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Using Cost of Ownership in a Corporate Strategy

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Executive Summary

The role of finance in an organization has changed from a focus on historical accounting to one of implementing and directing cost management and control strategies. New software based tools can be used to help implement those strategies in the organization. One such tool is the use of life-cycle cost analysis such as cost of ownership (COO) modeling and simulation. COO is an implementation of Activity-Based Costing (ABC) that helps to understand all costs associated with a decision; especially those that extend beyond initial purchase and installation costs. It improves decisions by relating incurred costs to the products, processes, and services the drive the cost requirement. Without such a linkage it is difficult for other organizational functions to understand the full impact of COO on their operations.

The semiconductor industry leads the use of COO for purchasing processing equipment. COO was developed for semiconductor fabrication tools and has been extended many other applications. Using cost of ownership has significant benefits for the end user. It is neither complex nor hard to do. With a few significant details about purchase, operation, utilization, and performance, users can determine the life-cycle cost of a project or system.

Total Cost of Ownership

Historically, purchase decisions have been based on initial purchase and installation costs. However, purchase costs do not consider the effects of reliability, utilization, output and yield. Over the life of a

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July

7-8 SEMI-sponsored seminar
"How to Successfully Manage New Product Introductions"
San Francisco, California

11 SEMI-sponsored seminar
"Understanding and Using Cost of Ownership"
San Francisco, California

13 SEMI-sponsored seminar
"Understanding and Using Cost of Ownership: A&P Emphasis"
San Jose, California

October

17-18 SEMICON Southwest 2000
Austin, Texas

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system or project, these factors may have a greater impact on cost of ownership than initial purchase costs. Lifetime cost of ownership per manufactured unit is generally sensitive to production throughput rates, overall reliability, and yield. In many cases it is relatively insensitive to initial purchase price.

COO analysis has several benefits for the end user. COO provides an objective analysis method for evaluating decisions. First, it provides a clear estimate of the life-cycle cost. The analysis highlights details that might be overlooked, thus reducing decision risk. The COO model can also evaluate processing and design decisions. Finally, the COO model provides communication between equipment suppliers and users. They are able to speak the same language, comparing similar data and costs using the same analysis methods. Both suppliers and manufacturers can work from verifiable data to support a purchase or implementation plan.

Using COO analysis helps the organization address issues of productivity, performance, and optimization. The results of a cost analysis can show the factors that are impacting organizational cost structures for a particular decision. Will the decision impact labor cost? Capital cost? Materials and components cost? COO analysis also helps management understand the interactions among the several cost drivers. For example, management might ask the following questions:

- Will an increase in capital costs for automation be justified by reduced labor costs?
- Will pre-assembled component modules reduce overall manufacturing costs?
- How does the bulk distribution of chemicals impact manufacturing costs?
- How will manufacturing costs change if equipment utilization rates change?

These and other similar questions can be better understood using total cost of ownership modeling and simulation.

What is COO?

Cost of Ownership is an approach to understanding costs associated with a purchase in addition to purchase and installation price. For production equipment it includes the full cost of embedding, operating, and decommissioning a processing system in a factory environment[1]. For component and materials it may include costs of supplier selection, qualification or certification, order placement, payment, disposal, incoming inspection, and quality related issues. SEMATECH began developing a COO model for the semiconductor industry in 1990. Since then, standard definitions for COO have been published by Semiconductor Equipment and Materials International (SEMI®). A commercial COO model, based on these standards, has been introduced in a cooperative effort between SEMATECH and Wright Williams & Kelly (WWK).

With a few details about costs and productivity, users can determine the life-cycle cost of owning and operating a piece of equipment[2]. Fixed costs include purchase, installation, and facility costs. Operating costs such as material, labor, repair, utility and overhead expenses are costs incurred during equipment use. Throughput is the time to meet a process requirement such as depositing or etching a nominal film thickness. Composite yield is the operational yield of the tool and may include breakage, processing errors, and defects. Utilization is the ratio of production time compared to the total time available. Yield loss cost is a measure of the value of production lost through operational losses and defects. With these details, COO provides an objective analysis method for evaluating decisions and provides a systematic focus on issues that might otherwise be overlooked.

Cost of Ownership Examples

The simplest example of cost of ownership is in estimating the life-cycle cost of a process or an operation. The following table summarizes the major cost drivers for a simple example in terms of cost per good manufactured unit.

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	Cost per Good Unit
Materials	$0.702
Scrap	0.650
Equipment	0.557
Maintenance	0.408
Labor	0.345
Floor Space Allocation	0.152
Overhead Personal Allocation	0.052
ESH Costs	0.027
Training	0.005
System Qualification	0.002
Total COO	***$2.90***

Many times a detailed COO analysis is not needed. Proper decisions may be made by understanding the relative differences between two options. For example, a decision must be made whether to implement a liquid chemical process or an alternative dry, gas-based process. Either process will produce the same level of quality and will require about the same level of process utilization. COO analysis shows a difference of about $0.40 in cost per processed unit, with the wet process being less expensive than the dry process.

The following figure shows the relative difference between several cost drivers for the processes:

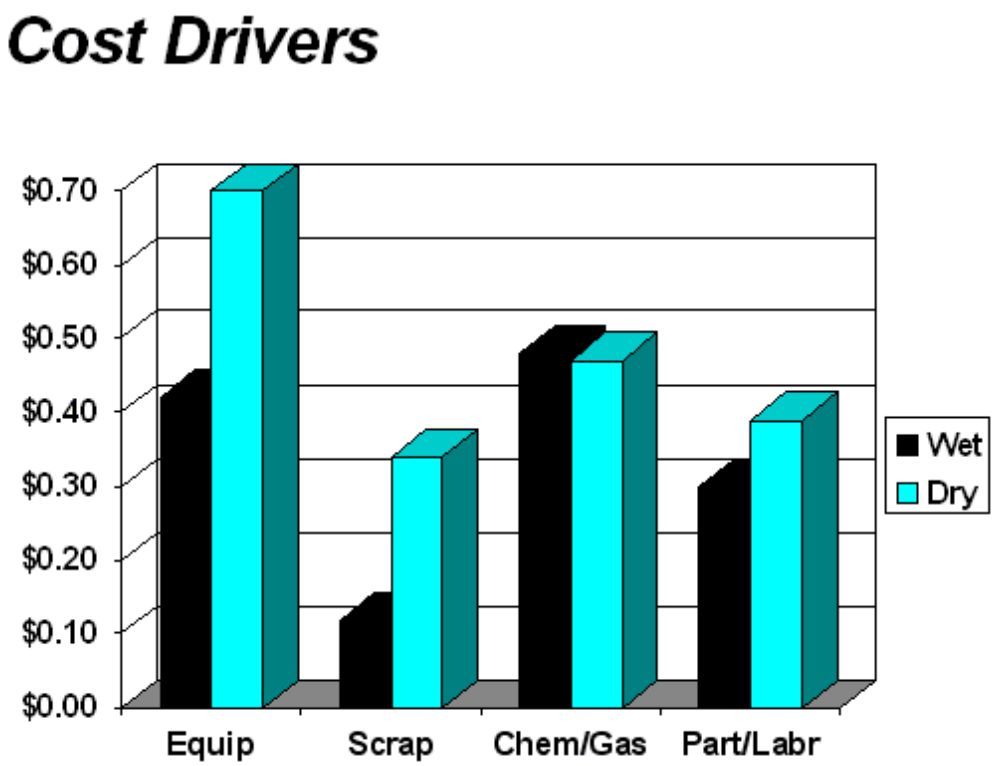

Figure 1: Cost of Ownership Drivers

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COO and Decision Strategies

Senior management has always been heavily involved with developing and implementing cost and decision strategies within an organization. With growing centralization in many companies, many decisions are now made at executive levels rather than at the operational or technical levels of organizations. Some of the reasons driving decisions up the corporate ladder include the following:

- Corporate purchasing controls limit discretionary spending
- One division can't purchase for cross division use
- Risk avoidance
- Conflicting priorities in organizations
- Lack of use or acceptance of decision making tools

The ultimate decision-makers are not spending more time on analysis. Instead, they are worrying more and enjoying it less. Detailed analysis is precluded by the increasing number of decisions executives must make. Decisions are frequently made based only on the simplest data to gather. The following table shows some of the information useful for an equipment purchase decision, the ease of gathering the data and the impact on life-cycle costs.

Data Source	Collection and Analysis Effort	Impact on COO
Purchase price	Low	Medium *
Delivery and installation	Low	Low
Gases, chemicals, and materials	Low	High
Repair parts	Medium	Medium
Direct and indirect labor	Medium	High †
Qualification, training, and startup	Medium	Low ‡
Output and utilization	Medium	High
Yield and process control	High	High
Overhead and administration	High	Low

Thus, considering only data requiring low collection and allocation effort may not result in the best decision.

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* Low for capital equipment with long life cycles
† Medium for highly automated systems
‡ Medium for introducing new types equipment or processes

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Each decision requires balancing priorities, addressing limited resources, providing constant oversight, and considering who screams the loudest. The result is more pocket vetoes, push back for more analysis, or gut-feel decisions rather than data-driven decisions. These decision delays are counter to the need for increased agility in a very competitive business climate.

The use of cost of ownership as part of a sound decision strategy overcomes some of these challenges. Cost of ownership analysis can be automated to minimize efforts spent on repetitive, low-value purchase decisions. It also provides a consistent data-driven method for arriving at more important, strategic decisions. We will discuss the use of COO in two types of decisions: prioritization and optimization.

A very important use of cost of ownership for equipment and material suppliers is project prioritization. Which project will provide the largest cost benefit to the organization? What will be the impact on productivity? On manufacturing? Project evaluation starts with a baseline COO analysis under normal operation. Once a baseline cost of ownership is run, projects of interest can be evaluated. By modifying one parameter at a time, the COO impacts of the projects can be determined. Armed with improved cost performance data and knowing the cost of implementation, return on investment (ROI) for each project can be estimated. Implementation costs would include equipment and material purchases and other costs incurred by the end user. Applying ROI to the cost of ownership of each potential project provides insight into which changes will provide the largest return to both users and suppliers.

Optimization is also an important application of COO analysis. It is the means by which the impacts of changes to existing equipment are determined, processes are improved and upgraded equipment and materials purchases are evaluated. For existing equipment and material sets, changes in the current process can have significant impact on total costs. Optimization in this case is not a technical optimum; it is a cost optimum. Essentially it asks, “What is the most cost effective method to do the job?”

Figure 2 illustrates the use of COO to determine the optimal lamp replacement strategy for a lithography tool. As lamp intensity degrades over time with use, the throughput of the tool is reduced. However, lamps are expensive and the maintenance time to replace a lamp reduces tool availability. This complex optimization requires information about the lamp intensity over time and the cost of replacing the lamp. We estimated average production throughput, annual maintenance impacts, and COO for several lamp replacement strategies. Figure 2 shows the normalized results.

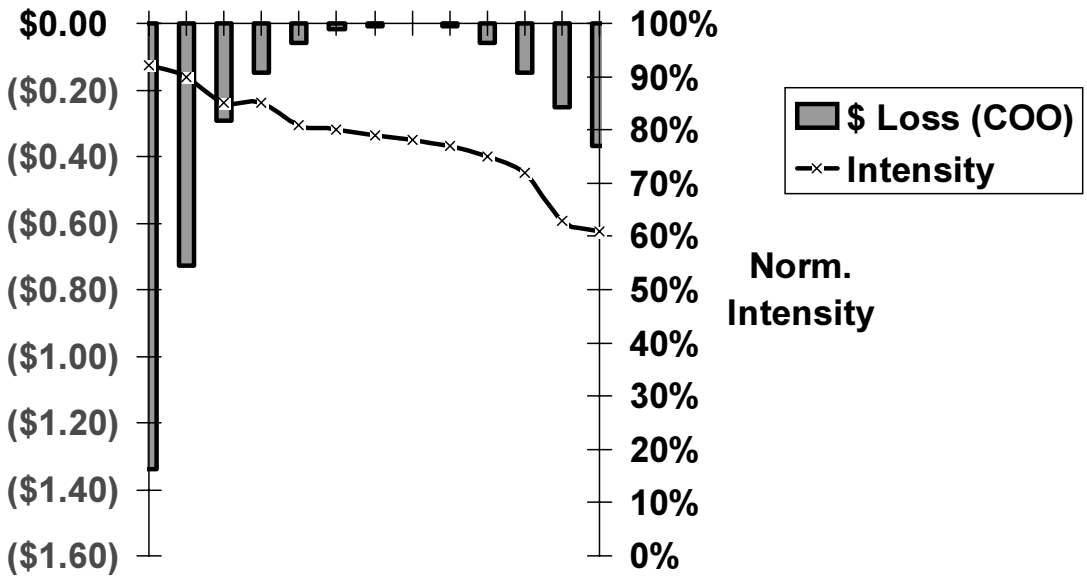

Figure 2: COO and Lamp Intensity over Time

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Sometimes optimization just requires improved operating methods. The enhancements yielding the best COO performance will most likely be given priority. The least expensive materials and equipment for today's complex processing systems may not have the lowest long-term cost.

To Share or Not To Share?

A complete cost of ownership analysis often requires information that many organizations would consider proprietary. Thus the issue of whether or not to share COO analysis with suppliers is frequently raised. Cost of Ownership analysis of new purchases produces valuable information that can benefit both the supplier and the user. A 1994 study[3] by the Center for Advanced Purchasing Studies of 11 organizations using COO analysis found that most of these organizations shared detailed COO data with their suppliers. This data was used as an objective tool for supplier evaluation and as a metric for measuring and focusing continuous improvement efforts. The organizations studied believe that using COO has a positive impact of their relationship with their suppliers and suppliers were favorable toward receiving objective feedback.

The semiconductor industry has provided one solution to COO data sharing. The SEMI International Standards committee has published a set of example values[7]. The examples include values[4] for:

- Production Schedules
- Labor and Salary Rates
- Space Rental Rates or Costs
- Depreciation Parameters

COO analyses using the example values can easily be shared and focus on equipment or process operating parameters instead of company to company differences. Standardized models benefit both the manufacturer and equipment/material supplier communities. A standard COO model can provide a clear estimate of the cost of ownership. It allows users and suppliers to speak the same language, comparing similar data and costs using standard software and equations.

The "Total Cost Modeling in Purchasing," study also showed that the use of COO had a favorable impact on internal relationships within a company. In most of the organizations surveyed, a multifunctional team is responsible for COO analysis. Such a team may include the user organization, purchasing, finance, and operations; with representation from other support organizations as needed.

Because of this team approach, one might think that COO data is widely disseminated throughout the organization. However, this study showed that wide dissemination of COO data is limited[5]. For the most part, the data is not used extensively outside of the team. Even an organization with an automated system for calculating COO did not pass that data along to accounting or finance for use on product costing or pricing decisions. Thus the strategy for sharing data internally is as important as the strategy for sharing data externally.

COO and ABC

Activity based costing and management (ABC) is a valuable tool for addressing product, process, and customer profitability[6]. Cost of ownership is an implementation of ABC. COO focuses on specific cost drivers that impact life-cycle costs. Much of the value of COO is wasted if the data gathered in only used a for a specific purchase decision. Broader analysis of that information through ABC makes COO an integral part of day-to-day operations. The valuable COO data can be used to determine how various costs should be allocated, which products or services are profitable, and how those products or services should be priced. COO analysis can help identify non-value-added operations in both internal systems and with external suppliers. It improves decision making by relating incurred costs to the products, processes, and services the drive the cost requirement. Without such a linkage it is difficult for other organizational functions to understand the full impact of COO of their operations. Linking incurred costs to products, processes, and services, becomes part of an ongoing, continuous improvement process.

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Conclusion

The role of finance in an organization is increasingly focused on implementing cost management and control strategies. Software tools such as cost of ownership modeling and simulation can be an important part those strategies. COO includes the full cost of embedding, operating, and decommissioning a processing system. It may include costs of supplier selection, qualification or certification, order placement, payment, disposal, incoming inspection, and quality related issues.

Senior management has always been heavily involved with developing and implementing cost and decision strategies within an organization. The ultimate decision-makers are not spending more time on analysis. Instead, they are worrying more and enjoying it less. Better analysis leads to better decisions. Better tools for that analysis leads to quicker decisions. The use of COO as part of a sound decision strategy overcomes some of the challenges that decision makers face.

COO has a positive impact on the relationship between manufacturers and their suppliers. Equipment and material suppliers are favorable toward receiving objective COO feedback. A standard COO model provides a clear estimate of the cost of ownership, allowing users and suppliers to speak the same language and to compare similar data and costs using standard software and equations. A cost strategy using COO analysis improves decision making by relating incurred costs to the products, processes, and services the drive the cost requirement, becoming part of an ongoing, continuous improvement process.

Biographies

Daren L. Dance is Manager of Applications Research and Development for Wright Williams & Kelly and is chairman of the SEMI Standards Cost of Ownership Subcommittee.

Susan King is Chief Finance Officer for Industrial Design Corporation.

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[3] Dr. Lisa Ellram, "The Use of Total Cost of Ownership in Purchasing," Applied Cost Modeling, July, 1994, Pleasanton, CA, p. 6.

[4] SEMI E35

[5] Dr. Lisa Ellram, "The Impact of TCO Analysis on Intra-organizational Decision Making," Applied Cost Modeling, November, 1994, pp. 4-5.

[6] For an ABC implementation example, see Alan Stratton, "Using ABC for Intelligent Process Reengineering," Corporate Controller, January/February 1999, p.15.

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Wright Williams & Kelly Offers Free Web-based Defect Target Calculator

Wright Williams & Kelly (WWK) has announced the availability of a free web-based defect target calculator designed to help users of the International Technology Roadmap for Semiconductors (ITRS) predict fault specifications. The random defect targets recently released by the Semiconductor Industry Association (SIA) are based on predefined technology nodes using data collected by SEMATECH member companies on 164 tools, which are divided into 30 generic tool categories.

"The ITRS roadmap has grown in complexity," states Daren L. Dance, WWK's Vice President of Technology and a member of the roadmap committee's defect reduction technical working group. "Even with the additional targets for memory and logic products, rarely do actual circuit line widths and areas match the ITRS technology node assumptions. We developed the defect target calculator to help semiconductor suppliers and manufacturers compare the roadmap targets to their current or planned needs."

"The defect target calculator allows users to confidentially enter key parameters for a selected tool and estimate a defect target for a specific chip. The only parameters required are the chip area, minimum line width, mask levels, and random defect-limited yield requirement. We use the same scaling method and generic tool categories as the roadmap to provide specific target estimates. Posting the calculator on our web site makes this service widely available and makes the roadmap more useful."

The calculator can be accessed free of charge at: http://www.wwk.com - select the “Product” button then the “ITRS Defect Target Calculator” under Yield Modeling.

Additional information about the ITRS roadmap can be found at: http://www.semichips.org

WWK Releases Factory Explorer® v2.7

WWK is pleased to announce the latest release of Factory Explorer®, its integrated capacity, cost, and discrete event simulation tool. This latest release includes a variety of useful enhancements including:

- The ability to model individual consumption expense items (specialty gases, etc) in a highly flexible fashion. Consumption rates can be specified at the tool level for any of the SEMI E-10 operating states or on a unit-by-unit processing basis.
- The user can now specify goto’s on alternative process steps to model complex routings, can use additional random variable distributions to better fit actual data, and can simulate potential deadlock situations.
- The capacity analysis engine is enhanced to be faster and to require less memory when analyzing very large models.

This update is provided free of charge to existing Factory Explorer® customers covered by warranty and maintenance agreements.

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Applying Cost of Ownership Modeling at Texas Instruments

By David L. Bouldin and Tim Szabo

Texas Instruments competes in an environment of highly cost-sensitive, leading-edge technologies. Several years ago, TI recognized that a unified Cost Of Ownership (COO) strategy and tool set could help make accurate capital investment decisions and avoid or reduce manufacturing costs. COO modeling is used to understand and then drive down the costs in the major areas of chip building: wafer fab, assembly & packaging, and test. COO modeling is now a key component of TI's Equipment Capability Comparison Decision Matrix.

The COO strategy was simple. It included training key personnel in COO modeling techniques, providing a user friendly COO model and maintaining a flow of current internal modeling information. Hundreds of our employees worldwide have been trained. Our internal support structure provides our user base with advanced training, technical assistance on complex analyses, help with interfacing with other COO models, setting internal standards and acting as a clearinghouse for worldwide COO information.

How does COO modeling affect the bottom line? Individual cases have been documented of multi-million dollar cost avoidances on new equipment purchases and new process implementations. Among the intangible benefits that have been discovered are an increased objectivity and confidence in the decision process, a higher sensitivity to cost impacts, and better communication internally and with suppliers. Use of the industry standard SEMI E35-compliant model is essential to maximum supplier communication. Lately, TI has seen how a better understanding of COO methodology has enabled its suppliers to improve their products and control pass-along costs.

TI started using COO for capital equipment decisions, but has expanded COO modeling techniques to areas like equipment upgrades, material changes, and process changes. In a business where cost per bit is critical, COO techniques, backed by a commitment from senior management, can have decisive strategic benefits.

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David L. Bouldin is the Equipment Evaluation and Improvement Methods Manager for the Semiconductor Group of Texas Instruments Incorporated. David earned his B.S. degree in Physics and Math from Tennessee Technological University.

Tim Szabo is an independent consultant and former Cost Of Ownership Coordinator for the Semiconductor Group of Texas Instruments Incorporated. Tim earned his B.S. degree in Business and Public Administration from the University of Texas at Dallas.

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Factory Commander™ Version 2.4 Released

Driven by customer response, WWK has released the latest version of Factory Commander™. The v2.4 release contains numerous enhancements and represents yet another milestone in Cost and Resource Evaluation modeling capability. Managers in the IC, FPD, solar panel, disk drive, silicon and other electronic component manufacturing industries can quickly and accurately evaluate their strategic and tactical options.

This release of Factory Commander™ now allows modeling of longer timeframes (up to 12 years), and greater discretion for time period interval. These intervals include years, quarters, months and weeks. For instance, months or weeks can be modeled in the early period of a model, and quarters or years for the later periods. Eight pre-designed timeframes are available to accommodate differing event horizons.

The capability now exists to do automated evaluations of input sensitivities. Many of the most commonly investigated input parameters can be independently evaluated by simply settings a few parameters and clicking the run button. Final Yield, Throughput Capacity, Equipment Capital Cost are among the many inputs that can be evaluated in user definable ranges. This feature also provides more than 20 different response variables, with the ability to print or export multiple selections.

Some of the other functionality and interface enhancements include…

- Distributed payments for tool capital. Individual equipment group can now have their expenditures spread out over a wide range of time, as opposed to having a lump sum expended at the time when the equipment is installed. This enables payment or installment plans to be accommodated to more accurately reflect the anticipated cash flow.

- Future building and facility expenditures. Planned expenditures for building shell construction and facility expansions can now be accommodated. Also, expenditures for initial or additional facility construction can now be designated by expended amounts and by user-definable categories (e.g., chillers, ultrapure water systems, HVAC, steam & boiler systems, etc.). These inputs can be specified for the period prior to the modeling timeframe, and into the future. Different depreciation methods can be assigned to each category of expenditure.

- Several new reports have been added - capital cost summary, labor cost summary, unit cost per sector, and a financial summary. The capital and labor reports allow a consolidated listing of the building, facility and equipment expenditures and labor total cost, respectively, on a quarterly or annual basis. The sector unit cost report shows the cost per production unit (wafer, die, display, etc.) summed over all steps associated with a process sector. The financial summary presents key financial metrics for the project or business (cash flow net change, net present value, payback period, time when positive cash flow occurs, etc.).

- Improved header labeling for exported spreadsheets. When exporting model data from Factory Commander™ to M.S. Excel format, the spreadsheet column headers have been improved to include units (e.g. wafer/hours, $/year) and more descriptive labeling that closer resembles the printed report.

- Enhanced data input screen interface. In particular, the Process Step screen is now arranged so that yield, throughputs, and process routings data are presented in a spreadsheet-like grid. In addition to providing more efficient data editing, this feature enables simultaneous viewing of multiple steps without having to navigate between steps.

Factory Commander™ is the best choice for your factory's cost/resource evaluations needs. Let Factory Commander™ reduce the confusion of manufacturing costs and show you the way to increased profitability. For additional information contact Wright Williams & Kelly at 925-485-5711.

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