decision process.

Part of the product-oriented structure is the use of analysis integration teams (AIT). These teams are composed of representatives that go across the entire product. The team's major objective is to produce a program execution plan (PEP). The PEP is the design/build strategy document for the product line.

The product-oriented structure looks like that shown in Figure 2, on the next page. The structure is dominated by integrated product teams (IPT), with only the program support functions and the AIT not being so designated. On the IPTs there is strong customer link-up with actual customer participation and involvement in the meetings.

The IPT program is being institutionalized throughout the entire corporation.

Because of its responsibilities, the AIT is the first team to be established. This team quickly defines the IPT structure, which is then implemented. The company believes that early staff-up results in a net reduction in resource requirements. This concept is illustrated in Figure 3, on the next page. The product team concepts reinforces the earlier staffing concept.

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[2]Terry Donlin (See appendix A for complete title and address)

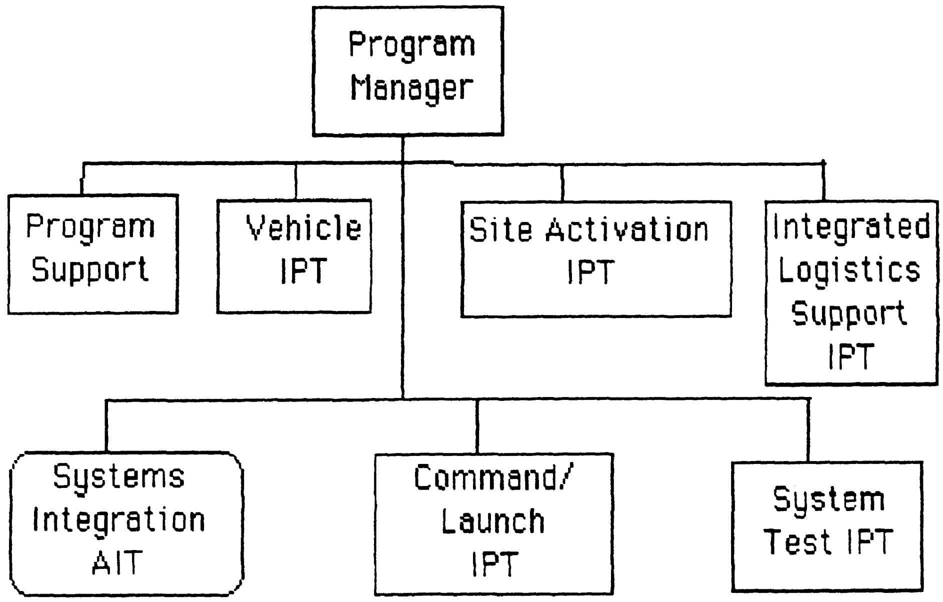

Figure 2. Product-oriented Organizational Structure

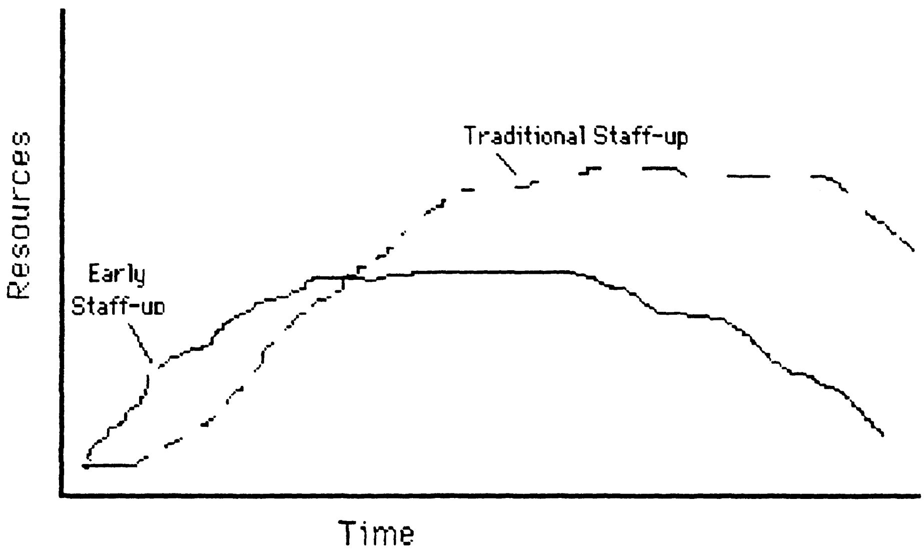

Figure 3. Comparison of Resource Expenditures Based on Staff-up Timing

One of the major decisions on the project team formulation occurred in 1993 when senior management decided that product definition and product production must be a seamless process, with complete integration. Once this principle was accepted, the IPT implementation proceeded quickly.

B. Cost Modeling

The interviewees for the cost modeling topics were Steve Otrosa, Joe Hunt, and Ken Vergone.

The sequence of developing a cost estimate is as follows:

1. The function to be evaluated is defined.
2. The process changes that will occur are highlighted.
3. The trade studies are performed.
4. The trade studies are documented.
5. Catalogue is developed to support detail estimates.
6. Impact statement is prepared for the processes.
7. New estimated is prepared.

There are basic task unit (BTU) templates for about 60 tasks that describe the major processes. Each template shows the process sequence, task and products, cost drivers, and charging guidance. These templates have been developed from historical data. There is an analysis of the effects of the task templates, which are then applied against some reduction factors. The technique of analysis is the following:

1. An analogy is constructed using pre-established cost drivers.
2. Parametric models are utilized.
3. Cost estimating relationship is developed.
4. Detailed estimate judgments are defined.

A composite assembly factor is then developed, which is used to determine the revised cost estimate.

One of the important aspects of the cost estimating system is the data base clearing house. There are five sections:

1. Library
2. Boeing initiatives
3. Cost analysis of each initiative
4. Master matrix

5. Boiler plate support packages.

The company has developed a method of evaluating improvements.

1. The suggested change is detailed against the existing system.
2. Each detail is evaluated as to its discrete effect.
3. The sum of the changes for the details reflects the total effect of the overall change.

A significant comment offered by one of the supervisors was that "Boeing's commercial product cost estimating system is moving away from labor estimating, and into process accounting procedures."[3]

There is a Joint Advanced Strike Technology (JAST) project office that is seeking to develop an improved cost estimating model.

There is a process cost model data base that includes the following:

1. includes internal information, EIS, EDIS, vendor quotes, industry data.
2. organized by hardware category, CER category, operating environment, and program phase.

The parametric estimating methodology is a combination of the following techniques:

1. cost models, both internally developed and purchased.
2. analogy.
3. vendor quotes.
4. discrete estimates.

Mention was made of a model based on the "Marquardt" Theory, which is a mathematical technique of developing additional information from a model. There was also mention made of the TCM Cost Estimating Model. Their system is capable of having an input tailored for elements (e.g., structure modifications), and also functions (e.g., design engineering).

Their major model is the BCCM model, using the Oracle platform, and links to CATIA. The model was developed for the Airforce. It will be extended to incorporate an element for estimating cost of composite construction.

[3] Joe Hunt [see appendix for address]

The effort to develop a cost model for composite construction will be based on process estimates, and will closely mimic the concept of activity based costing. The estimate to construct this model is about 20 man-years of effort.

IV. FINDINGS

A. Use of Activity Based Costing

Both companies use a modified form of activity based cost estimating. Caterpillar's system is built around a machine burden unit system, which is an activity orientation. The variable costs are summarized into the following activities: freight, material handling, assembly, machine, and labor. The period costs, too, are mostly activity oriented: material handling, assembly, and machine. Only "normal" overhead is the only period cost that is not activity oriented. Appendices B.2 and B.3 describe the details of the Caterpillar activity based cost estimating system.

It appears that Boeing uses both the traditional costing method and activity based costing. The latter has been brought into play more recently; it will be the approach utilized in a cost estimating model being developed for composite structure. With regard to this model, Boeing indicated the development effort would approach 20 man-years, which is indicative of the complexity of establishing an appropriate data base, and linking it up with the cost estimating system.

B. Use of Integrated Product/Process Design Approaches for Innovative Cost Proposals

Both companies indicated that the cost management system is an independent of the financial accounting system, and that there is integrated product/process relationship. Caterpillar put into place a company-wide reorganization plan about 10 years ago that is driving toward a life cycle cost management system with a very strong customer feedback.

Boeing's approach of having multiple cost estimating models and methodologies gives them the ability to develop a cost at any level of accuracy, even down to specifically tailored assemblies or functions.

C. Business Approach, Competition and Culture

Both companies are similiar in their business approach, the competition, and their culture. Perhaps the most apparent similarity is the focus on the customer. Boeing involves their customers in the design process by inviting them to evaluate prototype designs. Caterpillar has developed their management decisions system around the concept that the total life cycle is within the envelope of their concern.

Both companies consider themselves as market leaders, and both feel they are in a very competitive environment. As a result they place great emphasis on cost management and cost control, feeling that the costs (both first cost and life cycle costs) are perceived by the customer as one of the main factors in the purchase decisions. The consequence is that both companies have developed systems that can provide quick response to cost questions at any level of inquiry.

The culture at both companies seem to emulate that found in world-class organizations. The people have have long tenure, they view themselves as life-time employees, and appear to have deeply ingrained loyalty. The company, and the employees, place major emphasis on the team approach, and as a consequence, the inclination of an employee to be cooperative is viewed as a necessary requirement; one person at Boeing even stated that a "cooperative spirit" is more important than a "technological skill."[4]

In view of the foregoing, it is reasonable to expect that the two companies would be innovators in implementing integrated design/production concepts, and that these concepts be closely connected with intensive cost management and control systems that can positively respond to cost estimating needs at any level of inquiry.

D. Parallels to Shipbuilding Business

Both companies are world class enterprises, and in that relationship they have the same profile as world class shipyards. A world-class enterprise (whether it be Boeing, Caterpillar, or a shipyard) has a vision of the future, and is able to translate that vision into developing products that can meet customer needs, and at a competitive price. We saw that at Boeing and at Caterpillar. We have also seen the same characteristics at world-class shipyards.

---

[4]Banquet Speaker, Boeing Corporation, SNAME Ship Production Symposium, January 27, 1995, Seattle, Washington.

APPENDIX "A"

NAMES AND ADDRESSES

OF

PERSONS CONTACTED DURING TRIP

CATERPILLAR, INC.

1: Mr. Lou Jones
Manager, Cost Management and Business Systems
Peoria, IL 61629
309/675-4721 FAX:309/675-4588

2. Ms Karen M. Erikson
Project Manager, Business Analysis, Corporate Accounting.
100 N.E. Adams, Peoria, IL 61629-5250.
309/675-5119. FAX: 309/675-4588.

3. Mr. Robert A. Polizzi
Manager, Cost Management Services, Corporate Accounting.
Peoria, IL 61629-5190.
309/675-5190. FAX: 309/675-4598.

THE BOEING COMPANY

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Director, Estimating and Pricing
Boeing Defense and Space Group
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Seattle WA 98124-2499
206/773-3992 FAX: 206/773-3787

2. Rich Fichera
Boeing Defense and Space Group
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Seattle WA 98124-2499
206/773-3985 FAX: 206/773-3789

3. Steve Otrosa
Boeing Defense and Space Group
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Seattle WA 98124-2499
206/773-???? FAX: 206/773-3787

4. Terry E. Donlin
Manager, "Define" Processes, Eng/Product Division
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5. Henry F. Schwartz
Assistant Controller
The Boeing Company

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206/655-3244

6. Frank M. Rafchiek
Director, Research and Technology
Boeing Defense and Space Group
PO Box 3999, MS85-31
Seattle WA 98124-2499
206/773-8585 FAX: 206/773-9308

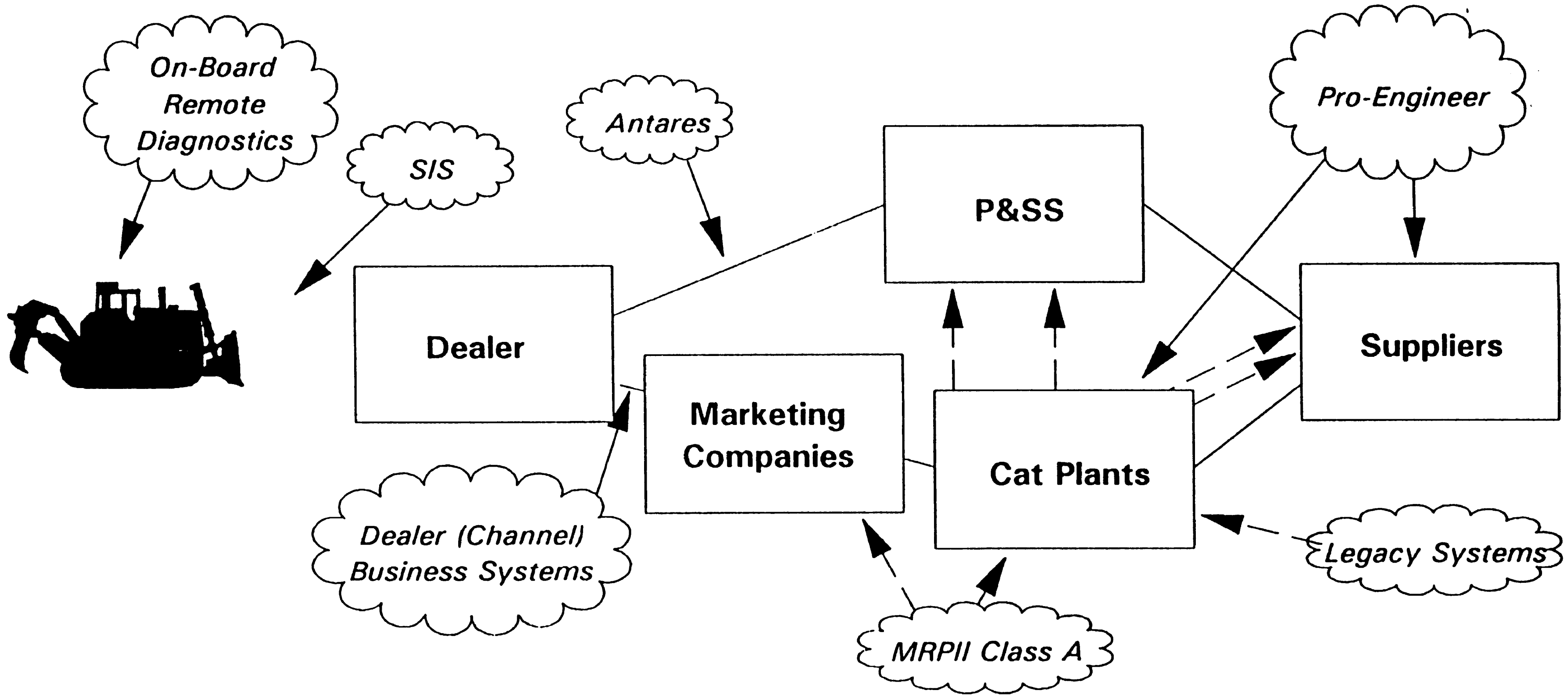
7. King G. Yee, PhD
Manager, Image Technology & Geometry Modeling
Boeing Commercial Airplane Group
PO Box 3707, MS6H-AF
Seattle, WA 98124-2207
206/237-3401 FAX: 206/237-3428

APPENDIX "B"

CATERPILLAR CORPORATION MATERIAL

APPENDIX B.1

Creating A High Velocity Caterpillar



Communications/Linkage/Speed Are Critical:

- Faster Customer Service → Competitive Advantage
- Better Asset Utilization
- Lower Costs

} → Superior Financial Performance

5.1

Reengineering At Caterpillar

Business Issue	*Action*	*Timeframe*
✓ Customer Focus	Reorganized Marketing	1983...
✓ Manufacturing & Logistics	Plant With A Future (PWAF)	1987-94
✓ Product Development	Shortened & Streamlined Process	1989...
✓ Strategy & Decision Making	Reorganized Company...Profit Centers/Service Centers	1990...
✓ Performance Measurements	Threw Out The Old... Developed New	1990-91
✓ Business Support Processes	"ON DEMAND, NO ERROR" (BHAG)	1993...

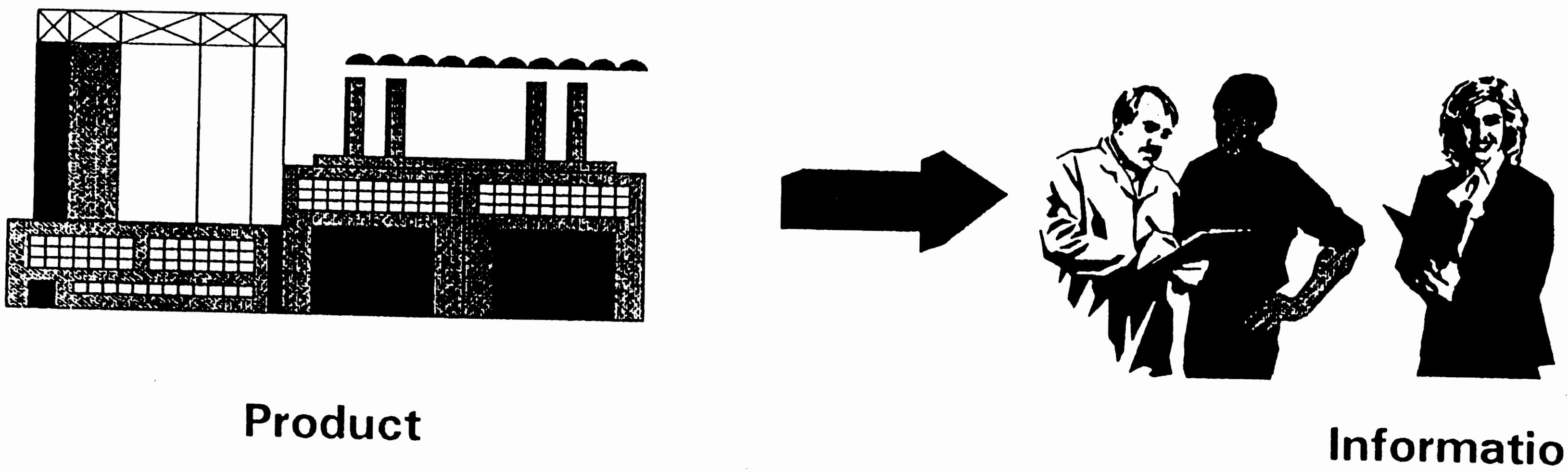
B.1

Do You Know The

BHAG?

ON DEMAND, NO ERROR Business Information

This initiative is the logical and necessary next step of driving plant modernization from the factory floor to the office environment and assisting the company with its ongoing cultural change toward increased accountability.



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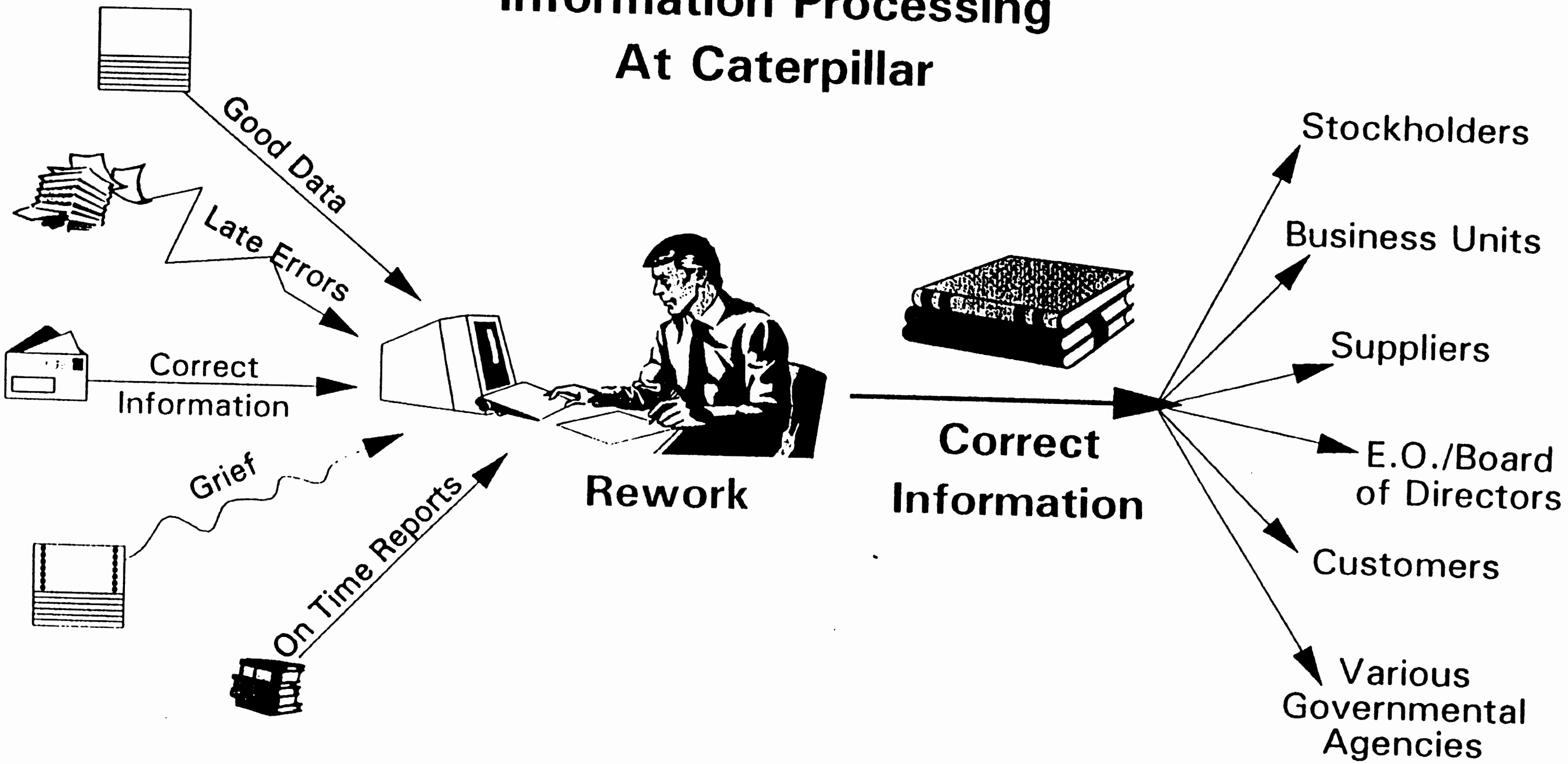
8.1

ON DEMAND, NO ERROR Business Information

Information Processing At Caterpillar



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3.1

ON DEMAND, NO ERROR Business Information

ON DEMAND, NO ERROR Is...

- People Involvement
- Total Quality Management
- Continued Cultural Change
- Use of "Time" For Competitive Advantage

⬇

Does Drive....

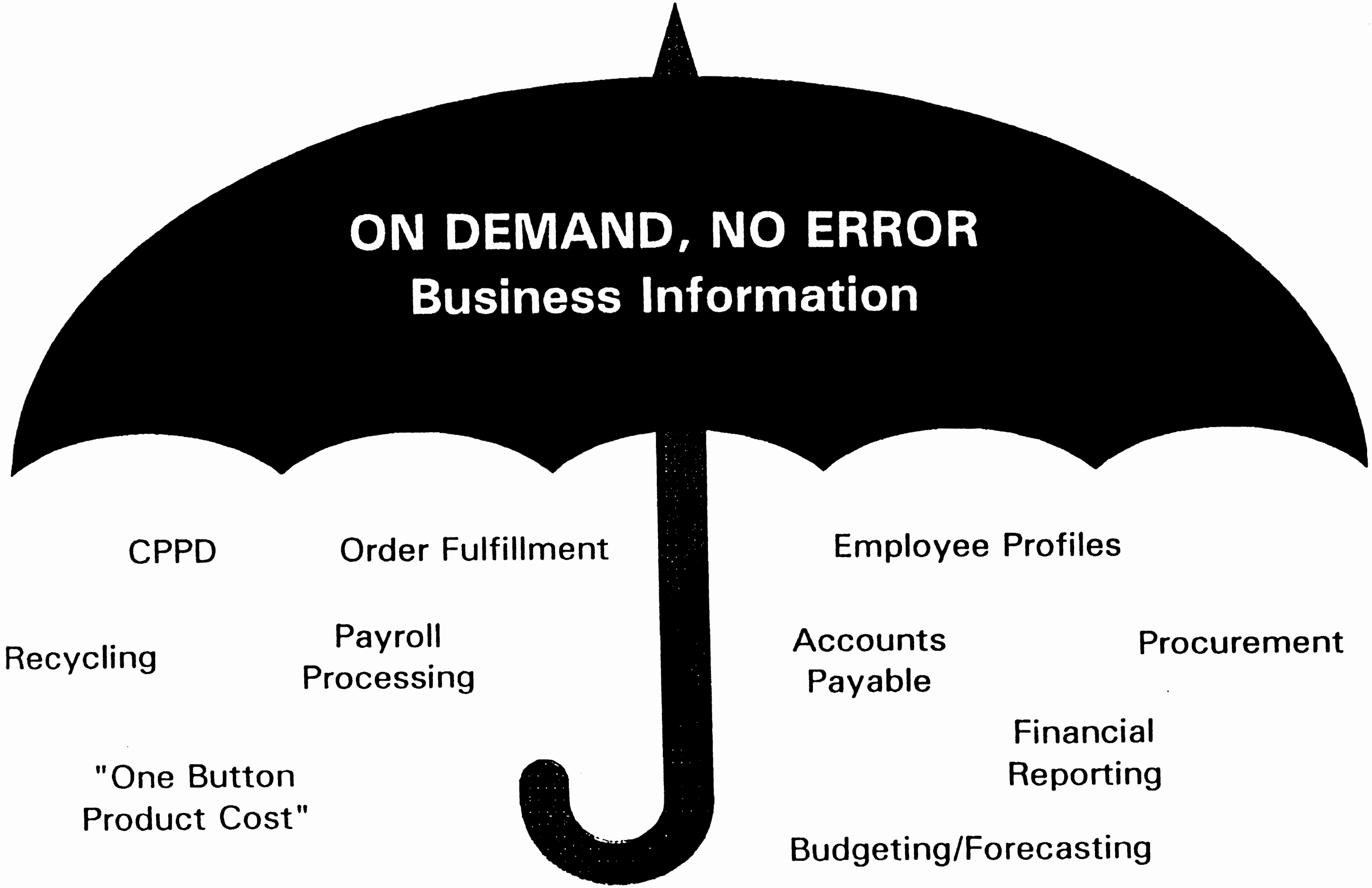
- Cost Reduction
- Quality Improvement

ON DEMAND, NO ERROR Business Information

ON DEMAND, NO ERROR Is Not...

- A Systems Driven Initiative
- The Program of the Month
- Just Getting Reports Completed Faster
- Only Financial Information
- An Employment Reduction Effort

ON DEMAND, NO ERROR Business Information
Supports Caterpillar's Desire To Be A High Velocity Company



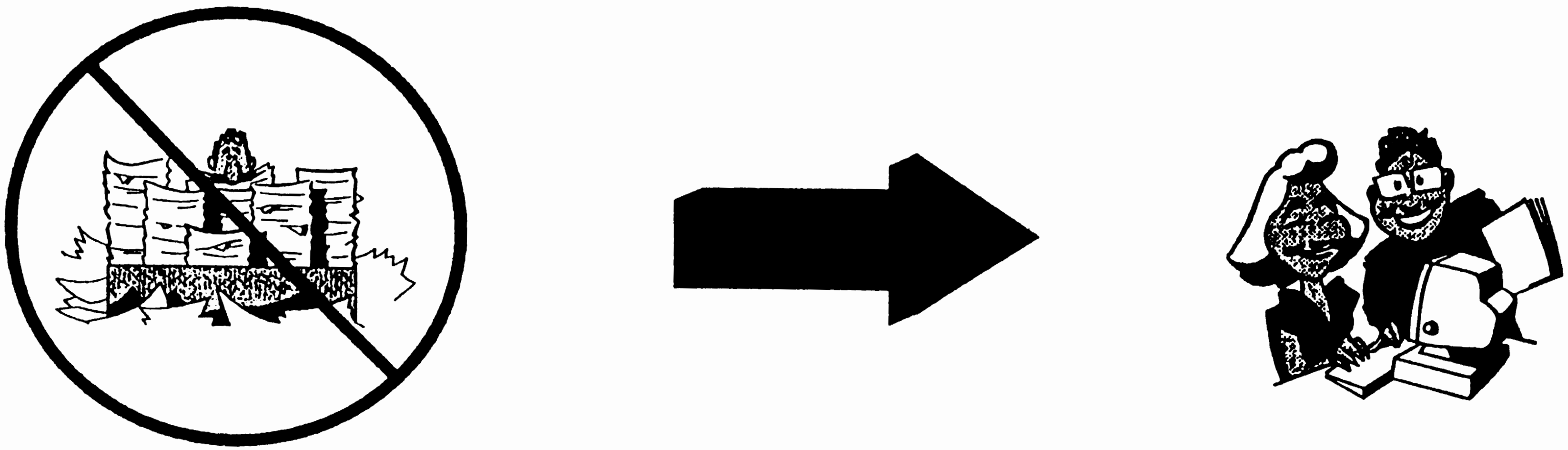
Cost Management Services

To Accomplish ON DEMAND, NO ERROR Cost Information...

...We Will Drive Toward "One Button Product Cost"

"One Button Product Cost"
Vision

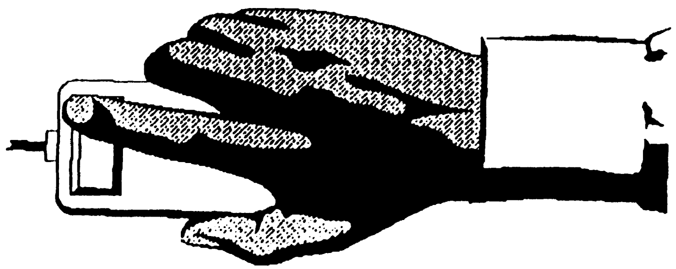
Provide managers with the product cost information needed to run their business - instantaneously, on line



Providing ON DEMAND, NO ERROR Cost Information

B.1

"One Button Product Cost"



ON DEMAND, NO ERROR

Cost Information

"One Button Product Cost"
Strategy

✓ Work as partners with the business units to understand their cost management needs

✓ Improve the processes to provide ON DEMAND, NO ERROR Cost Information

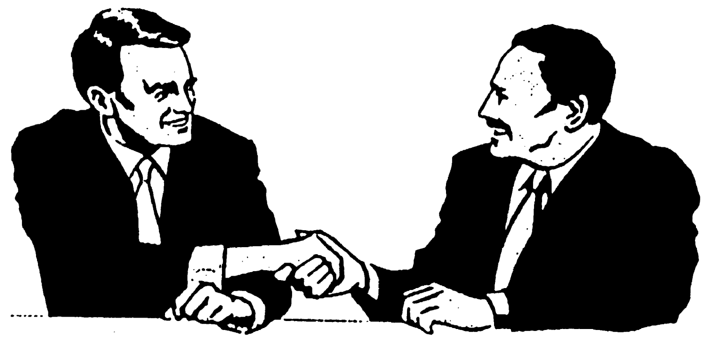
B320-32a

B.1

Cost Management Services

Working as partners with the business units to understand their cost management needs...

✓ Sign partnership agreements tailored to the specific needs of the business units

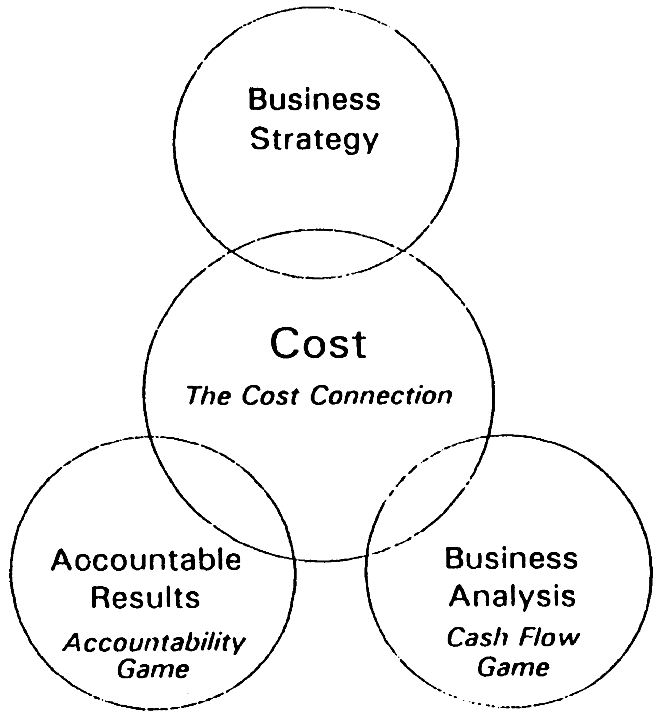


3.1

Cost Management Services

Working as partners with the business units to understand their cost management needs...

✓ Enhance the understanding of the uses of cost information by training managers at all levels throughout the organization



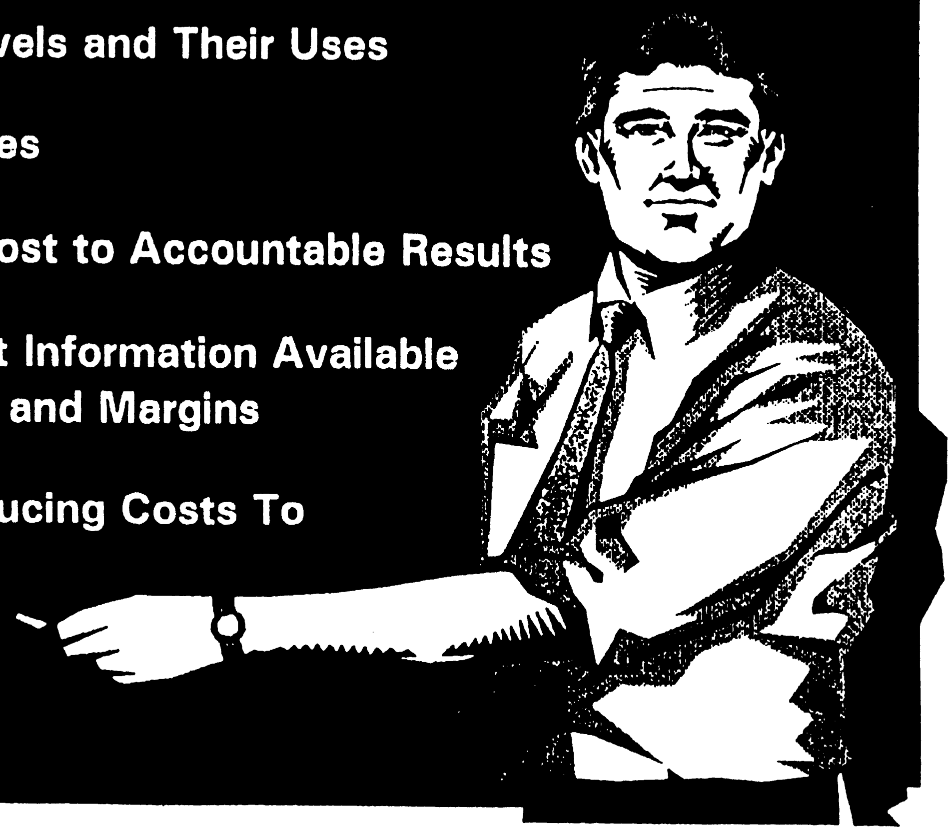
B320-4

B.1

Cost Management Services

The Cost Connection...

- ✓ Converting The Budget To Product Cost
- ✓ Different Cost Levels and Their Uses
- ✓ On-Line Capabilities
- ✓ Linking Product Cost to Accountable Results
- ✓ Methods and Cost Information Available To Analyze Costs and Margins
- ✓ Simulation of Reducing Costs To Optimize Profit



B

Cost Management Services

Working as partners with the business units to understand their cost management needs...

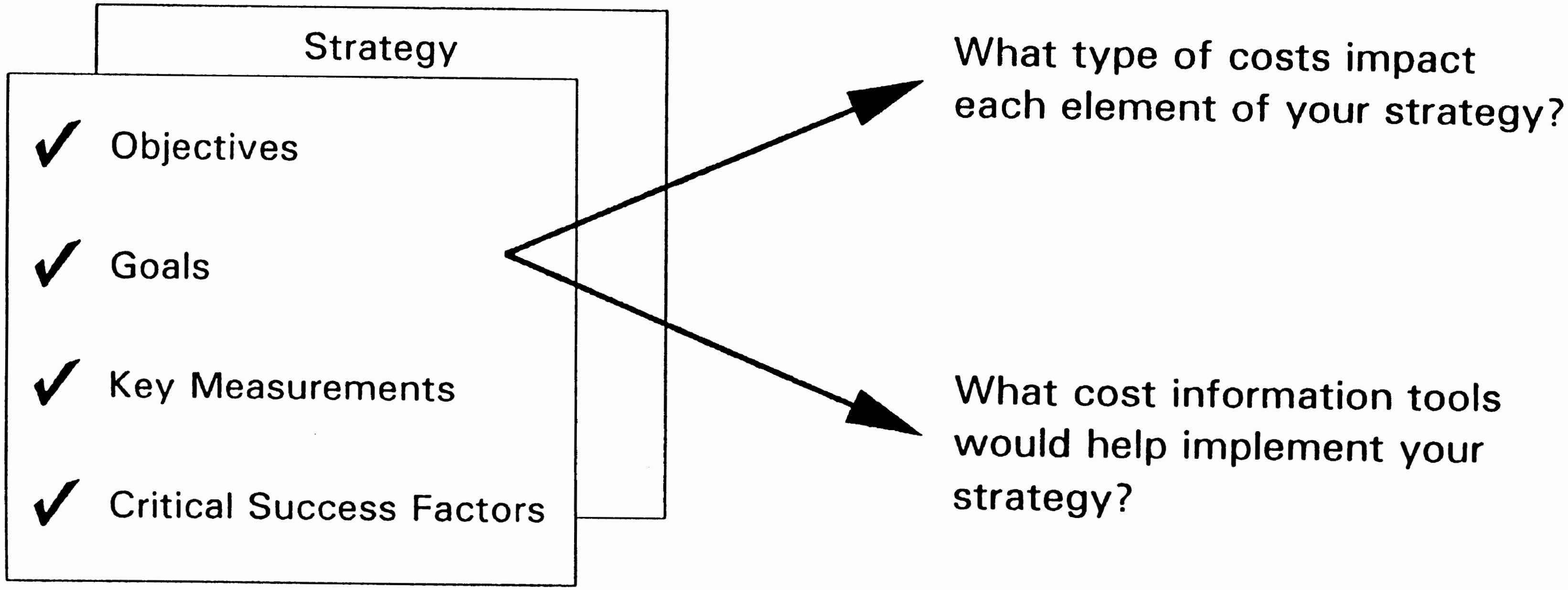
✓ Utilize a cost management strategy toolkit to work with the managers to understand their cost management needs

B320-6

B.1

Cost Management Services

Cost Management Strategy sessions...



...approached as if we were investing in a new cost system

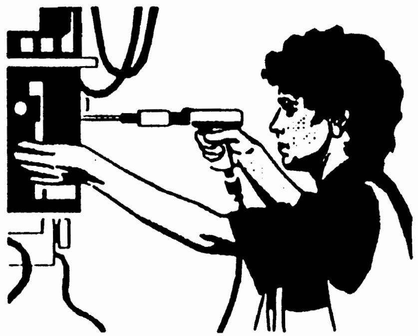
B320-7a

B.'

Cost Management Services

Working as partners with the business units to understand their cost management needs...

✓ Assist business units with cost analysis to understand their operating environment and provide training, where requested



Cost Management Services

Working as partners with the business units to understand their cost management needs...

✓ Refocus cost system development work from refining costing routines to providing cost management tools

Cost Management Services

Working as partners with the business units to understand their cost management needs...

- ✓ Sign partnership agreements tailored to the specific needs of the business units
- ✓ Enhance the understanding of the uses of cost information by training managers at all levels throughout the organization
- ✓ Utilize a cost management strategy tool kit to work with the managers to understand their cost management needs
- ✓ Assist business units with cost analysis to understand their operating environment and provide training, where requested
- ✓ Refocus cost system development work from refining costing routines to providing cost management tools

"One Button Product Cost"
Strategy

- ✓ Work as partners with the business units to understand their cost management needs

- ✓ Improve the processes to provide ON DEMAND, NO ERROR Cost Information

"One Button Product Cost"
Today's Processes...

- 2 Months To Develop Cost Rates
- 1 Month For System Updates
- 3 Months To Complete PMCM

} 6 Months After Budget?

This Is Not Acceptable In Today's Dynamic Operating Environment

B.(

"One Button Product Cost"
Process Improvement

Accomplished by forming BPI partnerships with the business units to...

- ✓ Streamline rate development and cost change analysis
- ✓ Simplify costing methodology
- ✓ Eliminate grief by improving source data information

"One Button Product Cost"
Initial Processes

Process	*CMS Responsibility*
Normals	Bob Hill
Business Unit Cost Rate Development	
P&V System	
System Update	Ed Miller
Cost Level Update	
Monthly Update	
PMCM	
Product Cost Development	Craig McGregor
Cost and Margin Reporting	Lilli Davis & Sue Driscoll
System Grief	Kevin Sears
PMCM Not Costed	
Incorrect PMCM Costs	

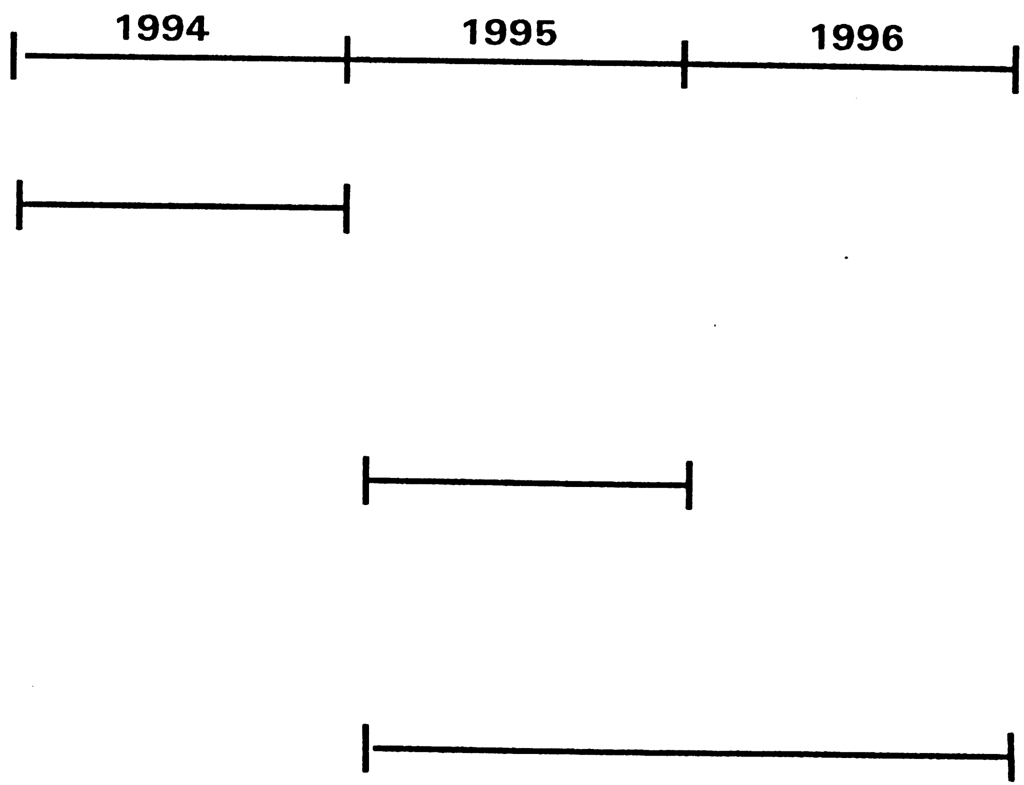
B.1

"One Button Product Cost"
Process Improvement Timeline

Phase I
Identify Improvements

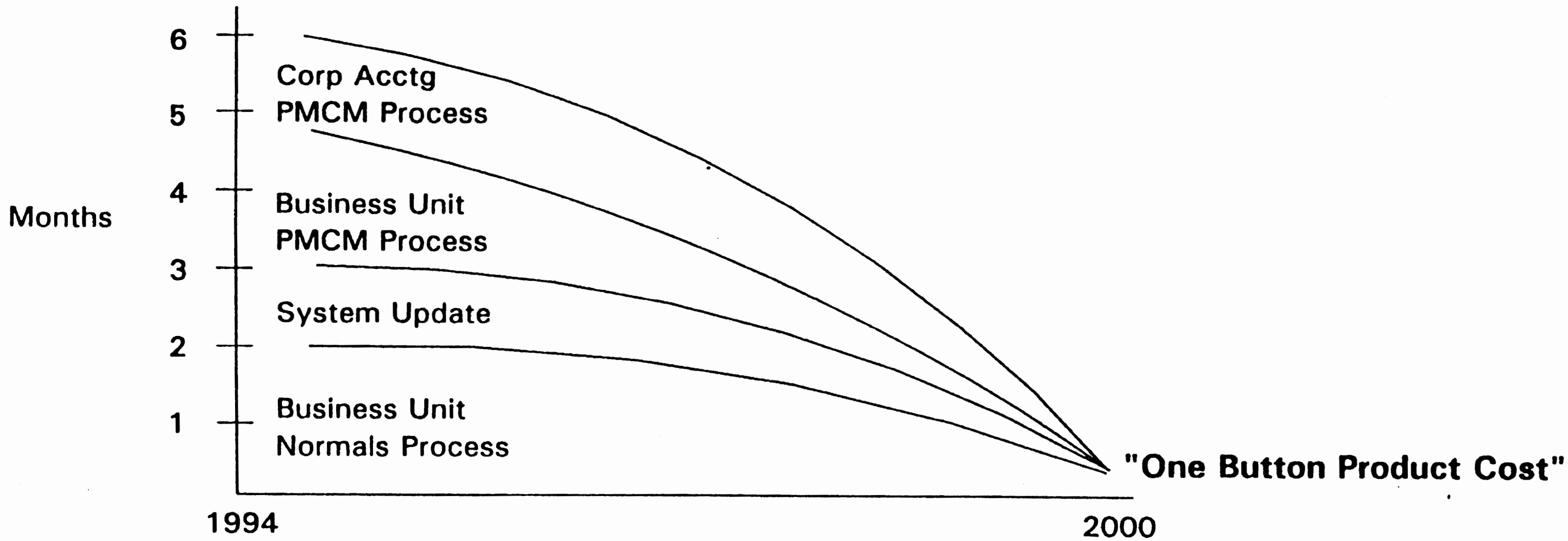
Phase 2
System/Process Changes

Phase 3
Implement Improvements



"One Button Product Cost"
Process Improvement

Partnership arrangement is the key to improving the processes...



"One Button Product Cost"
ON DEMAND, NO ERROR
Cost Information

"One Button Product Cost"
Summary

- ✓ Work as partners with the business units to understand their cost management needs
- ✓ Improve the processes to provide ON DEMAND, NO ERROR Cost Information

B.1

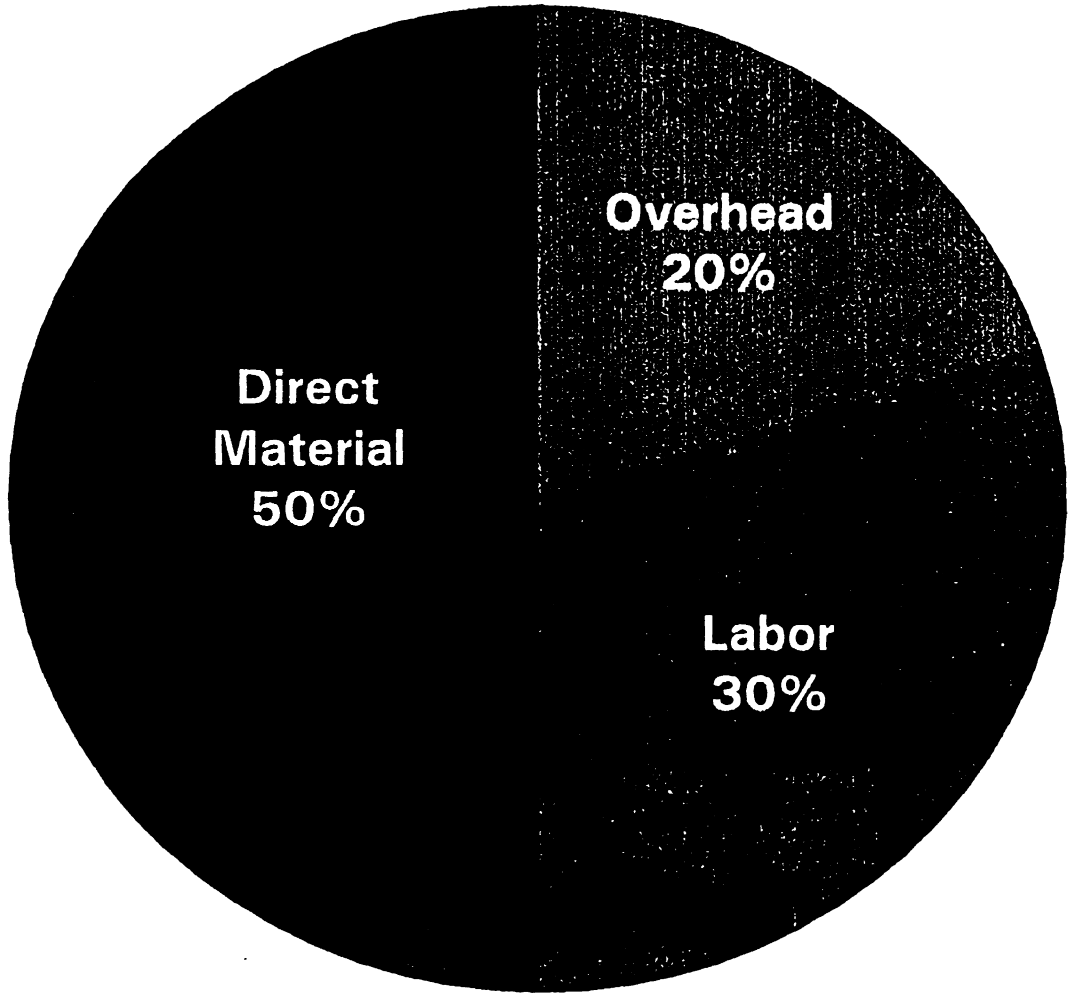
APPENDIX B.2

Through the product life cycle, cost management focuses on internal management needs of the business rather than on financial accounting external requirements.

Cost Management

- Measure how well we do against targets and competitors
- Provide price setting bases
- Measure margins
- Analyze design, process, and sourcing decisions — One of Biggest areas. Multi-Product teams. ~~Product~~ Teams are involved at earliest stage.
- Provide cost trends
- Measure impact of corrective actions
- Measure impact of strategic decisions
- Measure productivity and overall cost effectiveness
- Measure complexity and cost drivers
- Identify and analyze nonvalue added activities
- Top tier measurement

BASIC ELEMENTS OF PRODUCT COST



323-4

B.2

PLANT BUSINESS PLAN

FOR A PLANNED PRODUCTION VOLUME

DEPARTMENTS BUSINESS PLANS — DIRECT MATERIAL PURCHASES — PLANT OVERHEAD

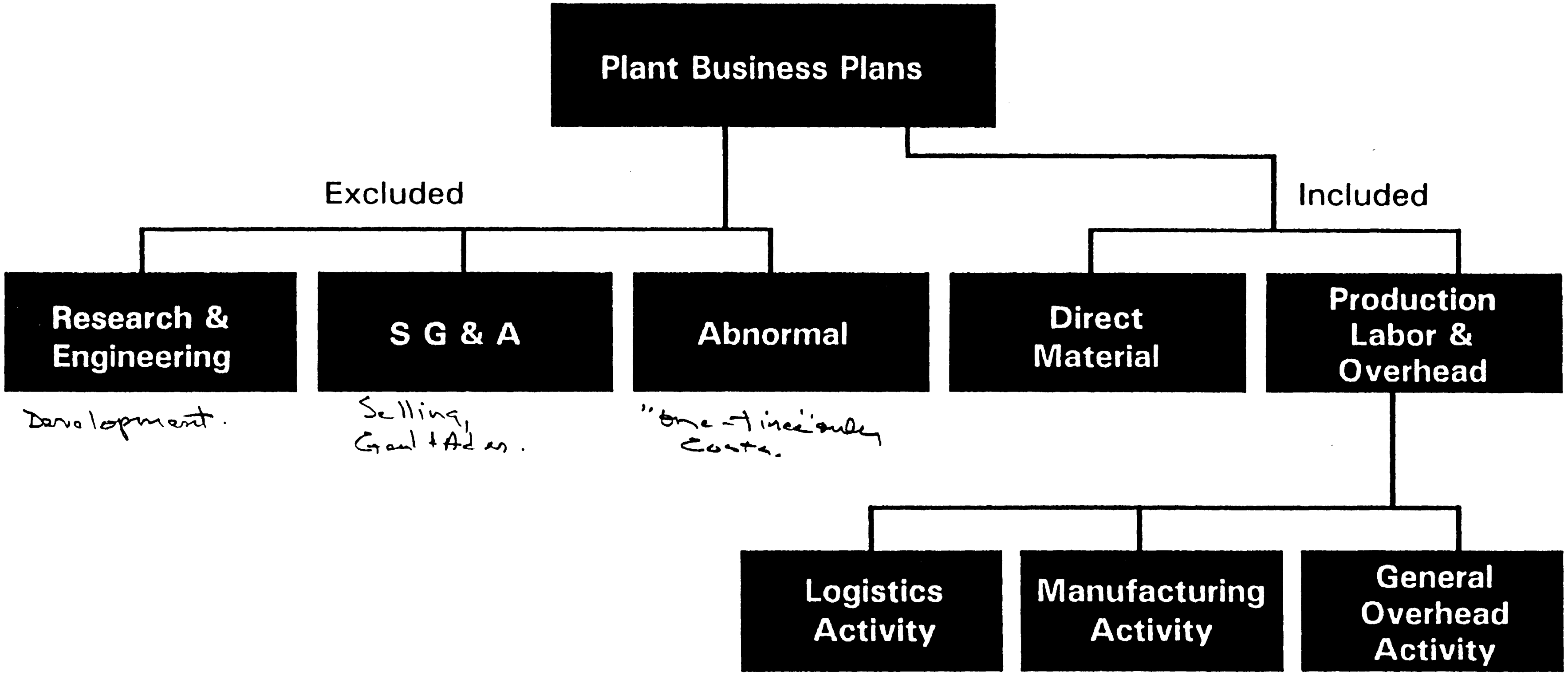
- Labor Costs
  - Number of Employees
  - Wages and Fringes
- Department Overhead Costs
  - Indirect Material & Expense

Excludes Department Costs.

- Freight
- Utilities
- Depreciation
- Taxes
- Etc.

323-11

FROM BUSINESS PLAN TO PRODUCT COSTS



323-12

8.2

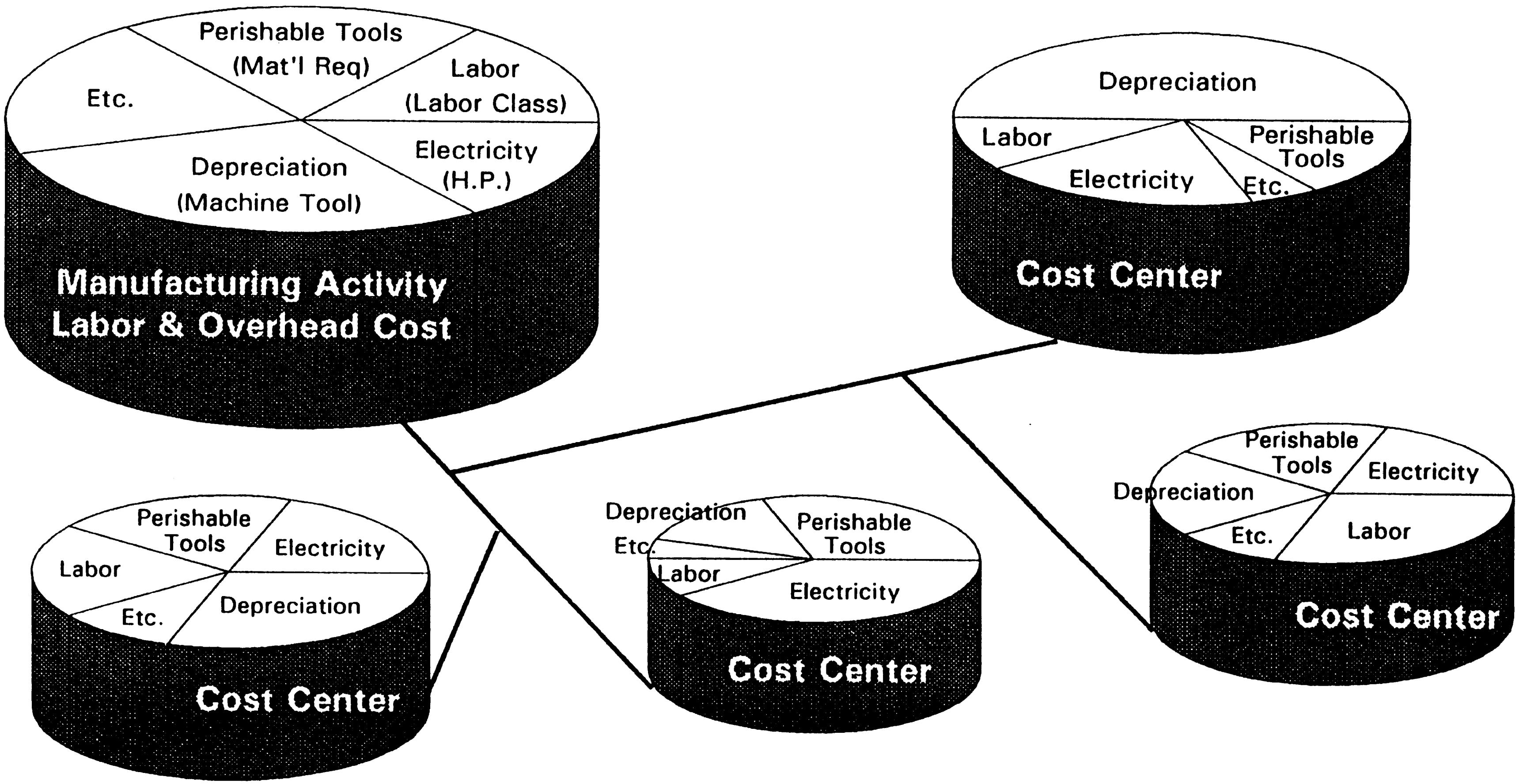
Normal Plant Cost Methodology

- Includes costs of current products at normalized production volumes.
- Excludes the effect of short-term changes in operating levels and start-up conditions.
- Not to be defined as costs incurred under ideal conditions.

Examples of Abnormal Costs:

1. Start-up costs related to the introduction of new products and new processes or systems.
2. Expenses related to short-term operating conditions (e.g. production levels, strike pulls).
3. Major rearrangements/infrequent plant repair (e.g. PWAF, resurface parking lot).
4. Manufacturing inefficiencies that are short-term (< 1 yr) and identifiable by section or cell (e.g. PWAF start-up).
5. Unallocated floorspace.
6. Surplus equipment.

MANUFACTURING ACTIVITY
Labor & Overhead Cost



323-14

R.2

labor updated biennially
other updated monthly...

Caterpillar Cost Methodology

Rates by Machine

Variable Labor	*Variable Machine*	*Period Machine*
Direct Labor	Material Handling	Depreciation
Fringes	Perishable Tools	Building (occupancy)
Performance Percent	Support Labor	Durable Tools
	Supplies	Planning
	Spoilage & Rework	Machine Repair
	Inspection/Quality	Mfg. Departl Burden
	Power/Fuel	
	Unabsorbed Direct Labor	
(Drivers) Activity Base		
Labor and Set-Up Hours	Machine Run Hours	Machine Run and Set-Up Hours

323-15

B.1

CATERPILLAR COST METHODOLOGY
RATES BY MACHINE

VARIABLE MACHINE

ACTIVITY BASE: MACHINE RUN HOURS

MATERIAL HANDLING

INTRAPLANT MATERAL HANDLING (0015/1015)

PERISHABLE TOOLING

PERISHABLE TOOLING (0055)
DISBURSING TOOLS (0062)
GRINDING TOOLS (0071)
TOTAL LABOR & FRINGES
PERISHABLE TOOLING (1055)
GRINDING TOOLS (1071)

SUPPORT LABOR

FIRST LINE SUPERVISION WAGES PLUS FRINGES
FACTORY CLEANING DEPT.
CLERICAL AND FOLLOW-UP (0012)
MATERIAL CLEANING (0016)
HOUSEKEEPING (0020)
OPERATIONS NOT ON BASE (0025)
FRINGES ON ABOVE HOURLY LABOR

SUPPLIES

PAINT/RUST PROOF (2242)
CLEANING MATERIAL (2244)
GAS & OIL (2245)
WELD/CUTTING GAS (2276)
WELD ROD (2289)
MISC. SUPPLIES (1087)

SPOILAGE AND REWORK

SALVAGING DEFECTIVE LABOR (0073/1073)
SPOILAGE DUE TO LABOR (2240)

INSPECTION/QUALITY

INSPECTING (0013) & FRINGES
LABOR & FRINGES FOR INSPECTION DEPARTMENT

POWER/FUEL

UNABSORBED DIRECT LABOR
(FOR CELLS)

CATERPILLAR COST METHODOLOGY
RATES BY MACHINE

PERIOD MACHINE

ACTIVITY BASE: MACHINE RUN AND SET–UP HOURS

DEPRECIATION

COST DEPRECIATION ON MACHINE TOOLS
& SUPPORT EQUIPMENT

OCCUPANCY

BUILDING EXPENSES (INCL. DEPRECIATION)
BASED UPON FLOORSPACE ALLOCATED
TO THE MACHINE

DURABLE TOOLING

DEPRECIATION ON DURABLE TOOLS
TOOL ROOM AND TOOL DESIGN:
TOTAL DEPARTMENTAL EXPENSES
OCCUPANCY COST FOR FLOORSPACE
DEPRECIATION ON TOOL ROOM M&E
REPAIRS TO DURABLE TOOLS (0026/1026)
REPLACEMENT DURABLE TOOLS (0040/1040)

FRINGES ON ABOVE HOURLY LABOR

PLANNING

PLANNING DEPARTMENT LABOR & FRINGES
(INCLUDING WORK STANDARDS)

MACHINE REPAIR

REPAIRS–MACH TOOLS (0067/1067)
MAINT.–MACH TOOLS (0029/1029)
EQUIPMENT REPAIRS (0066/1066)

FRINGES ON ABOVE HOURLY LABOR

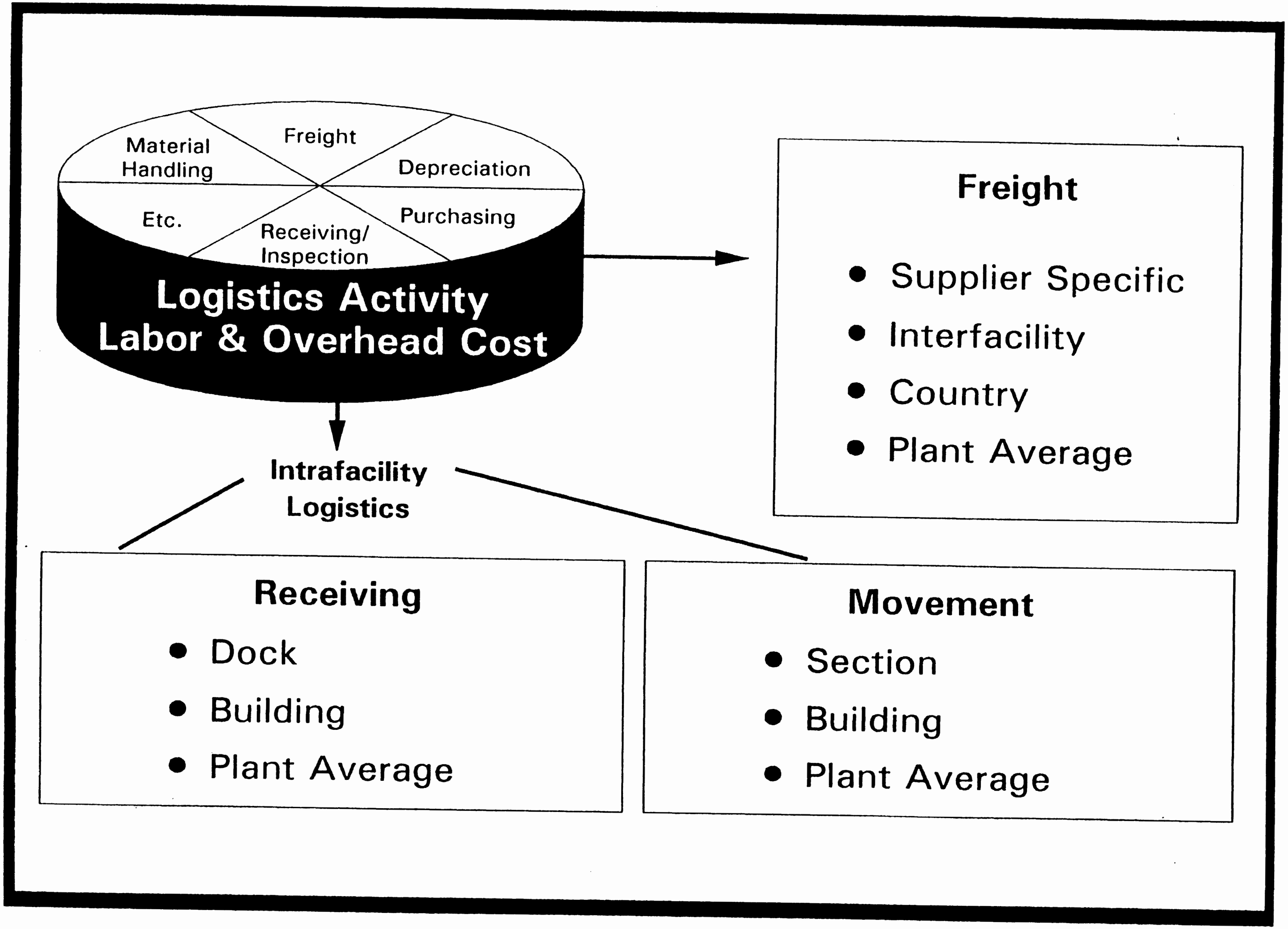
OTHER PERIOD MACHINE

PROVING NEW MACHINE TOOLS (0028/1028)
REARRANGING FACILITIES (0033/1033)
INSTRUCTING (0039/1039)
REPAIR & REPLACEMENT OF INSPECTION
EQUIPMENT (0041/0042/1041/1042)
OTHER SPECIAL ORDERS (0094/1094)
OTHER INDIRECT LABOR (0090)

FRINGES ON ABOVE HOURLY LABOR

RENTALS OF VARIOUS EQUIPMENT

R.


Material Handling
Freight
Depreciation
Etc.
Receiving/ Inspection
Purchasing
Logistics Activity
Labor & Overhead Cost
Freight
Supplier Specific
Interfacility
Country
Plant Average
Intrafacility Logistics
Receiving
Dock
Building
Plant Average
Movement
Section
Building
Plant Average

323-17

R.2

LOGISTICS ACTIVITY

Expenses Associated with Buying, Shipping, Receiving and Moving Parts To and From Point of Use

Variable

- Freight (Outside Supplier & Moving Parts Between Faciltiies)
- Material Handling and Receiving Labor
- Fuel and Electricity on Material Handling Equipment

Period

- Purchasing Personnel (Direct)
- Depreciation and Maintenance on Material Handling Equipment
- Depreciation, Utilities, Insurance, Taxes, and Maintenance on Receiving and Storage Space
- Clerical Support in Receiving and Receiving Inspection

Cost Base

• Material Movement	Piece Part Weight Weight Moved
• Freight and Receiving	Piece Part Weight

GENERAL OVERHEAD ACTIVITY

Expenses Not Directly Associated with Logistics or Manufacturing that Apply to the Whole Plant in General

Period Only

- Accounting
- Employee Relations
- Labor Relations
- Plant Administration
- Engineering Maintenance
- Medical Services
- Scheduling and Inventory Control
- Information Services

Cost Base

- A Percentage of The Total of All The Other Costs

323-18

R.2

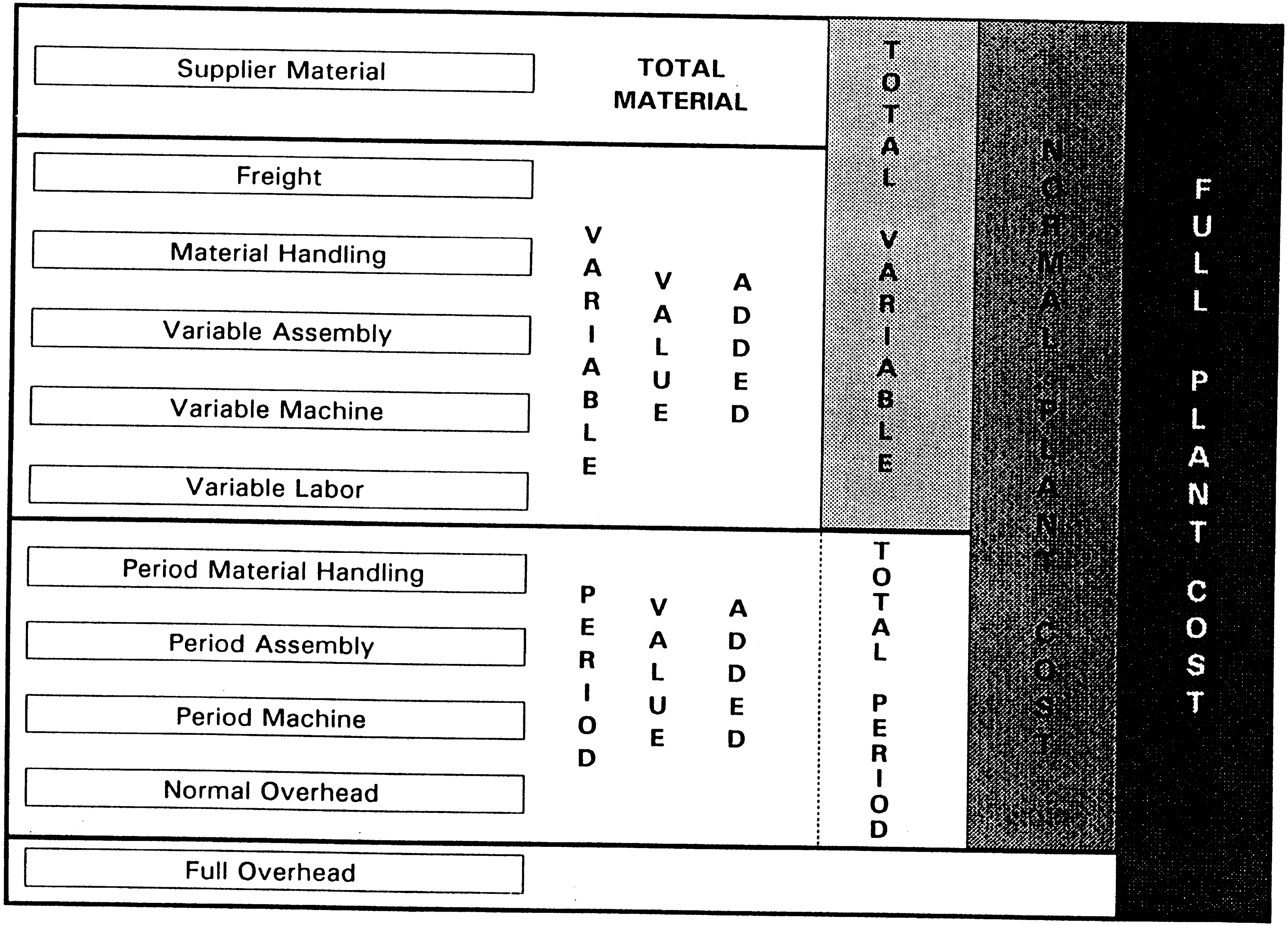
Allocating General Overhead Expenses To Product Groups or Building

5-20-92
J. Maz

General Overhead Expense	*Aurora by Product Group*	*Joliet by Building*
Personnel/Medical/Benefits	Variable Labor	Total Headcount
Labor Relations	Variable Labor	Hourly Headcount
Training	Variable Labor	Actual History
Information Services	Unique Part Numbers	Info Services Reports/Usage
Engineering Maintenance	PAC2	PAC2
Business Analysis	Surveys	Surveys
Capital & Indirect Purchasing	Surveys	Indirect Tool Items by Commodity, Open POs
Product Group General Admin	Specific	Specific
Requirements/Releasing	Unique Part Numbers	Commodity Spec/# of Releases
Quality Support	Surveys	Number of Warranty $ and Time Allocation
RSSM	Extended Material $	RSSMs by Commodity
Depreciation	Depr $ by Product Group	Period Machine Floorspace
External Purchase Services	Similar Plant Expenses	Lower Tier Reporting
Period Building	Depr $ by Product Group	Period Machine Floorspace
Other Minor Expenses	% of General Overhead by Product	Lower Tier Reporting

323-19a

ACCUMULATION OF COSTS



323-13

R. 2

GUIDELINES FOR DISTRIBUTING DEPARTMENTAL EXPENSES TO BURDEN POOLS

Acct #	Description	Mfg. Gen'l.	Plant Engr., Plant Prot., Bldg. Maint.	Tool Room, Tool Design, Mach. Repair	Tools & Supplies, Disbursing & Grinding	Planning, Work Standards	Machine Shops Exc. Cleaning	Assembly, Test, Paint Ship
0001	Direct Labor				Variable Labor			
0002	Special Direct Labor				" "			VA
0003	R. Orders				" "			VA
0004	Install. of Attach. & Box				Variable Assembly			VA
0010/1010	Special Order-Def. Prod.				S. G. & A.			
0011/1011	Eng. Orders-Towmotor				Engineering			
0012	Clerical & Stock Follow-Up	PL	P Bldg	PMB	VMB	PMB	VM	VA
0013	Inspecting	PL	P Bldg	PMB	VMB	PMB	VMB	VA
0014/1014	Product Eval. Testing				Period Assembly			
0015	Intraplant Matl. Handling	PL	P Bldg	PMB	VMB	PMB	VM	VA
0016/1016	Material Cleaning	PL	P Bldg	PMB	VMB	PMB	VM	VA
0017	Interplant Matl. Handling				Variable Material			VA
0018	Plant Protection				Period Building			
0019/1019	Capital Add'ns - Canada				General Burden			
0020	Housekeeping	PL	P Bldg	PMB	VMB	PMB	VM	VA
0021/1021	Forge Shop Dies				Forge Shop Variable			
0022/1022	Repairs & Maint. Vehicles	PL	P Bldg	PMB	PMB	PMB	PM	PA
0023/1023	Capital Add'ns. - Burlington				General Burden			
0024/1024	Eng. Orders - Decatur				Engineering			
0025	Operations Not on Base Time	PL	P Bldg	PMB	VMB	PMB	VM	VA
0026/1026	Repairs & Maint. D. Tool				Period Machine Burden			PA
0027/1027	Capital Add'ns - Davenport				General Burden			
0028/1028	Proving New Machines				Period Machine Burden			PA
0029/1029	Maint. of Machine Tools & Equip.	PL	P Bldg	PMB	PMB	PMB	PMB	PA
0030/1030	Capital Add'ns - Aurora				General Burden			
0031/1031	Capital Add'ns - G.O.				General Burden			
0032	Altering Product for Shipping				Period Asssembly			
0033/1033	Rearranging Facilities	PL	P Bldg	PMB	PMB	PMB	PMB	PA
0034/1034	Experimental - Qualifying				Engineering			
0035/1035	Eng. Orders - Solar				Engineering			

FACILITY BUSINESS PLAN EXPENSES INCLUDED IN PLANT COST

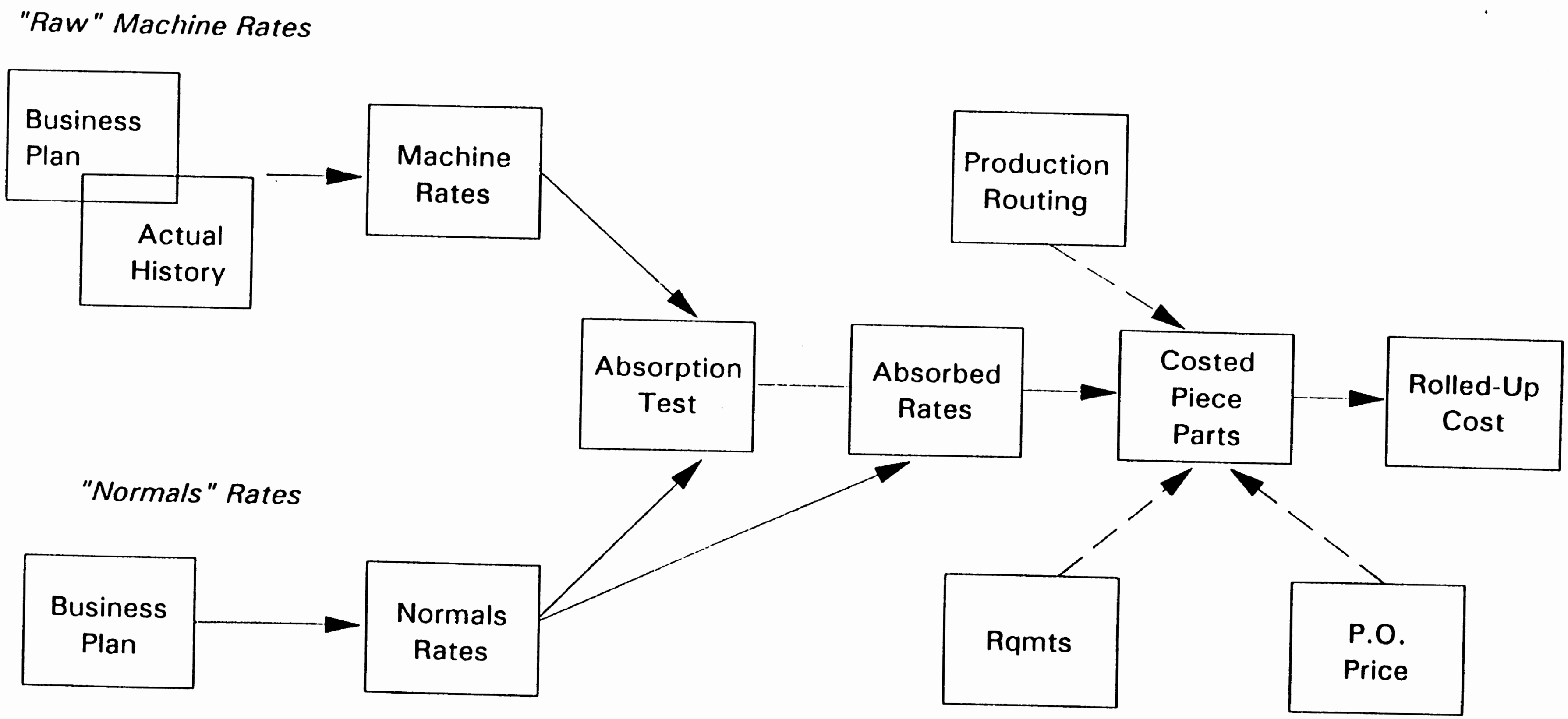
"NCFC" - Normal Cost Factor Computation

	Total Bus. Plan	Total Plant Cost	General Overhead	-------Period Expense------- Bldg	Material	Machine	Assembly	-------Variable Expense------- Material	Man	Machine	Assembly
TOTAL MATERIAL											
TOTAL DEPT. EXPENSES											
UNALLOCATED EXPENSES: Reproduction Depreciation Freight Expense - Other Insurance - Fire and Misc. Power and Gas, etc. Taxes - Other than Income Allocate Engr. Maint. (U.S. only) Reallocate Eng. & Exp'r. burden Overtime Penalty											
DEPT. & UNALL. EXPENSES											
DEDUCTIONS: Supplies Added to Prod Inv. Labor & Burden Export Boxing Crating Mat'l to Cost of Sales Other Account T1897 Cash Discount & Scrap Recr. Ft. & Ins. on Imports T1910 - Offset to Dept'l Exp											
TOTAL DEDUCTIONS											
TOTAL EXP. LESS TOTAL DED.											
Adjust./Accts. 2240, 2241 & 2340 Other Mat'l Cost and Variances Var. 7 Loss on Ind. Inventories Charges to/from Plants (U.S. only) Reallocate Period Bldg. Expenses Reallocate Variable Labor											
LABOR & BURDEN ALLOCATED TO PROD.											
UNITS OF BASE Normalized Plant Cost Rates			0.0788			61.32	49.40		19.12	18.82	91.81

323-25

B.2

Current Cost Calculation



323-5

B.2

Budget Absorption Test

	Period Machine		Variable Man		Variable Machine	
	Hours	*Expenses*	*Hours*	*Expenses*	*Hours*	*Expenses*
Extended Machine Rates	269,594	$16,105,546	170,428	$7,446,451	255,950	$4,632,695
Average Machine Rates		$59.74		$43.81		$18.10
Normals Rate		$63.32		$45.12		$18.82
Absorption Factor		1.06		1.03		1.04

323-23

COMPONENTS OF COST INFORMATION SYSTEM

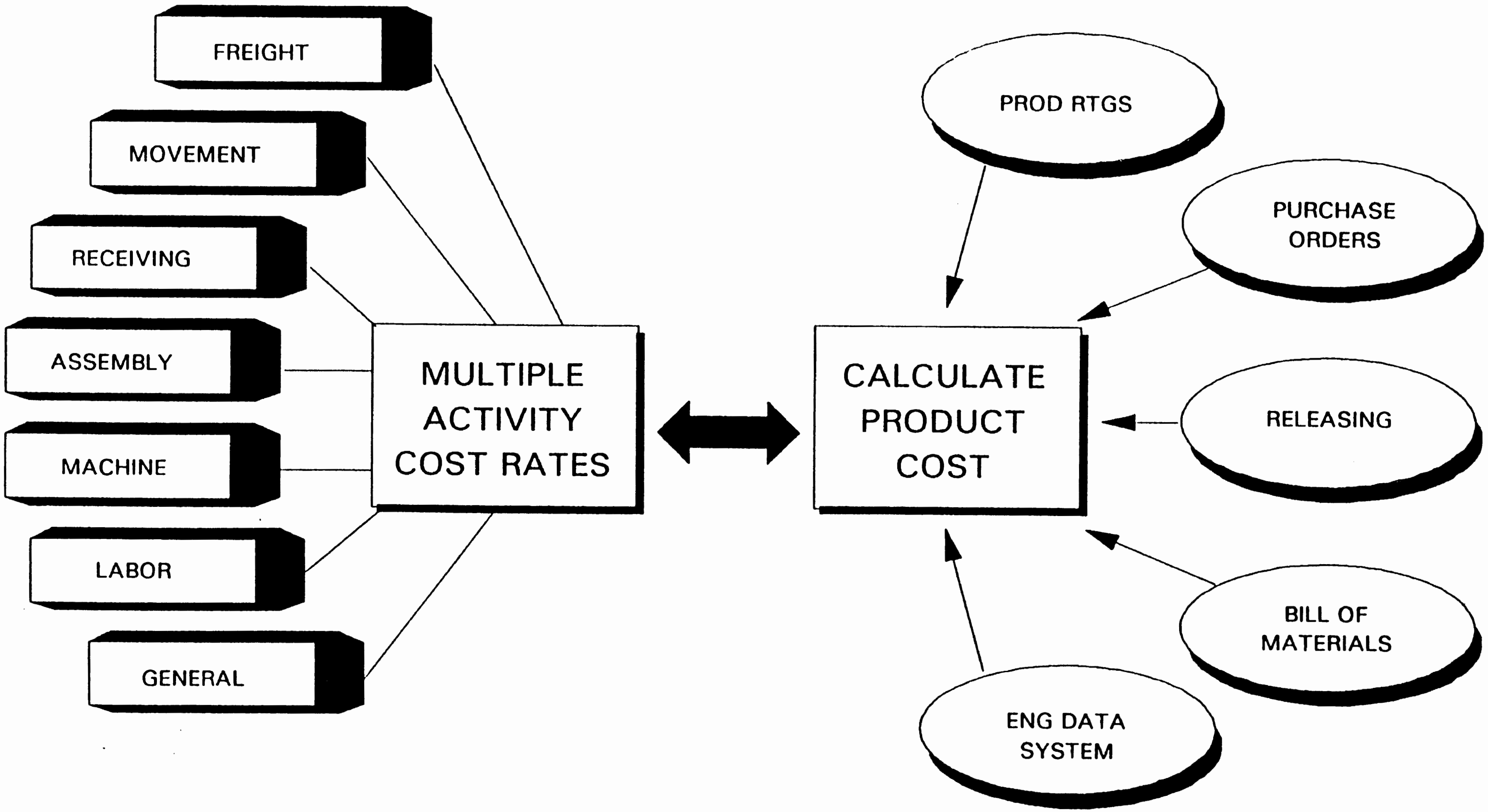


ILLUSTRATION 9031A – PRODUCTION ROUTING

CATERPILLAR
FORM NO
[illegible]
PAGE

PRODUCTION ROUTING

COPIES

PART NO
1A1

OPER NO	MACHINE NUMBER / FACTORY SECT	LOCATION / CLASS	OPERATION SET UP (C) / PCS/HR	BURDEN SET UP / HRS/PC	PERFORMANCE SET UP (C) / HRS/PC
10	M3880 1740	S12M	.30 20.000	.30 .0500	.30 .0500
	CUT TO LENGTH				
20	M6510 1740	D10M	2.2 25.0000	2.2 .0400	2.2 .0400
	DRILL, 8 HOLES				

COPIES TO

REMARKS

MATERIAL DESCRIPTION

1E065 H.R. Bar 1.000 X 5.500 X 241"

MATERIAL CODE	ROUGH WT	PART NAME
0312126855	20.000	Bracke:

COMPARABLE PARTS

ROUTING TYPE
1A1

B.2

Calculating A Current Cost

Labor and Machine Costs

Part No. 1A1	Oper. No.	Mach. No.	Hours/ Piece	X	Rate	=	Operation Cost
Variable Labor	10	M3880	0.056		$43.085		$2.413
Variable Machine			0.050		26.221		1.311
Period Machine			0.056		79.415		4.447
Variable Labor	20	M6510	0.084		38.298		3.217
Variable Machine			0.040		23.307		0.932
Period Machine			0.084		70.591		5.930
Totals							
Variable Labor							$5.630
Variable Machine							2.243
Period Machine							10.377

Lot Size = 50 Pieces

323-6

Calculating A Current Cost

Direct Material	Cost Per Pound	X	Rough Weight/ Piece	=	Direct Material Cost
0312-126-855 Bar	$0.160		20.0		$3.200

Direct material used is indicated on the production routing

Logistics	Rate	X	Rough Weight/	=	Logistics Cost
Freight	0.02454		20.0		$0.491
Variable Receiving & Storage	0.00386		20.0		0.077
Period Receiving & Storage	0.05443		20.0		1.089
Variable Material Movement	0.00416		80.0 *		0.333
Period Material Movement	0.00205		80.0 *		0.164

* *Rough weight times number of moves (i.e. number of operations plus two)*

General Overhead	Rate	X	Mfg. Cost	=	General Overhead Cost
General Overhead	0.11750		$23.604		$2.773

Adding the general overhead cost to the manufacturing cost provides the normal plant cost

Calculating A Current Cost

Cost Summary Sheet

Part No. 1A1

Variable Costs			
Direct Material	$3.200		
Labor	5.630		
Machine	2.243		
Logistics			
Freight	0.491		
Receiving & Storage	0.077		
Material Movement	0.333		
Total Variable Costs		$11.974	
Period Costs			
Machine	10.377		
Logistics			
Receiving & Storage	1.089		
Material Movement	0.164		
Total Period Costs		11.630	
Manufacturing Cost			$23.604
General Overhead			
Normal Plant Cost			

323-9

B.2

B.2

Calculating A Current Cost

Cost Summary Sheet

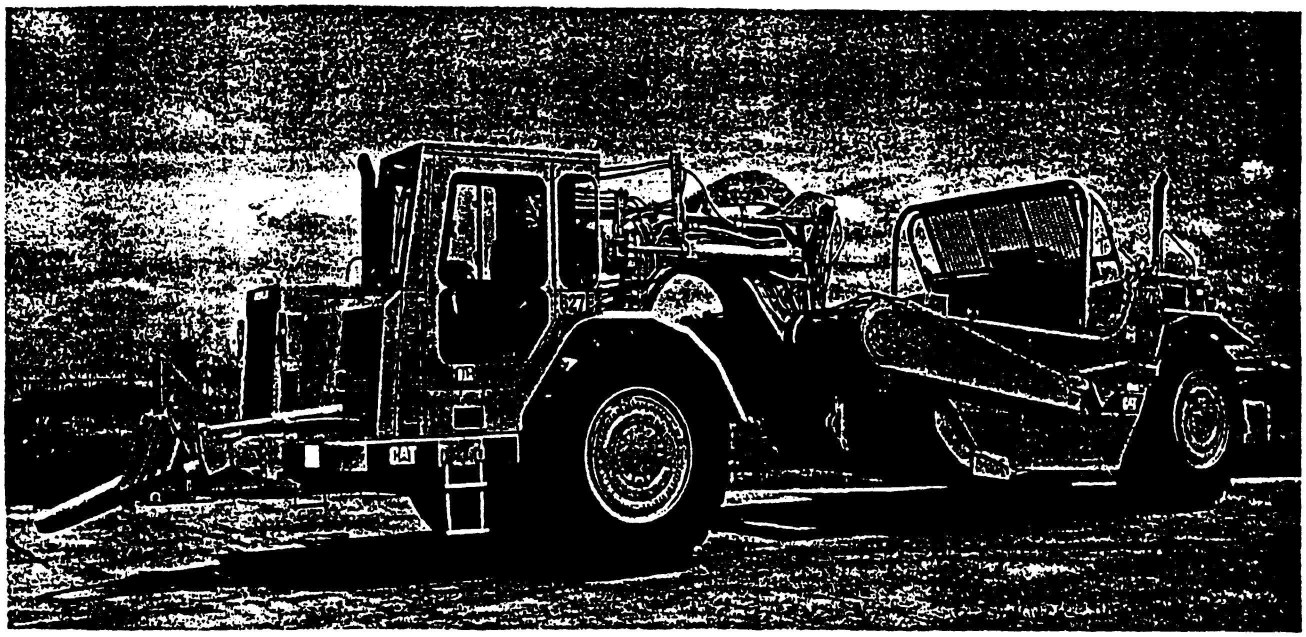
Part No. 1A1	
Variable Costs	
Direct Material	
Labor	5.630
Machine	2.243
Logistics	
Freight	
Receiving & Storage	
Material Movement	
Total Variable Costs	
Period Costs	
Machine	10.377
Logistics	
Receiving & Storage	
Material Movement	
Total Period Costs	
Manufacturing Cost	
General Overhead	
Normal Plant Cost	

323-8

APPENDIX B.3

PRODUCT COSTING AT CATERPILLAR

It's a vital link in an entire business process.



The scraper is one of Caterpillar's popular large, complex products.

BY LOU F. JONES

Certificate of Merit, 1989-90

Today's competitive environment makes it imperative for manufacturers competing globally to know their costs. They need to understand costs at several levels, the activities that are driving costs, the link between management decisions and subsequent costs incurred, and the areas where improvement opportunities lie. A topnotch costing system is one of the most powerful information tools a management team can have, especially if it provides a clear picture of the activities that are driving costs and the ways individual products and processes consume resources.

At Caterpillar we use costing in three distinct ways: standard costing, for inventory valuation; operational controls, for tracking and managing operating costs and other key operating characteristics; and product costing, for a variety of longer-term strategic decisions.

Standard costing is a bookkeeping activity for valuing inventory in the financial reporting cycle. The standard cost system has been kept simple, and we update standard costs only every five or six years, using variances to keep them updated to actual levels. (Remember—we use them for inventory valuation only, not cost management!) To update standard costs, we simply extract information from the product cost system data files and make necessary GAAP financial reporting adjustments.

Operational controls and product costing are cost management[1] tools. Our major efforts through the years have been in the development of and ongoing improvements to operational control and product costing systems.

Although our three cost systems have different missions, they are linked through a common database—the budget. The budget is "tapped into," and each system employs unique subroutines to format the information for its intended use. With operational control formats, the information is ordered so that actual material prices and operating costs can be compared to budget and targets. Our rolling budget process allows this report to recognize changes in product mix, volume, and other operations.

PRODUCT COSTING

Caterpillar's financial people long ago recognized the need for and potential competitive advantage of having the ability to cost products reliably. Caterpillar produces a variety of large, complex products (several kinds of heavy equipment, for example) at varying volume levels using many manufacturing processes and sources of supply. A simple cost system would not provide the level of accuracy required for sound cost management on these products.

Simple cost systems are accurate enough for assigning costs that are easily traceable to the production process, such as production material and direct labor, but they don't specifically assign costs such as machine tool energy consumption, setup, machine repair, perishable and durable tooling, and manufacturing support activities. Such systems also fail to recognize the product-by-product cost effects of volume, product and process complexity, product design, and the different values of capital assets used in the production process.

Simple systems are fine for valuing inventories, but if used for cost management they misstate the costs of manufactured products, especially at the part, component, major activity, and cost element level. Directionally accurate costs are needed at this level of detail if a cost system is to come alive as a powerful tool for internal cost management.

A good cost system mirrors the manufacturing process and related support activities and quantifies them product by product. The more complex and inconsistent these processes are the more difficult it is to assign costs to products accurately. Thus, the cost system becomes more complex as it attempts to compensate for the lack of simplicity of the manufacturing processes. The complexity of manufacturing operations "drives" the complexity of the cost system.

Conversely, as manufacturing operations are simplified, costing becomes simpler. When processes are simpler, repeatable, generate a consistent pattern of resource consumption, and produce consistent quality, then costing becomes easier. "Simple" cost systems are desirable, but "simplistic" systems in a complex manufacturing environment usually will generate misleading product cost information.

Such considerations led Caterpillar to develop a product costing system separate from its standard cost system. This managerial costing system is a variation of what is popularly called an "Activity-Based System."

We have a common system worldwide. As an international manufacturer, we must be assured of comparability when analyzing the cost of identical products produced at multiple loca-

CATERPILLAR'S ACCOUNTING VISIONARY

One of the most popular debates in accounting today is the appropriateness and usefulness of existing cost information. Critics point out that most cost accounting systems have not kept up with the changing business environment, yet there are some companies that have focused on continually improving the quality of cost information provided to management for strategic and tactical decision making.

One such company is Caterpillar Inc. For more than 40 years, Caterpillar has dedicated significant resources to providing good cost information to management and has continually updated its cost system to reflect the operating conditions in the factory. In the late 1940s, Caterpillar dismissed the relevance of a product costing method that many companies still rely on today: a single plantwide overhead rate based on direct labor. Caterpillar had found this method of overhead allocation inadequate, given the machine-intensive nature of its manufacturing processes. While direct labor and related overhead still represented a significant cost, depreciation, maintenance, utilities, tooling, and other machine-driven costs constituted a large share of factory overhead. To match these costs to products properly, the company implemented its MBU (Machine Burden Unit) System.

This system was significantly different from most companies' cost systems in at least three respects: (1) The MBU System classified factory overhead into two primary categories: *machine burden*, or overhead expense believed to vary with the machines used, and *man burden*, or overhead expense believed to vary with direct labor on a plantwide basis. (2) The different machines that were required to produce a variety of parts presented the need for separate machine rates (in terms of MBUs), which were calculated for several cost centers including assembly lines and large groups of like machines such as lathes and drills. (3) The MBU System, which was developed to provide product costs, operated independent of the existing standard cost system that was used for inventory valuation. This separation, which has continued to the present, laid the foundation for the development of a cost accounting function autonomous from financial accounting at Caterpillar.

This system was implemented under former CEO William H. Franklin while he was assistant controller. It emphasized the "allocation of overhead based on the plant activities causing the expenditure." Mr. Franklin fostered the development and use of accurate cost information until he retired as chairman of the board in 1975.

He said that good cost systems provided several benefits: "We were setting our parts prices much better. We found we were selling some parts way below cost. When we got [the parts] really costed right, some were [priced] way above cost... If you don't look out, you'll be wondering why you're not making any money on these parts or not getting any of the business. It costs quite a bit to have a good cost system. ...The investment in the system and in the people to support it ought to bring back more than its cost... I'm afraid most companies don't appreciate the value of what accounting can do for them."

In the August 1951 issue of the *NACA Bulletin*, Mr. Franklin published an article on "Allocation of Overhead Costs—a Short-Cut" in which he described Caterpillar's first attempt to cost products based on the specific activities and related costs that each consumed in the production process. When asked to discuss readers' responses, he said, "I don't think there was any reaction at all. I don't think I ever received a letter from anyone." When asked why so few companies took the lead in improving their cost systems, he replied, "I don't know why they didn't listen. Maybe I didn't make it plain." Anyone who knew Bill Franklin would disagree. ■

This sidebar was based on an interview by Stephen Soucy and Marcus Moore of Howell Management Corp. for a case study on Caterpillar Inc. Their research was sponsored by the Financial Executives Research Foundation and will be published later this year along with several studies of other leading companies' cost management practices.

tions. How could a company make good cost decisions if it had different cost systems from one location to another?

The objective of Caterpillar's cost system is to identify the activities consumed by products and through a logical, reliable, and consistent process assign the related costs properly to each.

In our factories, each machine tool, manufacturing cell, and assembly area has distinct owning and operating costs. As products pass through these areas they consume differing amounts of these costs. We establish specific cost rates for these areas and develop logical bases upon which the appropriate amounts of cost can be assigned to individual products as they move from area to area. These two concepts, specific costing rates and bases for applying them to products, are at the heart of Caterpillar's product cost system.

Our system is forward looking. The process begins with the business plan for the upcoming six months. The forecasted schedule of products and the resources to produce them are transformed into an operating budget. The budget is distributed into pools of costs as the initial step in establishing cost rates.

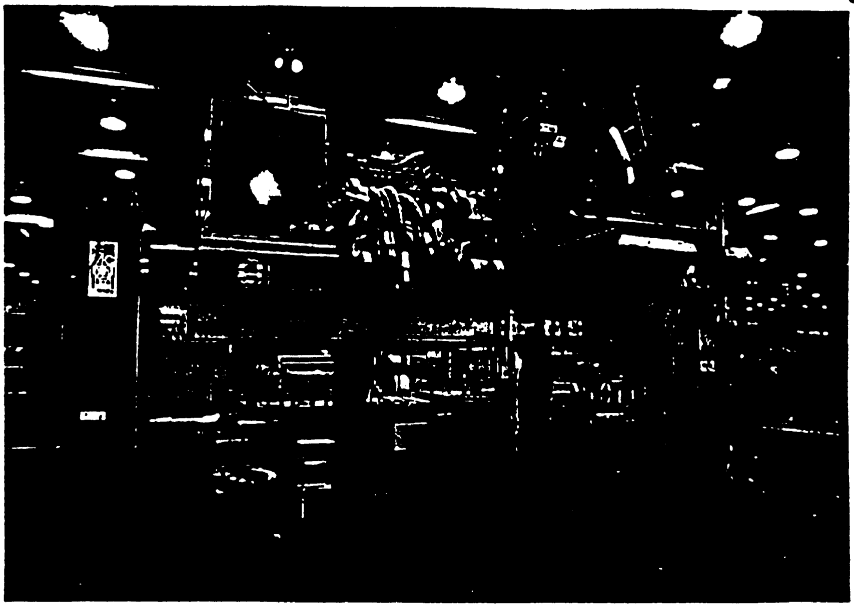
Specific costing rates and bases for applying them to products are at the heart of Caterpillar's product cost system.

Some costs are included in product cost pools, and some are not. Included are direct material, production labor, and all manufacturing-related overhead. Labor and overhead are further subdivided into logistics, manufacturing, and general overhead cost pools.

Excluded are:

- Research and development cost related to future products. Engineering related to current products is included in product costs.
- Parts distribution costs for warehousing and merchandising replacement parts.
- Selling, general, and administrative (S, G, & A) costs that do not support plant operations directly.
- Other costs of doing business such as interest, income taxes, warranty expenses, and abnormal costs.

Although excluded from unit-of-one product costs, these costs are *included* in profitability studies, investment analyses, and other analyses that require consideration of all "life-cycle" costs.



The multi-axis assembly platform in Gosselies, Belgium, which allows the assembler to position machine for ease of assembly.

NORMALIZING IS NECESSARY

The next step in Caterpillar's product costing system is called "normalizing." Normalizing smoothes the up-and-down effects that volume changes can have on unit period costs. Period costs exist for future levels as well as for today's level of business. We do not manage period costs to short-range volume swings, so if they aren't normalized, they could distort the inherent cost of products as volumes increase and decrease. Normalizing is accomplished by spreading period costs over long-term average volumes rather than current volume levels.

Another aspect of normalizing is the exclusion of abnormal costs such as start-up, learning curve, major factory rearrangements, and unusual levels of education and training. Normal costs are not "ideal" costs. These costs, such as desired efficiency, usual on-the-job training, and such, are treated as normal if they typify longer-term operations. Abnormal costs are not swept aside and forgotten, but they are quantified and kept in front of management.

Normalizing is necessary because most product decisions are long term and can involve product design, manufacturing process, logistics, capital investment, and supplier selection. At Caterpillar we are spending hundreds of millions of dollars on start-up to modernize our factories. Including these one-time-only expenses in cost rates would misstate the inherent costs of our products.

Obviously, normalized costs differ from actual costs incurred. When business is constant or growing and internal operations are relatively stable and to plan, actual and normal costs will be close. In a downturn, when operations are not stable, or if there are significant changes occurring in factory operations, actual and normalized costs can be quite different.

The cost analyst must stay attuned to the operations to normalize costs properly. If there are abnormal costs that aren't eventually managed out or that otherwise become normal to the operations, then they will be borne by the product. Therefore, the practice of normalizing requires close attention.

ASSET DEPRECIATION

Another important aspect of Caterpillar's costing approach is the specific assignment of depreciation to cost rates. Depreciation is assigned to cost rates based on usage and assumes an indefinite life for major productive assets. Basing depreciation on usage has the effect of removing the costs of unutilized machine capacities from current costs.

Setting cost rates involves taking normalized expenses from the budget and distributing them into variable and period cost pools for logistics, manufacturing, and general overhead activities.

TABLE 1

Variable	Expense Distribution	Cost Rate Base	Rate
Unformed—Wt. Base	$ 200,000	10,000,000 #	.0200/#
Casting/Forging—Wt. Base	360,000	12,000,000 #	.0300/#
Unformed—Moved	170,000	38,000,000 #	0045/#
Casting/Forging—Moved	250,000	50,000,000 #	.0050/#
Subtotal	980,000		
Purchased Finished	588,000	$21,000,000	.0280/$
Total	$ 1,568,000		
Period		*	
Unformed—Wt. Base	$ 72,000	12,000,000 #	.0060/#
Casting/Forging—Wt. Base	225,000	15,000,000 #	.0150/#
Unformed—Moved	43,000	43,000,000 #	.0010/#
Casting/Forging—Moved	56,000	56,000,000 #	.0010/#
Subtotal	396,000		
Purchased Finished	480,000	$24,000,000	.0200/$
Total	$ 876,000		

* **Period rate bases are set on longer-term volume trends.**

LOGISTICS ACTIVITY POOL

Caterpillar products are large and heavy. They are made from great amounts of plate steel (unformed material), castings, and forgings in addition to a wide variety of purchased components. It is costly to buy, transport, receive, and handle this material. Even when our factories are fully transformed into a just-in-time (JIT), synchronous flow mode of operation, logistics will be a major expense. Oversimplification in this area would greatly distort product costs.

Average monthly costs of logistics activities are assigned to five subpools. Costs of obtaining unformed material are grouped under "unformed weight base costs." Costs for moving the material to and from points of use in the factory are grouped under "unformed weight moved costs." In the same way, costs for castings and forgings are grouped into weight base and weight moved cost pools. Finally, the costs of buying, receiving, storing, and moving purchased finished material are grouped together.

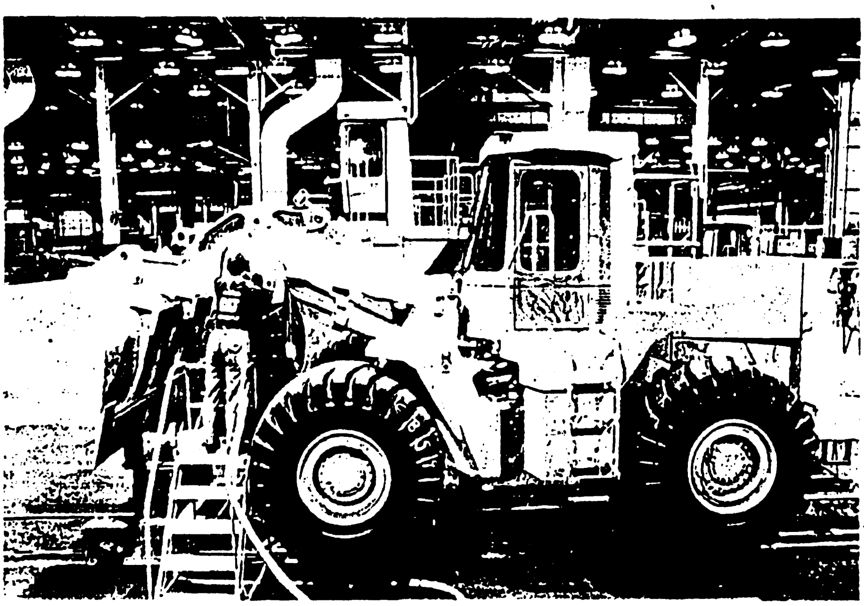
Within the weight base cost pools are the activities on the shipping docks, in the receiving areas, and in the storage areas. The weight moved cost pools are for the intraplant handling of material as it moves through the production process.

The variable pools for these rates include costs such as freight on production material, material cleaning, receiving inspection, material handling labor, and fuel and electricity for operating material handling equipment.

Period cost pools include purchasing personnel, specific depreciation and maintenance on material handling equipment, utilities, insurance, property taxes, maintenance, and clerical support.

For unformed material, castings, and forgings the various expenses are distributed to the appropriate logistics cost pools and aggregated. Rates based on product weight are calculated using the poundage of material that will be used to produce product in the upcoming period. For weight moved, the poundage is multiplied by the number of times the material moves in the production process.

For purchased finished parts—those ready to be assembled into the product upon receipt—the rate is based on material prices. We do not have weights for all of these parts in our data files, but we are in the process of establishing a weight database for these items so we can improve this area. We believe weight is a good basis for assigning logistics costs to our products. Table 1 illustrates the rate calculations (not real numbers).



Wheel loader assembly process in Aurora, Illinois.

MANUFACTURING ACTIVITY POOL

In the manufacturing activity pools are costs associated with operating machines, manufacturing cells, work stations, assembly, test, painting, and shipping areas. Expenses are categorized on a period and variable basis and are assigned to individual cost centers by specific cost element.

Establishing the manufacturing activity rates is the most challenging aspect of our cost system. Typically, a Caterpillar factory has hundreds of cost centers for which rates are set. The logistics cost rates and the many manufacturing cost center rates are the unique elements that set Caterpillar's system apart from simple cost systems.

"Mini-budgets" of estimated expenses are prepared for each cost center. In each machining and fabricating area are three rates: a variable man rate, a variable machine rate, and a period machine rate. To aid in the rate-setting process for each area, cost information is entered on appropriately formatted data sheets. Ultimately it is entered into the computerized cost system for use in product costing.

The variable man rate is simple. It contains the pay rate and fringe benefits of the direct labor worker. No other expense is assigned to a product based on direct labor hours.

The variable machine rate includes costs related to operating the machine. Perishable tooling expense includes not only the tools—such as drills, taps, and cutting tools—but also a portion of the costs of operating the tool crib and grinding reusable tools. Power expense is based on the energy consumed while the machine is running. Other consumables, such as gas, propane, shot peening, cleaning materials, and weld flux, and the costs of handling them are included. Spoilage and rework, quality auditing, first-line supervision salaries, and other variable support costs complete this rate.

The period machine rate contains the depreciation for the specific machine or machines and other equipment in each cost center. Also included in this rate are the costs related to building occupancy, which are treated as a rental charge. These costs are assigned based on the floor space occupied by the cost center and include the depreciation on the building, heat and lights, plant security, and building maintenance and repair costs. The durable tool element includes the depreciation and expenses related to dies, jigs, and fixtures and the costs for storing and maintaining them. The repairs to machines, tooling, and equipment and related supervisory and management costs are based on machine repair and maintenance records. Planning expenses are based on the salaries of the industrial engineers who support each area. Other period machine expenses and period labor complete this rate.

The man rate is based on the direct man hour. The variable and period machine rates are based on the machine hour. The calculations in Table 2 illustrate the rate calculations (not real numbers).

TABLE 2

VARIABLE MAN RATE

Machine or Cell Area No.	M25
Machine Class	D8R (Drill)
Section No.	100
Operator Class	A500
Top Rate of Classification	$15.00
Fringe Benefits (Vacation, Holiday, etc.)	8.00
	23.00
Efficiency Factor	92%
Rate Per Man Hour	$25.00

PERIOD MACHINE RATE

Depreciation	$30.00
Occupancy Cost	8.00
Durable Tooling	7.00
Machine Repair	4.00
Process Planning	6.00
Other Period Machine Expense	3.00
Period Labor	2.00
*Rate Per Machine Hour	$60.00

VARIABLE MACHINE RATE

Perishable Tooling	$10.00
Energy Consumption	3.00
Indirect Material:	
Gas/Propane	N/A
Shot Peening	N/A
Cleaning Material	.50
Weld Flux	N/A
Material Handling	N/A
Spoilage and Rework	.50
Quality Auditing	2.00
Supervision	3.00
Other Variable Labor Support	1.00
Rate Per Machine Hour	$20.00

*Period rate base set on longer-term volume trends.

ASSEMBLY ACTIVITY POOL

The other manufacturing activity center rates are set for product assembly. Rates are set for each of the assembly areas and the related test, paint, and shipping areas. The attribution of costs involves a process similar to that used for man and machine rates. Variable and period rates are set based on average monthly expenses for each area and related support activities.

Variable rates include the costs of assemblers, test people, painters, and shipping personnel. Other costs are for clerical support, quality assurance, housekeeping, factory accounting, handling of products, tooling, indirect material and expenses, power, gas, supervision, and other support costs.

The period rate takes in specific depreciation on productive assets, occupancy costs, training, tool and equipment repair, and other supervisory and management costs.

Expenses are distributed to the assembly, test, paint, and shipping areas, and rates are set for each. The bases for determining the rates are the average monthly hours to assemble, test, paint, and ship product in each area in the upcoming period. Table 3 illustrates assembly area calculations (not real numbers).

TABLE 3

Variable		Expense Distribution	Assembly Hours	Rate Per Hour
Assembly Line	A	$ 500,000	10,000	$50.00
	B	300,000	5,000	60.00
	C	800,000	20,000	40.00
	D	700,000	10,000	70.00
Total		$ 2,300,000		
Period				
Assembly Line	A	$ 240,000	12,000	20.00
	B	180,000	6,000	30.00
	C	600,000	24,000	25.00
	D	480,000	12,000	40.00
Total		$ 1,500,000		

* Period rate bases are set on longer-term volume trends.

Costs traceable to the production process are assigned to logistics and manufacturing activities. Assigning these costs properly involves extensive data gathering, functional surveys, and ongoing interaction with factory and support personnel. A good cost system must be flexible enough to accommodate changes in the operating environment. Support activities migrate as products mature, new products come on stream, and manufacturing processes stabilize. The consumption of these activities by products will change over time, and cost rates must be adjusted accordingly.

GENERAL OVERHEAD

Many cost elements such as direct labor, energy, machine depreciation, and maintenance can be identified reliably and assigned specifically. Others require more effort. The further removed an activity is from identification with a specific manufacturing process the more difficult it is to assign costs reliably. At the far end of this spectrum are costs that are so general in nature that it is difficult to identify with a product on any reliable or consistent basis. These costs go into general overhead activity pools and include some of the period expenses for accounting, employee relations, labor relations, plant administration, medical services, scheduling, and inventory control. Two rates are established—one for in-house manufactured parts and one for purchased finished material. These pools of cost are small in relationship to the total.

These costs are assigned to products based on a percentage of the total of all other costs, including production material. Parts costing the most will absorb a larger portion of general overhead. Table 4 illustrates these calculations (not real numbers). (We are currently developing methods to make general burden costs more product specific.) The logistics, manufacturing, and general overhead cost rates are updated every six months based on the latest budget.

The entire organization must "own" the cost system and be involved in keeping the databases accurate and up to date.

OTHER KEY INPUT

That's the cost rate side—but product costing requires other key information. Our system uses several other data files to provide all the ingredients that are necessary for costing:

- *The Purchase Order File*—Provides the direct material price based on the latest purchase order.
- *The Station List File*—Provides descriptive data about the product by part number, such as source of supply, rough weight, quantity per piece, and parent part number.
- *Production Routing File (work order)*—Provides man and machine time by operation, machine numbers, setup times (if any), lot size indicator, and other key information. A separate file contains the product assembly, test, paint, and ship times.
- *Requirements File*—Provides the production requirements (quantities) for all products, attachments, replacement parts, and interplant material to be produced.
- *Product Structure*—Level-by-level bill of material.

It is vital that the entire organization "own" the cost system and be involved in keeping the databases accurate and up to date. A good cost system is more than an accounting responsibility. These files are updated monthly.

COSTING THE PRODUCT

To understand the costing of an individual part is to understand product costing at Caterpillar. Table 5 explains the process, using part number 1A1 housing made from an iron casting as an example.

The table shows how the 1A1 casting goes through the production process, drawing costs to it as it moves toward completion. The appropriate rates assigned costs based on how the product consumed activities along the way and assigned the costs to each operation.

TABLE 4
GENERAL OVERHEAD

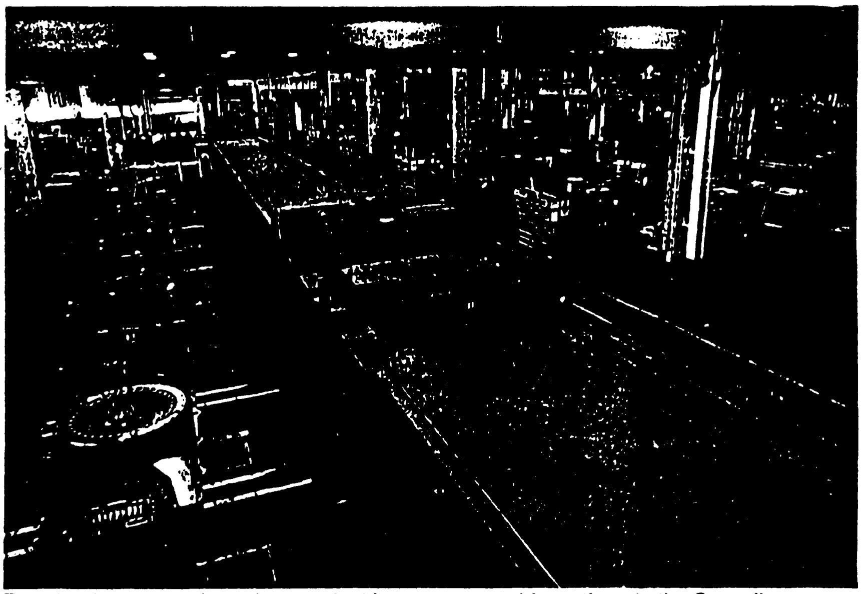
	Worked Material	Purchased Finished
Overhead Expense	$2,000,000	$1,800,000
Total Material, Logistics, and Manufacturing Cost Base	20,000,000	24,000,000
Rate Per $	.1000	.0750

In this example, the logistics costs were significant, which is typical of the handling costs on large components. Also there was a wide variation in the costs of operating the various machines used to produce the part. These differences in resource consumption illustrate why simplistic cost systems that don't recognize such differences will distort product costs.

The cost system has the capability to take 1A1 costs and the costs of all other parts, components, and assemblies and roll them up to produce the total cost of a complete salable product. The system uses a level-by-level bill of material to accomplish this roll-up.

HOW COST INFORMATION IS USED

A standard cost system accumulates and reports costs for products as they move through the production process. The need for this information is driven by the financial



The shuttle transporting prime product between assembly stations in the Gosselies, Belgium, facility.

reporting cycle. To satisfy this need, the day-to-day stream of manufacturing events activates the standard cost system.

Our managerial cost system has no such repetitive driver. It is "activated" by requests for cost information on specific parts, products, and processes. In this regard it is a "database in waiting"—a computerized cost consultant. It is used only when its services are requested. If no questions are asked, the system sits there, like the lonely Maytag repairman, waiting for a call. But be assured, unlike the situation of the Maytag man, the phone is always ringing.

Caterpillar's system is called the "Cost Information System" or CIS. A variety of product cost and descriptive data are available on-line as printed output or in user files. In each of these applications the user can select the information desired, from the cost of an individual machining operation to one part to any level up to and including a complete product.

The system also includes an "estimated cost" module for use in estimating new product costs. This system soon will be augmented by another costing tool called "predictive costing," which will provide the design and industrial engineers with quick turnaround on the estimated costs of various design and processing alternatives. It is crucial that product cost estimates be provided at the earliest stages of product development. Most of a product's cost is locked in during the development phase, so it is vital that cost targets are attained. The "pay me later" rendition of cost management is expensive and disruptive.

Cost information from Caterpillar's system is used by individuals and teams for strategic purposes such as product development, component and piece part design decisions, sourcing decisions, quality and cost improvement analyses, investment justification studies, pricing analyses, competitive cost analyses, manufacturability, and manufacturing process alternatives.

OTHER CONSIDERATIONS

Any costing system, regardless of its quality, provides a "formula cost." If from a good system, this cost can be very useful for cost management. But cost systems, as any other management tool, have limitations, and the formula approach is not appropriate for all cost management issues.

"Unit of one" costs, for example, ignore economic factors such as inflation; time value of money; currency fluctuations; S,G,&A; R&D; parts distribution costs; new capital investment requirements; working capital; and income taxes. Other methods of analysis are needed.

Finally, cost systems are tools—no more, no less. Even the finest cannot assure cost management success. To be successful, a company must first have a cost management philosophy that is brought to life through a well-conceived, clearly understood cost management strategy. And, the entire organization must be involved. Additionally, the management accountants must understand the company's products, processes, engineering systems, suppliers, customers, and competitors—and be part of the team. If these things aren't in place, a cost system can't compensate for the lack of them.

A cost system is just one part of the equation. If the other elements are in place, then the cost management process becomes a powerful force for improvement and for competitive advantage. ■

TABLE 5

Part number 1A1 housing made from an iron casting.

Material Cost				$ 500.00
Variable Weight Base Logistics (.0300 x 1,000 lbs.)				$ 30.00
Variable Man:				
Operation	**Man Hrs. Per Piece**	**Rate Per Hour**	**Cost Per Piece**	
5 Mill	.52	$23.00	$12.00	
10 Drill	.27	22.00	6.00	
15 Turn	.34	24.00	8.20	
20 Bore	.42	28.00	11.80	
25 Clean	.10	20.00	2.00	$ 40.00
Variable Machine:				
Operation	**Mach Hrs. Per Piece**	**Rate Per Hour**	**Cost Per Piece**	
5 Mill	.50	$16.00	$8.00	
10 Drill	.25	30.00	7.50	
15 Turn	.30	25.00	7.50	
20 Bore	.40	20.00	8.00	
25 Clean	.10	10.00	1.00	$ 32.00
Material Cost				

Note: Variable man hours include a proration of setup times based on average lot sizes. Variable machine hours do not include setup because machine-related expenses are consumed only when the machine is running.

Variable Weight Moved Logistics: (Moves are one from receiving area to the manufacturing cell, five between machining operations, one to the checkout area, and one to the next cell or assembly area.)				
8 Moves X 1,000 lbs. = (8,000 lbs. X .0050)				$ 40.00
Total Variable Costs				$ 642.00
Period Weight Base Logistics (.0150 X 1,000 lbs.)				$ 15.00
Period Machine:				
Operation	**Mach Hrs. Per Piece**	**Rate Per Hour**	**Cost Per Piece**	
5 Mill	.52	$61.50	$32.00	
10 Drill	.27	37.00	10.00	
15 Turn	.34	88.25	30.00	
20 Bore	.42	95.25	40.00	
25 Clean	.10	30.00	3.00	$ 115.00
Material Cost				
Period Weight Moved Logistics:				
8 Moves X 1,000 lbs. = (8,000 lbs. X .0010)				$ 8.00
Total Manufacturing Related Period Costs				$ 138.00
Total Manufactured Costs (Variable & Period)				780.00
General Overhead @ 10%				78.00
Total Plant Cost				$ 858.00

Lou Jones is business measurements and systems manager for Caterpillar Inc. He is a member of the Central Illinois Chapter, through which this article was submitted.

[1]Throughout this article I have used the expression "cost management" for descriptive purposes because it is a commonly used term. But cost management and companion terms such as cost reduction, cost control, and cost containment have onerous implications for an organization and do not squarely address the issue. What really needs to be managed are the key business processes across the entire value chain. When they are managed well, then effective use of costs and assets is a natural consequence. For example, manufacturing is a major business process. When this process is simplified through programs such as JIT and flow manufacturing, then cost benefits follow.

Appendix G

COST ESTIMATING AND CONTROL:
The Shipbuilder's Prespective

UMTRI-MSD

March 1, 1995

Cost Estimating and Control

The Shipbuilder's Perspective

Current Industry Status

- No significant commercial ship construction in over 10 years
- Navy funding decreasing
- Both Navy and shipyards need to improve business practices, including cost estimation and cost management methods

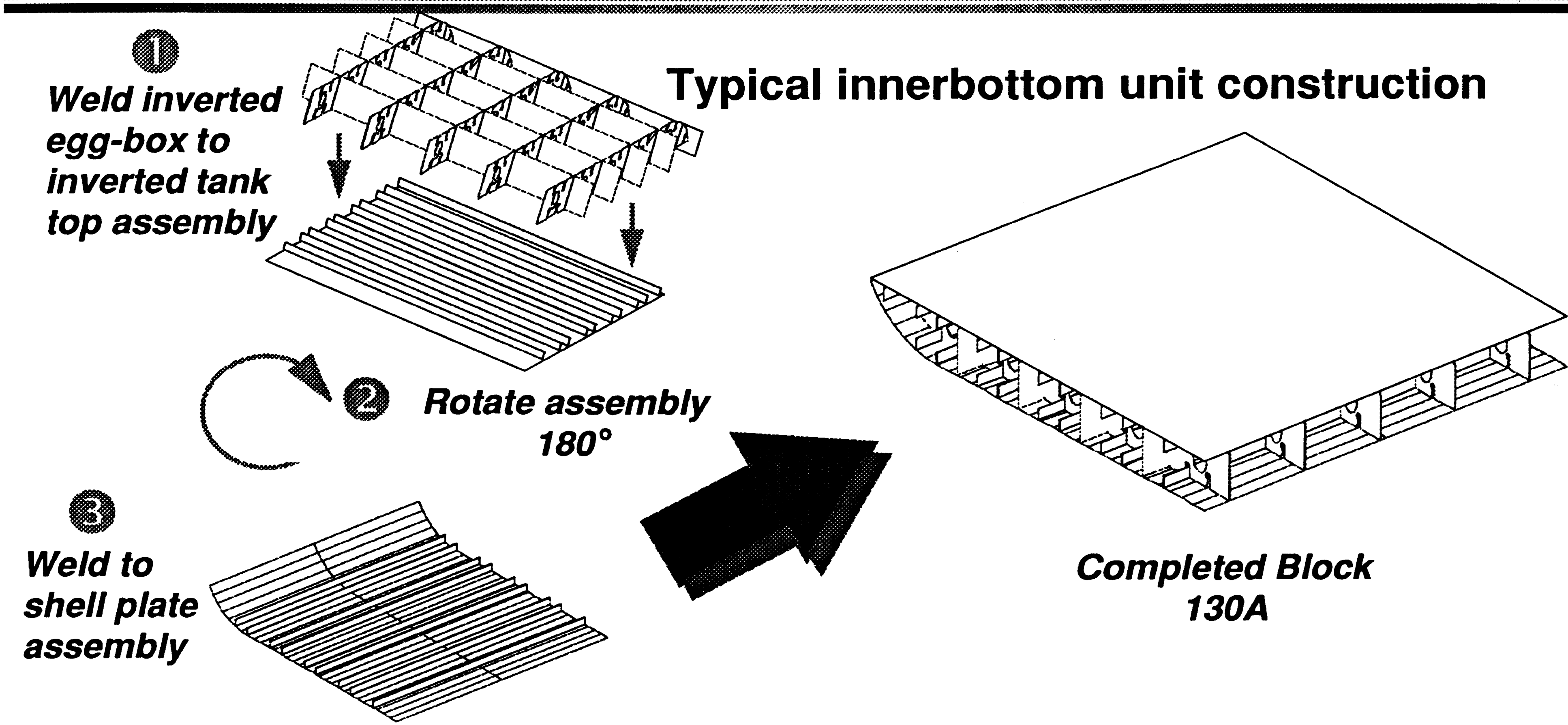
Product Oriented Design and Construction (PODAC) Cost Model

- **Navy established program to develop a credible, validated cost model tool that employs a product-oriented work breakdown structure and incorporates group technology. The model must:**
  - » help program managers manage costs
  - » support engineering development in conjunction with other tools
  - » support Navy needs and be adapted for use by shipyards

UMTRI Benchmarking Study

- **UMTRI Marine Systems Division task:**
  - » **Identify three non-shipbuilding, commercially competitive, industrial manufacturing companies that have successfully implemented new or innovative cost estimating and management systems**
  - » **Evaluate those systems for applicability to the shipbuilding industry**
- **Companies identified and contacted:**
  - » **Boeing**
  - » **Caterpillar**
  - » **Trane**

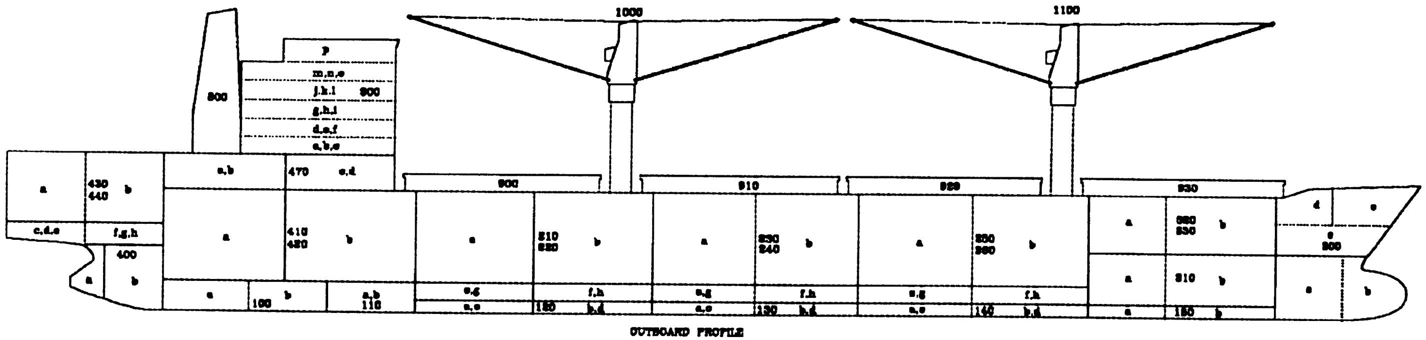
Ship Design and Construction



- **Employs group technology, with zonal design and in shop unit construction**

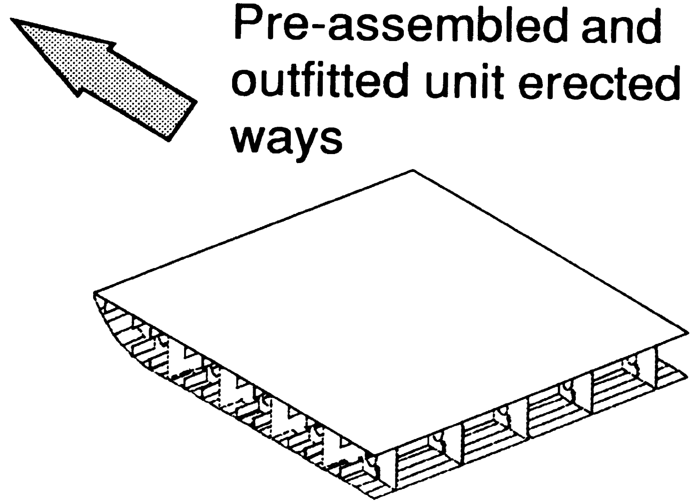
Ship Design and Construction

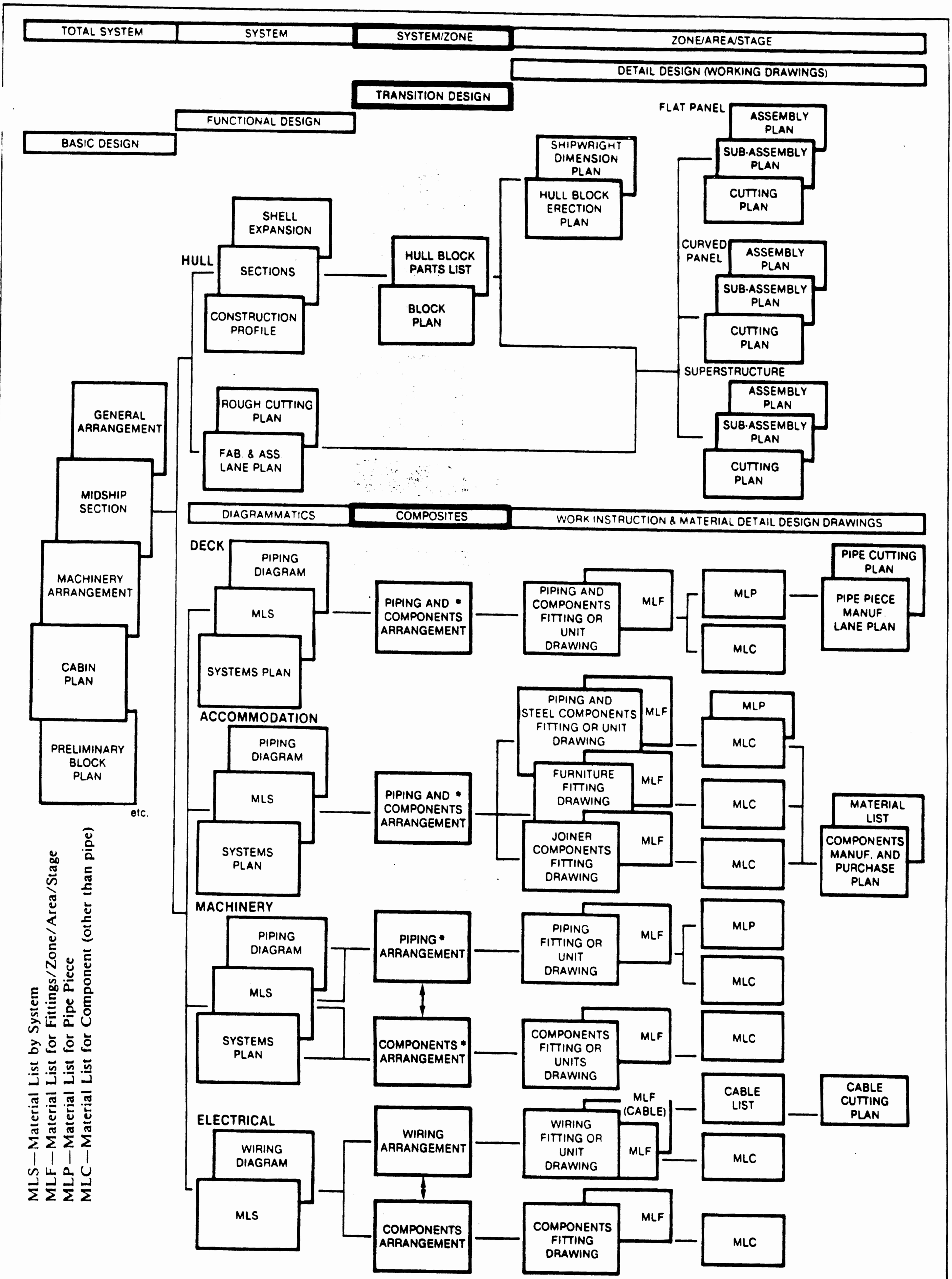
Typical block break scheme



Outfitting such as piping, ventilation, electrical components etc.... is installed on the assembled unit. Components not susceptible to blast and paint damage are installed during main assembly, taking advantage of downhand welding. Other items are installed during a pre-outfit stage of construction.

Pre-assembled and outfitted unit erected on ways





ƷURE 2-2: Product-oriented Design Process. Transition Design introduces zones and interrelations with systems. The items marked "*" are sometimes ɩreehand. But, they are sufficient for quickly conveying arrangements and system/zone relationships to detail designers. The latter refine arrangements and designate stages during preparation of work instruction and material detail-design drawings.

Outfitting Method

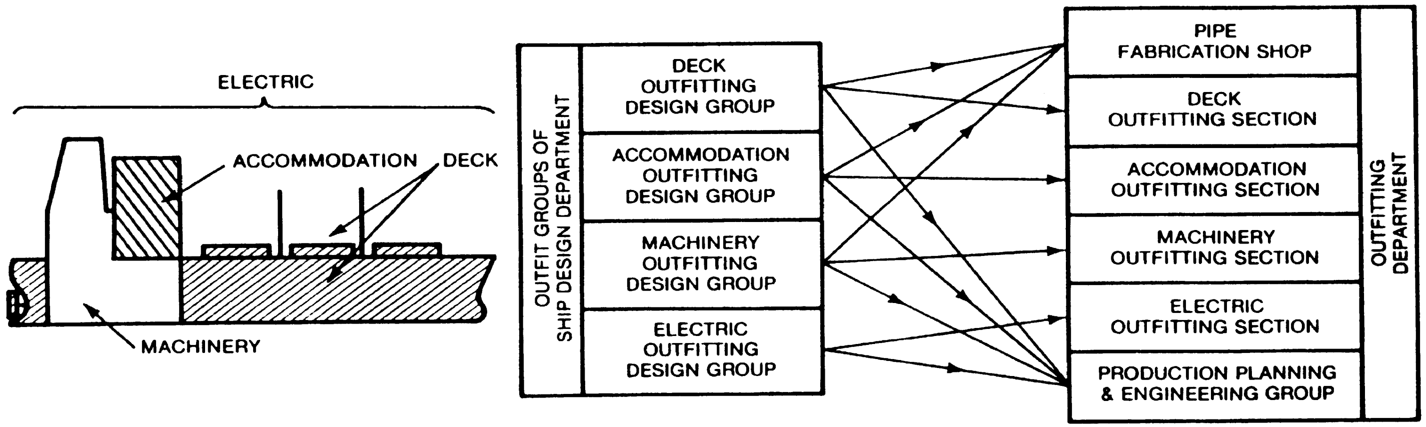


FIGURE 2-3: Where the Zone Outfitting Method (ZOFM) is used, design and production are organized to specialize by fabrication and assembly problems associated with deck, accommodation, machinery and electrical outfitting. This conforms with a basic tenet of Group Technology (GT), i.e., matching classes of problems to sets of solutions.

Current Navy Estimating Method

$$BCC = \sum_{SWBS\ 100}^{SWBS\ 900} (Labor\ Cost + Overhead\ Cost + Material\ Cost) + Profit + FCCM$$

Labor Cost = f_1 * Lc * CER * Unit of Measure * Labor Rate

Overhead Cost = Overhead Rate * Labor Cost

Material Cost = f_m * CER * Unit of Measure

Where:

f_1=f(shipyard work load, complexity, etc....)
f_m=f(quantity, material, complexity, etc...)
Lc=Learning Curve Effect
CER based on bid package, return costs, etc...
Units vary (hrs/ton, $/ton, $/kw etc...)

Shipyard Estimating Methods

- Parametric based on historic data
  - » Primarily system oriented (SWBS for Navy ships, ABS classification for commercial ships)
  - » Usually weight based
  - » Insensitive to production issues such as density, complexity etc...
- Overhead allocated as a percentage of direct labor hours

Ship Work Breakdown Structure (SWBS)

- **Up to four digit (extended SWBS) definition of system components**
- **1 digit SWBS:**

  Group 1: Hull Structure
  Group 2: Propulsion Plant
  Group 3: Electric Plant
  Group 4: Command and Surveillance
  Group 5: Auxiliary Systems
  Group 6: Outfit and Furnishings
  Group 7: Armament
  Group 8: Integration/Engineering
  Group 9: Ship Assembly and Support Services

Shipyard Cost Control

- Product Work Breakdown Structure PWBS implemented in 1970's
  - » Uses work package approach to schedule, track and manage labor and material
  - » Work packages still highly system oriented; product and process definition is lost below the level of large structural assemblies
  - » PWBS not linked to Estimating Breakdown Structure (EBS)

Product Work Breakdown Structure

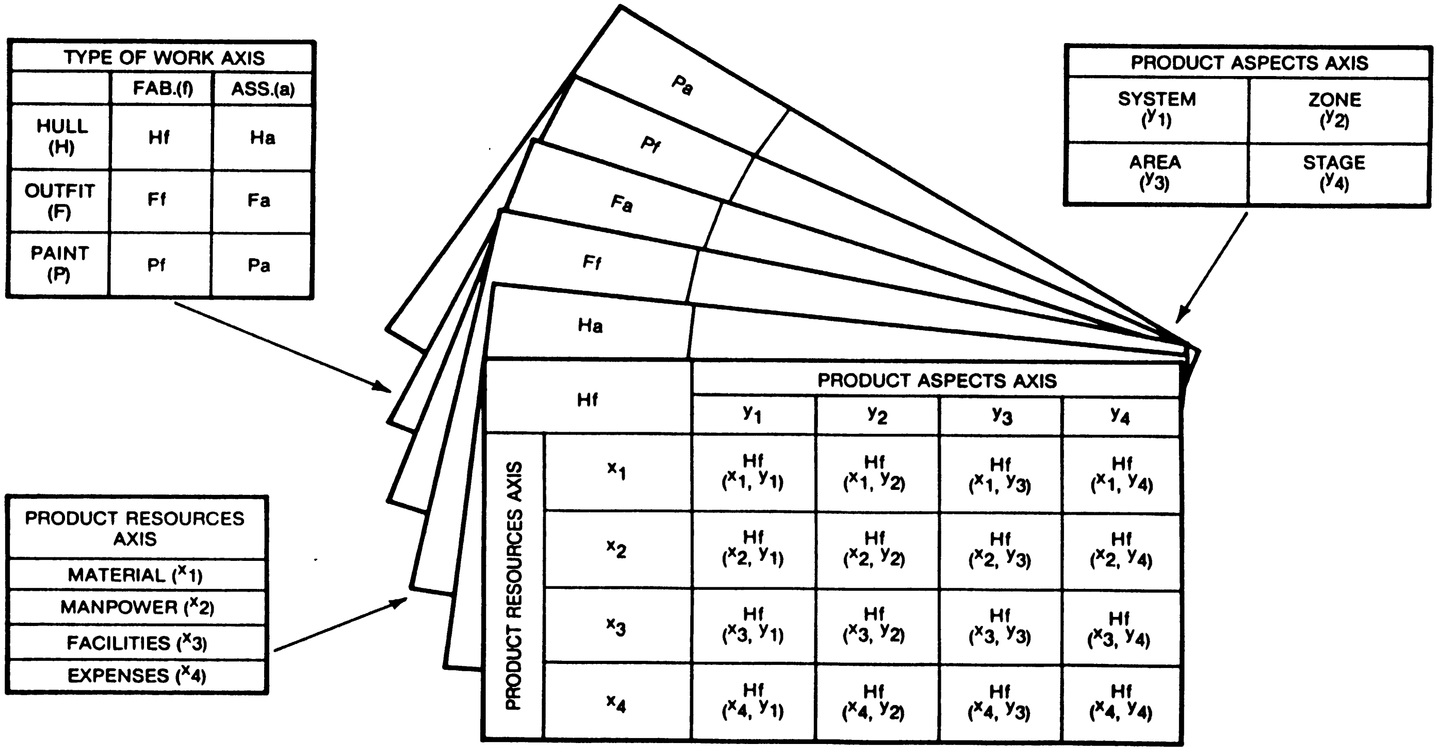


FIGURE 1-3: Elements of the Product Work Breakdown Structure (PWBS) and their relationships to each other. The three types of work are each subdivided into *fabrication* and *assembly* classifications which are normally associated only with hull construction and outfitting. Within the painting classification, *fabrication* applies to the manufacture or preparation of paint and *assembly* means its application.

Product Oriented Cost Estimating and Management

- The future of competitive shipbuilding
  - » Estimates cost of ships based on the cost of materials and production processes
  - » Establishes cost pools to correctly allocate indirect costs to products
  - » Allows estimating and management of costs with simultaneous commercial and government ship construction