

**Designing Measurement
Systems in a Manufacturing Environment**

by

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Abstract

In the increasingly complex world of manufacturing, the ability for an organization's leader to understand and control the systems by which an organization functions is becoming a prerequisite for success. In addition to setting a vision, building this vision into a shared commitment and providing the resources necessary to accomplish appropriate objectives, the leader must assume the role of designer of the structures by which the organization functions. Such systems may provide structure for capital budgeting decisions, evaluation and promotion, market evaluations, or even employee suggestion programs. Systems are the structure by which we operate. Failure to recognize, understand and control these structures will bequeath them to chance.

The goal of this thesis project was to demonstrate that a large corporation could benefit from a closer partnership between two internal divisions. One of these divisions functions as a fabricator and supplier to the other, a Line of Business involved in office equipment manufacturing. The existing relationship between these two internal organizations is strained and uncooperative. Management's original intention was to show that a closer relationship could reap benefits for the company. Consequently, demonstrated benefits would result in the impetus for further partnering. An approach of this manner fails to address the underlying structure or "system" that is truly causing the problem.

This thesis examines the systemic impact of the company's measurement system on the aforementioned relationship. It demonstrates how the metrics that management uses to evaluate the performance of three major constituencies inhibits productivity improvements, places little value on engineering partnerships and costs the company millions of dollars through poor purchasing decisions. This paper highlights the underlying structure and proposes a method for creating a new measurement system that is consistent and supportive of management's objectives.

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1 LEADERSHIP AS THE KEY TO COMPETITIVENESS

Successful companies are not managed; they are led. A manager, almost by definition, maintains the status quo. A leader, on the other hand, sets direction for the company. There are several basic responsibilities of leadership. Failing to acknowledge any of these elements presents the opportunity for failure. At the most fundamental level, leaders must.

- **Determine the vision.** They must decide, in the best interest of all stakeholders, the corporation's strategy.
- **Build a shared vision.** The leader cannot retain sole ownership of the vision; each individual in the organization must come to view it as theirs. The difficulty and time required in achieving this commitment should not be underestimated. Interacting with workers, leading by example, listening and opening the honest dialogue necessary to achieve a shared vision is challenging work.
- **Provide the resources necessary to realize the vision.** In addition to physical assets, the leader must delegate, mentor and train juniors. Leaders are responsible for the development, successes and inadequacies of their lieutenants. By failing to do so, leaders shoulder the responsibility for failure as surely as if they were the one assigned the tasks.
- **Design of the systems by which the organization functions.** Consequently, systemic failures or inadequacies are the sole responsibility of the leader.

Leadership styles will vary. These points can be accomplished through authoritarian or participative manners. However, recognition and mastering of these fundamentals is characteristic of effective leaders.

2 BACKGROUND

2.1 Systems Thinking is Essential

Perhaps the most overlooked of these fundamentals is the design of systems. Pioneered by Jay Forrester in the late 1950's and early 1960's, the importance of this new science, Systems Dynamics, has continued to become more evident. Forrester stresses the importance of recognizing that many of life's problems are the result of an underlying structure rather than a mere response to random events. Forrester continues to argue that understanding and controlling these underlying systems is the way to achieve a lasting solution to the fundamental problem.

More recently, many of these same ideas have coalesced into a discipline that management education and practice recognize as 'systems thinking'. Management texts and journals, spearheaded by Peter Senge's The Fifth Discipline, have promoted this concept to its rightful place among the responsibilities of leaders. Due to the relatively new prominence of this 'discipline', it is not surprising to find companies suffering from inadequate or even damaging systems.

This thesis will argue that current problems in the partnership between two Eastman Kodak divisions result from poorly designed systems. Chapter 2 provides the background necessary to understand the problem.

- Section 2.2 provides a framework for understanding the current problem by presenting a historical account.
- Section 2.3 defines the current problem.
- Section 2.4 explains the research methodology.

Kodak's measurement system relies heavily on information provided by the cost accounting system. Using three examples, Chapter 3 will show how this measurement system discourages the activities necessary to achieve the company's long term strategy.

- Section 3.1 establishes the benefits of cooperation between process

engineers and product engineers and argues that the measurement system places little value on these beneficial partnering activities.

- Section 3.2 argues that the primary objective of meeting budget does not encourage, and even discourages, manufacturing managers from seeking productivity improvements.
- Section 3.3 argues that the performance measurement for materials management personnel is also based on faulty metrics. This misunderstanding of accounting numbers and the consequent use in the material management's evaluation system actually costs the company millions of dollars. This section includes an estimate of the potential cash savings that can be realized by changing this measurement system.

The final chapter, Chapter 4, presents this thesis' findings and recommendations

- Section 4.1 recounts the lessons of this project and proposes a framework to aid leaders in designing measurement systems
- Section 4.2 returns to the point that changing and controlling the organization's system is a fundamental job of a leader

A companion thesis to this work is Measuring Customer Driven Manufacturing Process Improvement in a Multi-Divisional Corporation, Massachusetts Institute of Technology, 1993 by Jon Rennert, Leaders For Manufacturing Fellow, '93. The research that resulted in this work was done in conjunction with the research that Rennert performed for his thesis. Analyzing the same problem, Rennert provides a case study of how the accounting system, and measurements based on it, undervalue the potential savings for Eastman Kodak from a value engineering project. He provides an excellent specific example of how the current system will prohibit the company from realizing tremendous savings from the work of their employees. A copy of Rennert's abstract is included in Exhibit I.

2.2 History of the Problem¹

Changing Situations, Changing Strategies

In 1985, the Eastman Kodak Company faced an unprecedented situation. In its almost one hundred years of existence, profitability had never been in question. Previously, the company enjoyed tremendous profits harvested from its monopolistic silver-halide film business. The company invested in equipment manufacturing as a way to create a market for "consumables", such as film and toner.² Acceptable in this strategy is the production of hardware items at a loss, due to the profits they generate through increased sales of "consumables". This is not an uncommon strategy as demonstrated by Gillette and Polaroid. Until Fuji and Canon became players in the imaging industry, this strategy remained viable.

Led by Fuji's improvements in film quality and production, new competitive pressures squeezed the profit margins on film. As a result, "consumable" profits could no longer subsidize equipment manufacturing. Facing unsatisfied shareholders and a worsening situation, then-CEO Colby Chandler decided the answer to revitalizing profitability lay in decentralization. This resulted in 17 Lines of Business (LOBs). From that day forward, profitability became the responsibility of the LOBs. Those groups that could stand on their own would add to Kodak's bottom line; those that could not would be divested.

The Line of Business Structure

Prior to the decentralization, Kodak had been an extremely vertically-integrated company. In the new structure, LOBs are profit centers. Research and Development

¹ The facts of this history were established through conversations with numerous Kodak personnel and supplemented by information presented in Loyd, Bernard (1990). The systemic analysis presented in Section 1.3, Definition of the Current Problem, was derived by the author and checked during discussions with Kodak managers.

² Equipment Manufacturing involves the manufacturing of hardware devices, such as cameras, printers, and copiers, that use consumable material which Kodak also manufactures and sells. Film is Kodak's premier media, although paper, toner and other items are also in this category.

budgets, capital expenditures, raises and other business expenses come out of LOB profits. Each LOB contains most normal business functions: Marketing, Design, R&D, Finance and Support Services. However, the Manufacturing function of each LOB primarily performs only assembly operations. Functioning as a cost center, the Kodak Apparatus Division, hereafter known as "Core", retained the bulk of the "core" fabrication capabilities and is responsible for meeting all of the company's *equipment* manufacturing research and production needs.³ This function is retained centrally because each LOB needs some of Core's offerings; there is no way to divide the fabrication asset base between the new LOBs without destroying economies of scale. Product assembly, and other functions, share no corporate-wide scales.

Accountable for total profits, LOB managers requested the autonomy to make all decisions related to their business, including where to source components. Without being a fabricator, LOB managers have two primary options to control cost. The first option requires committing engineering resources to aid in making Core competitive; this indirect approach has a lengthy timetable for results. The other option gives more immediate returns by shifting purchasing away from costly Core components to non-Kodak suppliers. Given the low, or in some cases negative, profits at the start of the decentralization in 1985, LOB managers were under tremendous pressure to become profitable. External sourcing became the most expeditious route to profitability.

The Source of the Competitiveness Problem

Unlike their LOB counterparts, Core's success in the short run could not be achieved so readily. It confronted unique challenges. Core needed to solve the root cause of the original crisis by striving to increase productivity and install lean manufacturing. The existing equipment and asset base were purchased to support three high volume programs: the Instamatic Camera, the Disc Camera and copiers. Both camera programs

³ Film and chemical manufacturing are handled by separate organizations

have since been discontinued. Compounding this reduced demand problem, forecasted copier production volumes never materialized. Consequently, Core had an under-utilized asset base built for high volumes.⁴ Rather than reassess their manufacturing requirements and re-capitalize accordingly, Core felt the existing asset base could be re-deployed to serve LOB needs.

At the time of the decentralization, the entire company had suffered from the same problems plaguing other American manufacturers. Companies had become monolithic, lethargic and unresponsive to the rapidly changing business world. While LOB purchasing could achieve localized profitability gains, *long run returns for the company* would come from tackling the harder problems of increasing productivity and eliminating overhead and waste in Core. Decentralization failed to address this problem; this solution allowed LOBs to seek improved profitability by means other than solving the company's root problem. More importantly, decentralization created a system that resulted in a widening gap between Kodak divisions.

2.3 Definition of the Current Problem

The Declining Spiral of Core

Kodak's accounting system dictates price transfers be performed at fully burdened costs.⁵ To purchase internally, a LOB had to pay the full cost of Core's overhead and manufacturing inefficiencies developed through years of having a captive customer base. Core had been insulated from having to learn world-class manufacturing techniques or supplying their customers with competitively priced parts. Under pressure to immediately improve profits, LOBs could not wait for Core to fix its problems. Almost instantaneously, customers needed Core to master techniques that others had acquired

⁴ It is unclear why these assets were not written off as a loss with the failure of the project for which they were purchased; unfortunately, the accounting system continues to penalize the remaining customers for the failure of the other programs.

⁵ The full effects of the accounting system and the problems it causes will be discussed in section 2.3

over many years of practice. Clearly, this was not possible and they lost the internal business.

It is important to understand the systemic implications of the decentralization decision. It is destroying Core. By measuring LOBs on profitability, the system discourages the internal purchasing of components. *As production volume is outsourced, the transfer prices dictated by the accounting system continually increase, making it even less desirable for LOBs to use Core.* This robs Core of the volume it needs to become more productive. This system continually feeds on itself, compounding the problem. This thesis will argue that the systems, unwittingly enacted with the decentralization, are eroding Eastman Kodak's equipment manufacturing expertise.

Recognizing the Need for Manufacturing

The deterioration of the company's equipment manufacturing base is not in line with the company's strategic direction. Senior Kodak managers recognize the need to retain the company's manufacturing capability. They refute the claim that the company can succeed simply as an assembler of products. Consequently, the company has reaffirmed its commitment to being a fabricator of parts. To achieve this manufacturing rebirth, the relationship between the company's remaining fabrication division and Line of Businesses must be improved.

The Equipment Manufacturing Strategy

Improved design, lean manufacturing and reduced infrastructure are the major strategic benefits that will create Eastman Kodak's competitive position in equipment manufacturing. Core and many LOBs share Kodak's Elmgrove site and its fourteen interconnected buildings. The proximity of such a comprehensive manufacturing learning laboratory can serve to educate the product design and product engineering communities on how to design and maintain a low cost, efficiently manufactured product. This location

also provides the ideal Just-in-Time environment. Infrastructure can be reduced by eliminating redundant jobs and the requirements for personnel to interact with external vendors. Clearly the shared location of these organizations provides the opportunity for a considerable competitive advantage. Management's vision for manufacturing centers on a true partnership between the fabrication division and the LOBs

2.4 Methodology of the Project

Rebuilding the Relationship

This thesis is based on research and insights accumulated during a seven month internship at the Eastman Kodak Company. The purpose of this research project was to improve the relationship between a specific Line of Business, Office Imaging,⁶ and Core, in accordance with management's strategy. Assuming the role of a product engineer, I sought to accomplish two objectives outlined by Office Imaging's manufacturing manager and, more importantly, identify the source of conflict between the organizations. Management's specific goals were to lower the product's Unit Manufacturing Cost (UMC) and to increase internal purchasing to achieve an end goal of 75% (dollar cost) of parts being manufactured by Core. Unfortunately, most members of Office Imaging view these goals to be in conflict. This perceived inconsistency is an initial indication of a disparity between management's desires and the measurement systems

⁶ Office Imaging, is a combination of two former LOBs, Business Imaging Systems and Copy Products. Consequently the product line consists of copiers, printers and other related equipment

3 THREE EXAMPLES OF FAULTY SYSTEMS

3.1 Measurements Inhibiting Engineering Partnership

Study Introduction

The project associated with this paper had two major objectives. First, the project would demonstrate that the company benefits from partnering between the process engineers in Core and the product engineers in Office Imaging. Predicated upon the successful accomplishment of this objective was the pursuit of a second goal, to determine why an inherently beneficial activity was not occurring naturally. To define the scope of research, a particular Core department, Finishing Operations, was selected as a case study. Finishing Operations entail painting and plating of metal and plastic fabricated components. Plating involves both hand and automatic plating operations, including electrolytic and electroless nickel, zinc chromate, and other common industrial plating finishes. This project later expanded to include the Rotational Machining Department as well. My research methodology centered around gaining a firmer understanding of the fabrication operations through direct interaction with all levels of employees, to include working the finishing line for a few days. To facilitate communication, engineers from both the product and process areas were brought together in a team atmosphere to explore opportunities for cost reduction and reliability improvement.

Identifying Cost Reduction Opportunities

Several weeks spent with the Finishing Department's plating personnel highlighted the impact product design has on plating costs. This was quickly identified as a source of leverage to achieve one of management's objectives. By revisiting the material selection and design from a Finishing perspective, opportunities for cost reductions became evident. Through a planned meeting of product and process engineers, several proposals surfaced. Product engineers represented the end product, while process engineers were those from Finishing Operations. As a stimulus for discussion, the process engineers were invited to

the equipment assembly area to aid in identifying cost reduction and reliability improvement opportunities. After spending only a limited amount of time at the assembly area, finishing engineers raised several alternative processes for parts manufacturing and suggested ideas to reduce production cycle time.

Exhibit II shows the process and product engineering team's ideas for cost savings. Before enacting any of these changes, an engineering analysis of the proposals must be conducted. To define the scope of this paper, two parts were selected as case studies to demonstrate the value of this interaction. Below is an analysis of the changes for part #372730 (shaft deflector) and part #367538 (shaft-pivot center).

Analyzing the Cost Reduction Proposals

Both components are stainless steel shafts. The group consisting of engineers from the Finishing Department and Office Imaging proposed a material change to replace the stainless steel with cold-rolled steel, plated with electroless-nickel. The rationale for this suggestion centers on material cost. The price per pound of stainless steel is slightly more than twice that of cold-rolled steel. If the substitution is functionally appropriate, the company could realize more than a fifty percent reduction in material costs. In components where material constitutes a high percentage of the part cost, these proposals provide great potential for piece price savings.⁷

In this case, basic engineering knowledge validated the proposed change. Review of the specifications determined the appropriate material for this application is steel. A comparison of the material properties against the environmental and functional requirements of the components is all that is required to conclude that the cold-rolled steel is a valid alternative.⁸ Exhibit III details this comparison. The new material

⁷ Obviously, volume will have an impact of whether or not the economics of making tooling changes, if any, and the costs of engineering analysis justify pursuing this suggestion. In many cases, life cycle volumes will make these considerations negligible. However, in general they should not be ignored.

⁸ In all cases a formal engineering suitability evaluation of the suggested process or product change should be performed. In this case, rigorous calculations are not necessary. This suggestion does not

characteristics far exceed those needed by the design specifications; additionally, they exceed the characteristics of the old material in the critical performance measures of hardness, corrosion resistance and modulus of elasticity. While nickel plated steel has a lower tensile strength than stainless steel, it still greatly exceeds the requirements. Furthermore, the proposed change is the more cost-efficient option. This analysis confirms that the substitution is appropriate and opens the opportunity for the company to save fifty percent of the material costs on these two components

Lack of Partnering Leads to Costly Decisions

In the case studies, further investigation concluded that the original designers chose the more expensive material due to a concern that the vendor could not hold precise tolerances using nickel plated, cold-rolled steel. While the machining tolerance could be held, engineers questioned whether the additional variability induced by finishing would push the component out of specification. For this reason, designers selected stainless steel, eliminating the need for finishing and the risk of additional variability. Cost was most likely not a consideration in making these decisions. Rather than work with the supplier to improve precision or evaluate the need for such tight tolerances, the designers chose to use a more expensive material than needed.

As shown, the initial product designers overlooked some finishing design and cost factors. Most likely this oversight resulted from the complex nature of the equipment being designed and the abundance of technologies required in its manufacturing. It is unreasonable to expect product design engineers to know all the nuances, advances and capabilities of a specific technology. Likewise, it is unreasonable to expect process engineers to understand the technology and performance of the end product. However, by

require an alteration in part geometry or shape, it is a simple material change. Additionally, while the team suggested one alternative for a material change, other options not suggested should also be evaluated. The goal is to discover the lowest cost material and process combination that fulfills the functional requirements.

partnering, these two groups can combine their knowledge and arrive at a superior initial design.

The ideal place to address these issues is early in the design process. Eastman Kodak recognizes this concept in their push for concurrent and multi-functional engineering design teams. However, existing product lines that did not benefit from this enlightened approach must combine the talents of these two constituencies to look for cost reduction leverage through design changes. Even products that *did* benefit from the new design approach require continual review to take advantage of process technology advancements. True partnering between the design, product and process engineers will lead to less expensive, better designed components.

Interaction Leads to New Insights

While the interaction between process and product engineers yielded some significant cost savings, the importance of the cultural exchange should not be overlooked. When the engineers visited the assembly process, Core process engineers were able to view "their parts" in their functional environment. Additionally, these engineers saw other components that could potentially be changed to a plated material, resulting in a lower cost. This new exposure stimulated thoughts that could not be generated by viewing the component in isolation or on a blueprint. Simultaneously, the LOB product engineers saw "their parts" from the highly focused view of a finisher, and began to question their rationale for certain processes or materials. It was through the fusion of these two expert groups, product and process, that numerous ideas for real cost reductions were discovered. It is important to note that only through a willingness to listen and investigate proposals *as a team* were potential savings identified. Section 3.3 quantifies these savings

This knowledge transfer is the catalyst from which improved designs and future cost reductions will emanate. Prior to this project, these potential cost savings existed. Undeniably, many others still exist within the current product lines; however, these savings

opportunities will only come to light only through partnering. The interaction among product and process engineers, and the subsequent cost savings generated, will benefit the company.

The System Does Not Encourage Partnering with Core

The preceding section has illustrated the benefits of involving both Core and LOB engineers in the cost reduction effort, both pre- and post-production launch. Unfortunately, this interaction did not occur naturally, but rather was induced during the course of research.

While it is a stated goal of LOB and Core management to begin working together, and it is obviously beneficial to the company, the measurement system does not encourage the natural occurrence of this activity. Reliability of their components, floor support and UMC (Unit Manufacturing Cost) reductions are the performance measures for LOB product engineers. LOB management's goals place a heavy emphasis on UMC reduction. As section 3.2 will demonstrate, engaging in partnering activities may not reduce UMC, due to the nature of the accounting system; however, partnering will open the opportunity for reduced product cost and savings for the company. The reliance on a cost accounting-based measurement, UMC, undervalues partnering activities and precludes their occurrence. Furthermore, the system does not place any value on the product engineer achieving any goals *through direct interaction with Core*.

The point of this argument is not that partnering activities do not occur. It is that these activities do not occur with the frequency that corresponds to the value that they can produce. These case studies establish the value of working together and uncovering hidden opportunities through teamwork. In light of the benefits and strategy, senior leaders should want engineers to engage in these partnering activities daily. However, management communicates emphasis and direction not through words but rather through measurements. With the lack of metrics supporting this strategic activity, it is not

surprising to find the low frequency of partnering between the two groups

3.2 Measurements Inhibiting Productivity Improvements

The Creation of the Area Budget

Core managers are measured on meeting their budget, the Annual Operating Plan (AOP). On the basis of forecasted volumes from the LOBs, Core managers determine an annual budget necessary to fabricate these parts. In most cases, estimates of capabilities are projected based on last year's performance. The operating assumptions and yearly changes vary with the individual managers. In most cases, the customer's forecast is the greatest unknown. A large percentage of costs are fixed, such as building, equipment, and division infrastructure. Core managers scale their controllable expenses to meet the forecasted volume. Through review with their supervisors, Core managers reach a budget they feel demonstrates improvement; however, *implicit in this plan is a fixed level of productivity*. Furthermore, this procedure sets cycle times for parts and batches⁹. Once approved, supervisors measure the Core manager's on matching this plan. Measurements are adjusted to reflect volume fluctuations; Core managers are not penalized for the customer's failure to provide the forecasted volumes. A manager who matches or exceeds the adjusted plan is regarded as a good performer; likewise, a manager's performance is poor if the plan is not met.

Meeting the Annual Operating Plan as the Primary Measure

Consider the effect of this measurement system on productivity improvements in the Rotational Machining area. The area manager is aware of numerous opportunities for productivity improvements. A concept called 'group technology' could eliminate or

⁹ Batch cycle time is the amount of time required to fabricate a lot of parts. It consists of setup and machine run time. Part cycle time consists only of the machine run time or interval between finished units of a component.

shorten set ups.¹⁰ Redesign or other methods could reduce cycle times. Additional efficiencies exist in the labor pool. Currently, workers perform 5.5 hours, or 70%, of productive labor per shift. The area manager agrees that 6.5 hours, or 80%, is achievable while maintaining a comfortable work atmosphere for the workers.¹¹ Clearly there are ample opportunities for improvements that are not being exploited.

As mentioned earlier, failing to meet the AOP has dire consequences for a Core manager. However, by attempting to become more productive, a Core manager might actually be setting himself up for a poor review. By becoming more productive and lowering cycle time, the shop receives a lower payment, reflected in the same dollar per hour rate multiplied by a lower cycle time. Of course, the manager can do the work faster but charge the same amount; however, this would not result in any savings for his customers. In order for the productivity improvements to become real savings for the LOBs, the manager would have to reduce the cycle time estimates used in his transfer prices. An example may help in clarifying this point.

If the manager of the Rotational Machining area exercises any of the productivity gains listed in the preceding paragraphs, he or she would create unabsorbed burden. For instance, as the example in the accompanying box illustrates, with a dollar per hour rate of \$60, a reduction of 10 seconds on a 1 minute cycle time would lower the UMC from \$1 to \$0.83. Productivity improvements cause \$0.17 of unabsorbed burden.

Unabsorbed burden remaining at the end of a reporting period reflects negatively during the manager's performance review. Unabsorbed burden would not be a problem if additional, unanticipated work was acquired to absorb the budgeted expenses. As a captive supplier, Core managers must rely on their customers to provide this additional

¹⁰ Group technology eliminates setups through planning. By scheduling like-parts sequentially, the operator can produce greater volumes of unique parts with little or no setup. This effectively creates larger batches per set-up while retaining smaller batches per part.

¹¹ An 80% desirable utilization rate is used to avoid the negative effects of statistical fluctuations. Driving the shop to 100% utilization would inevitably lead to late orders. See The Goal, listed in the bibliography, for further explanations.

Example of the Negative Impacts of the AOP

Planning of AOP

- Dollar per hour rate = \$60
- Original Cycle Time = 1 minute
- Budgeted Costs, and *the costs charged to the LOB*, for this part excluding material = \$1
- A simplified AOP would, in effect, be \$1

Midpoint of the AOP cycle

An opportunity for a 10 second reduction in the cycle time is discovered. Reducing the cycle time to 50 seconds will provide \$0.83, charged at the \$60 dollar per hour rate. However, to meet the performance objective of recovering budgeting costs, the manager will resist passing along the cost savings to his or her customer. To do this will create \$0.17 (\$1 -- \$0.83) of unabsorbed burden that either must be made up elsewhere or will be seen as improper planning by the Core manager and reflect poorly upon an evaluation. Of course, if this \$0.17 of unabsorbed burden can be charged to other products that were unanticipated during the planning phases, such as an upturn in demand or addition of other work this would cease to be a problem. However, as demand cannot be controlled by the Core manager, the safest way to assure matching of the AOP and a positive review is to not seek improvements or continue to bill at the planned prices regardless of the true costs of manufacture. Measuring on AOP does not drive Core managers to seek better ways to manufacture products and may even encourage them to avoid such a situation.

volume. Historical precedent leads many managers to be skeptical of the prospect for additional volume. Section 3.3 will show how the cost accounting-based measurement system makes it undesirable for LOBs to source work internally, confirming Core's fear that volume may not be forthcoming. Due to the risk that productivity gains will cause a negative performance evaluation, it is far safer *not* to pursue productivity improvements in the first place.

While it can be argued that this provides an incentive to become less productive, the current system safeguards against this through the review process. It is highly unlikely that the area manager's boss will allow negative productivity growth to be approved during review of the AOP; undoubtedly, at some point managers realize the need to

continually increase productivity. However, in cases where the reviewing manager does not become intimately involved in the specific numbers or does not conduct a thorough review, a savvy area manager can pass along negative productivity numbers, thus providing an even greater cushion to meet performance objectives. It is feasible that this system will provide an incentive to become less productive; however, the review process makes this rather unlikely. Most area managers are well intentioned and strive for productivity improvements. However, the potential negative impacts of the measurement system cause them to be conservative in pursuing improvements. Measurement based upon adhering to the AOP provides a clear disincentive to make productivity improvements beyond those required to "look good"

The Unfeasibility of the Other Side of the Productivity Equation

There is another side to the productivity equation. Productivity gains turn into true savings by either doing more work with the same assets (growth) or the same work with fewer assets (rightsizing). Rather than relying on the LOBs to provide additional work, the manager could reduce the workforce and expenses accordingly. However, one must consider de-motivating factors, as well as practicality. If managers followed productivity gains with job losses, they would quickly find a workforce unwilling to make improvements. After achieving a productivity increase of 10% in 1987, Core laid off 1000 workers in 1988; not surprisingly, the productivity gains in the next year or any year since have been dramatically reduced. Few people are willing to work to eliminate their own job and then find themselves unemployed. The human factor of this approach makes it unpalatable

There is also considerable question of how much expense management could actually divest piecemeal. Clearly, reducing the size of one Core department is not going to eliminate the associated division's building costs, indirect salaries, or infrastructure. Divesting one machine (or department) may just make other machines more "expensive",

as the remaining machines share unchanged fixed costs. This again places the Core department in an undesirable position by making the remaining assets more expensive. Practical considerations lean toward realizing productivity gains through increased volume rather than asset reduction.

True Productivity Gains Come From Continuous Efforts

A final contrary point to the increased volume argument is found in the annual preparation of the budget. At this time, it is possible for the manager to reduce the cycle times in anticipation of improvements and budget accordingly. While some managers do this, there are two major constraints that limit the amount of productivity gains recognized at this time. First, without the continual pursuit of these options, managers can only make guesses of what these reductions might be. Once again, managers practice conservatism. Second, there is a strong possibility that without more volume, spreading fixed costs to the remaining hours will make the existing work more expensive. Again, the system encourages Core managers to have enough hours of productive labor in the system to continue to drive the dollar per hour rate down. Cutting cycle times without adding more volume will actually cause a rise in the dollar per hour rate, since the same costs must be covered with a decreased amount of work measured in cycle time. Even at the planning stage, the AOP discourages the Core manager from making the desired productivity improvements.

The System Blocks Desired Activities

To remove the negative consequences of becoming more productive, senior managers must alter the metrics used to evaluate Core managers. It should be emphasized that the failure to develop productivity gains is not due to a lack of desire or capability on the part of Core managers; rather, productivity gains are not pursued with vigor due to a faulty measurement system.

It is not the adherence to a plan that is at question here, it is the use of cost accounting measurements *as the plan*. The accounting system ties prices to costs through burden allocation or dollar per hour rate. "Revenues" derived from these prices are then used as a measurement to determine whether the manager can cover the costs set forth in the AOP. In an effort to meet this measurement, becoming more productive will upset the balance between "revenues" and costs. "Revenues" decrease as the cycle time is reduced; when cycle time is multiplied by the dollar per hour rate less income per job is provided. Cutting cycle time may be desirable if it can attract other customers; however, with this measurement system, it is disastrous. It is the use of the cost accounting system in the AOP that makes it a faulty measure.

Core areas must have assurance that volume will come to replace the effective capacity released through improvement efforts. This will provide the positive feedback necessary to propagate productivity improvements. Volume is not a long term problem if we expect our LOB product lines to grow. In the short term, the volume to realize productivity gains is present within the current system, given the substantial amount of external purchases. The next section will address the systemic problems that block the flow of this new work.

It is important to realize that even with the promise of volume, measuring people on meeting a budget is not the activity that senior management wants them to focus on. Consequently, Core managers should not be measured on this criterion. This is another example of a cost accounting-based measurement, the AOP, not encouraging and in some cases discouraging the activity truly desired, i.e., productivity gains. Through implementation of this measurement system, management has sent Core a message to not get more productive

3.3 Measurements Are Costing the Company Millions of Dollars

UMC as the Decision Criterion

The unwillingness of the LOB material managers and engineers to use Core does not come solely from their distrust of Core's ability to become more productive. This reluctance comes from the cost accounting measurement system imposed on them. The primary measure of a LOB is profitability. While applying pressure on marketing to increase sales, managers cascade the task of lowering the Cost of Goods Sold down to the material and engineering staffs responsible for production. Consequently, the message given to the executors who actually perform the work is to find the lowest Unit Manufacturing Cost (UMC) for the product, given that the supplier has acceptable quality and delivery performance. Quite often under this criterion, the accounting system eliminates Core as the supplier of choice. *Taken as a given that the highest levels of management are committed to the preservation of Core for strategic reasons*, this analysis shows that this measurement system hurts the company's cash position

As an example, an analysis of the costs for the shaft-pivot center referred to in section 3.1 demonstrates how cost accounting measures drive the wrong performance. Ignore for now the suggested engineering change to an alternate material. Currently, Office Imaging purchases this part externally for \$3.76, fabricated using stainless steel. A quotation from Core states their price at \$4.64, which is the fully burdened cost. Using UMC as a criterion, the buyer/planner achieves the lowest price by buying this shaft from the external vendor. The measurement system rewards the buyer/planner for saving the company \$0.88 for each unit. The buyer/planner has acted rationally to increase Office Imaging's profitability. While this decision achieves a local maximum, it creates a global loss. Analyzing this same decision from a cash flow perspective demonstrates this fact.¹²

¹² At this point, astute readers might question why Core transfers at fully burdened cost and whether it is a requirement, rather than the LOB's use of UMC as the purchasing criterion, that is the problem. These questions address *solutions* to flaws found in the system. This paper stresses the understanding of the underlying systems as a mean to solving problems. Indeed one of these solutions may be to alter the

Implications on Eastman Kodak Cash and Earnings

The cost of Core's quotations can be broken into variable and fixed cost pools. Variable costs are those costs that the company incurs only when work is internally purchased. In this case, assume them to be material and labor, although there will clearly be other negligible costs such as electricity, lubricant, etc. Fixed costs consist of all expenses necessary for production that the company pays regardless of whether they use these assets. Fixed costs include equipment, plant, infrastructure, indirect labor, etc. In a great deal of the cases, accountants include direct labor, dependent upon current utilization and company policy, as fixed costs. It is only when we have to hire new workers to perform this work that we should consider labor variable.

Looking at external cash outlays demonstrates the true cost of this part to the company under each scenario. Table 1 illustrates how these costs break down. For the external vendor, the cash outlay is the purchase price or \$3.76.¹³ For Core to fabricate the component, the cash outlay is only for the variable cost. In this case, the only variable cost is for material, since labor is currently available. This cost is \$1.17. From a cash flow perspective, the company pays far less to have the work performed internally. This shows that the supposed *paper* saving of \$0.88 is actually a cash flow *cost* to the company of \$2.59 (\$1.17 -- \$3.76). With an annual purchase of 3000 parts, the LOB thinks it "saves" \$2,640 while it is really spending \$7,770 in cash. This is hardly the activity that the designers of the measurement system desired.

Even if we add labor, the variable cost of the piece only rises to \$1.66, leaving a \$2.10 saving per part. *These savings per unit can go directly to the bottom line as earnings.* Additionally, they free up cash for other uses. Unequivocally, this is a desirable

method of transfer payment, maintaining the purchaser's criterion and thus allowing purchasers to seek the lowest costs. However, solutions to this problem should not come until a grasp of the systemic interactions is realized. Additionally, it should be noted that Kodak has chosen to transfer at fully burdened costs due to problems experienced with previous variable costing attempts. Consequently, they would be reluctant to attempt this solution again.

¹³ For simplicity, this argument ignores the cost of transportation and other minor costs that would understandably raise these prices slightly.

thing. However, the measurement used, lowering UMC, leads us away from this objective. A closer look at the accounting system reveals further damage caused by this measurement.

How Savings Are Manifested in the Accounting System

Even if the LOBs realize the negative cash implications of external sourcing, the accounting system provides another disincentive to purchase internally. In an effort to save \$7770, the LOB may select to move work inside. Unfortunately, the LOB will not receive the entire \$7770 saving nor will the saving they receive be reflected in the purchase price of the resourced component. As a supplement to the following text, Exhibit IV explains this phenomenon *in detail*.

The proceeding section shows that \$7770 constitutes cash that the company is currently paying *in excess* of the cash required to do the work internally. Obviously by purchasing the work internally, the company could save this sum. Recall that the cost-accounting-based transfer price system requires that work be transferred at fully-burdened, rather than variable, cost. The accounting system distributes any cash saving (through a lower burden rate) amongst the LOBs based on the previous percentage usage of a manufacturing cell. When a LOB absorbs \$7770, an equivalent amount of the existing

TABLE 1: UMC vs. CASH FLOW COMPARISON WITHOUT FINISHING

	External Vendor		Core, Labor Fixed		Core, Labor Variable	
	UMC to buyer	CASH outlay to EK	UMC to buyer	CASH outlay to EK	UMC to buyer	CASH outlay to EK
MATERIAL	unknow	unknown	\$1.17	\$1.17	\$1.17	\$1.17
LABOR	unknow	unknown	\$0.49	\$0.00	\$0.49	\$0.49
OVERHEAD	unknow	unknown	\$2.98	\$0.00	\$2.98	\$0.00
TOTALS	\$3.76	\$3.76	\$4.64	\$1.17	\$4.64	\$1.66

burden shifts away from existing parts. Effectively, each LOB receives a portion of this saving over its entire pre-existing purchase. In this case, Office Imaging had approximately 55% of the existing Rotational Machining work. Consequently, it will eventually receive approximately \$4200 of the saving. The rest of the saving spreads, through adjustment of the overhead burden rate, to other LOBs. *However, Eastman Kodak will retain it all.*

More importantly, the purchase price of the moved component will not reflect these savings. The internal price will still be \$4.64. In the first year, these savings, totaling \$4200, will most likely be passed back to the LOB in a lump sum payment at the end of the year following a positive cost variance. The prices for all parts should decrease the following year; however, this time lag of up to twelve months does little to appease the purchaser under pressure to attain low costs now!

Knowing how the accounting system manifests these savings is crucial to understanding its inadequacies as a tool on which to base measurements. Not only do purchasers see a dramatically higher cost inside, but they do not see any *direct* savings from purchasing work internally. This does not promote the accomplishment of a buyer's primary measure, reducing UMC, in aggregate, for the machine. The accounting system hides savings by dispersing gains as pennies on many products, most of which won't be handled by the initiating buyer. The lengthy time lag between action and favorable results negate any positive reinforcement aspect of this measure. This time lag is usually longer than the individual's rating period. Even in taking the correct actions, the buyer will not receive any direct reinforcement from the UMC criterion.

UMC Leads to Poor Engineering Decisions

In addition to poor sourcing decisions, lowering UMC as a performance measure can lead to erroneous engineering decisions. Once again the shaft case studies illustrate this phenomenon. Having agreed to purchase the component inside, I decided to make

the engineering change outlined in section 3.1 to achieve further cost reductions. However, the accounting system did not reflect savings; the accounting system shows a loss! Once again, the comparison between the UMC for each option and the cash implications will demonstrate the fallacy of using UMC as a measure.

Quoting the shaft #367538 as a stainless steel component, as stated before, has a UMC of \$4.64. However, with the engineering change, the quoted price becomes \$5.02. Table 2 breaks out these costs. If one uses UMC as a criterion, switching the material is the wrong decision. Again, cash outlay to the company should be the decision criterion. To make this switch, the only cost to the company is for material. The cost for the stainless steel component is \$1.17; the cost of cold-rolled steel is \$0.52 and the nickel is \$0.04 for a total of \$0.56. Once again a comparison indicates a loss of \$0.39 (\$5.02 -- \$4.64) while in reality the decision would result in a \$0.61 saving (\$1.17 -- \$0.56). The grossly underutilized assets in the Finishing Department explain the dramatic increase in internal price. By utilizing these assets, costs once again shift off existing parts and are absorbed by the new component. Regardless of what the accounting system tells us, the measurement that really matters is making money. In this context, the engineering change is appropriate.

TABLE 2: UMC vs. CASH FLOW COMPARISON WITH FINISHING

	Stainless Steel		Cold-Rolled Steel	
	UMC to buyer	CASH outlay to EK	UMC to buyer	CASH outlay to EK
RAW MATERIAL	\$1.17	\$1.17	\$0.52	\$0.52
FINISHING MATERIAL	\$0.00	\$0.00	\$0.04	\$0.04
FINISHING OVERHEAD	\$0.00	\$0.00	\$0.99	\$0.00
ROTATIONAL LABOR	\$0.49	\$0.00	\$0.49	\$0.00
ROTATIONAL OVERHEAD	\$2.98	\$0.00	\$2.98	\$0.00
TOTALS	\$4.64	\$1.17	\$5.02	\$0.56

UMC Measurements Miscount for Millions of Dollars

While this illustration uses seemingly insignificant numbers, it is important to recognize the corporate impact of this decision-making criterion. Exhibit IV provides a detailed analysis answering three questions necessary to calculate the saving in the Rotational Machinery department. First, the analysis determined that Office Imaging currently purchases approximately 24,580 hours of rotational machining work externally. Second, an estimate of the true practical capacity of the Rotational Machining shop is 102,375 hours. Since the current volume utilizes only 58,000 hours (57%), Core clearly possesses capability to perform this work. Current available capacity is not an obstacle. Third and most importantly, this analysis determines that *The Eastman Kodak Company could save approximately \$735,000 annually* by sourcing all of Office Imagings rotational components internally.

The difference between the outside price and the marginal cost of producing one more unit internally, given that the fixed asset base has excess capacity, generates these savings. *Conditional to this strategy's success is Core's commitment to not add infrastructure, capital or overhead of any kind*; Core will fabricate any additional volume with the existing structure and possibly the addition of *direct* labor. To do one more unit (or all the units) inside, Kodak needs only to add direct labor and purchase the material. Kodak should be able to purchase raw material at or below the prices provided to independent vendors; this removes material from the analysis. The cost of additional workers is typically less than an external vendor's labor costs, profit, fixed costs, and the remaining variable costs such as electricity.¹⁴ In cases of high labor content work, the incremental cash outlay for Kodak shows that some work should be done by external vendors. However, in the majority of the cases labor content is relatively low and Kodak can purchase work internally for variable cost of material, labor and other minor expenses

¹⁴ In almost all cases, this is true. In the rare case of highly labor intensive work, where Kodak competes with a vendor able to pay third world wages, the costs of additional labor exceed the external vendors total purchase price.

Contrasted with paying fixed cost, variable cost, and profit externally, Kodak is throwing away money.

Understandably, \$735,000 is a rough estimate based on a particular set of assumptions. However, the point is indisputable. Taken from the company perspective, Kodak has tremendous opportunities to increase its earnings. A quick analysis will demonstrate this potential

On every part purchased outside, roughly 15% of the price represent labor costs and 35% represents material. These are costs that Kodak would incur to perform the work inside. However, the other 50% of costs represents the profit and fixed costs of the external vendor that Kodak would not pay. By moving work inside, Kodak will save about 50 cents on the dollar. This is a linear argument, independent of the volume moved inside. Once again it must be stressed that this argument assumes that there is underutilized capacity, which there currently is, and that there is NO increase in overhead

A deeper understanding of the financial impact of this problem comes from an analysis of *all* parts purchased for the two current copier models. While obviously based on many assumptions, these numbers are considered to be very conservative. For the copier lines, Kodak purchases \$128 MM worth of components externally. Conservatively assuming that Core has the capability to perform half of this work inside, there is \$64MM available for inside sourcing. Several Kodak personnel have verified this assumption. This new work represents approximately a 12% increase in Core's business; therefore, it is reasonable to assume that Core could absorb this work *without adding capital or infrastructure*. This could lead to an annual saving of \$32MM (or fifty cents on the dollar).

Furthermore, these rough calculations do not consider the savings due to a reduced procurement staff, handling and transportation; neither does it consider the entire LOB (only two product lines were used for the estimate), nor does it address the practices of Kodak's other ten LOBs. It is also important to note that the estimate of these savings

does not include the potential for increased savings due to partnering activities. As earlier sections of this thesis and Mr. Rennert's thesis demonstrate, the potential for such cost reduction efforts is high. With these other factors included, the potential savings would surely increase. In short, Kodak's measurement systems and business practices are costing the shareholders tens of millions of dollars every year.

Cash savings will occur regardless of what happens to the UMC of particular products. As demonstrated above, the price may increase; however, this is only a manifestation of how the accounting system decides to allocate the costs that Kodak is currently paying. Over the long term with filled shops, Core must be able to contribute to Kodak's profitability in one of two ways: it must either provide parts for lower than the outside purchase price or must provide opportunities to realize efficiencies elsewhere in the system.¹⁵ These efficiencies must coincide with management's strategic intent and, in total, produce equipment of greater value than the competition. However, in the context of the current strategy of maintaining Core, measuring people on UMC will motivate them to do the wrong thing, cause the failure of management's attempts to reach the strategic efficiencies necessary to beat the competition, and ultimately damage Eastman Kodak's earnings and cash position.

¹⁵ Examples of these efficiencies are a reduced requirement for purchasing personnel to deal with external suppliers, internal estimators and material handlers

4 CONCLUSIONS

4.1 Design the System To Achieve the Strategy

The goal of Eastman Kodak Company must be to make money. The actions of every employee of this company must directly relate to achieving this objective. The company's strategy must constitute an approach for making money, in light of the competition. The body of this thesis has demonstrated how the current system of measurements does not support the desired strategy and thereby has failed to increase earnings. A better system, cemented in and supportive of a winning strategy, must be designed.

The Strategic Rationale for a Core/LOB Partnership

This document has been written given senior management's strategic rationale for being in the Office Imaging business and retaining the need for an internal manufacturing division. This paper does not question the validity of this strategy; rather, *it simply highlights that given management's professed intent to retain Office Imaging and Core, current business practices are wrong.* Strategic decisions cannot be made on short term financial measures. The strategy must reflect a long term belief that if every member of the organization fulfills their role, Eastman Kodak will make money. It is management's responsibility to communicate this vision to each and every worker. Not only must they win their support, but they must make each person's role clear. Formulating this strategy is the crucial first step to designing the system.¹⁶

Recapping the Failures of the Existing System

Given the strategy of true partnership, the preceding chapter has shown how the

¹⁶ Considerable debate is raised within the organization on whether or not the strategy of making commodities is a viable long term option. An article in the November/December 1992 issue of the Harvard Business Review entitled "Strategic Sourcing: To Make or Not To Make" provides useful insight into answering this difficult question

cost accounting-based measurement system fails to support the goal of making money.

- The benefit of having both the process and product engineers on site has been demonstrated. Clearly, the savings to be realized from this close interaction and the education for the designers of future products is an untapped competitive advantage. The proximity of Core and the LOBs presents many opportunities to realize the strategic rationale for a partnership. Engineers fail to engage regularly in this activity primarily because of the measurements used.
- Core managers do not pursue productivity improvements at the desired frequency. While productivity improvements alone do not provide savings, they are the crucial opening for the others in the system to exploit in order to make money. Again, this failure is the result of faulty measures.
- Third and most importantly, the LOBs waste company money due to erroneous measurements. Management cannot measure the purchasers on achieving the lowest price. To do so increases the LOB profits at the expense of the group. The immediacy of the current situation shows that this cannot proceed. The management team, from the Imaging Group to the product line managers, can reverse this trend and begin making money immediately. To do this, they must change the system of measurements.

Attributes of the System

In the proposed system, the attributes focus on non-financial measures. The body of this paper shows the dangers of financial measures, such as meeting budget and achieving localized profitability. Design of new metrics must be done in light of the strategy. The leader must choose the activities that each personnel group must perform,

consistent with the strategy to make money. If the strategy is sound, earnings will increase by rewarding the correct activities. Using this methodology, I suggest attributes of a measurement system in line with the chosen strategy. *The important point here is not agreement with the attributes outlined. The focus should be on the process of determining what activities the leader wants to occur that are consistent with the strategy. It is these activities and not how they play out in the intermediate financial reports that should be measured.* Furthermore, in an effort to illustrate a process rather than provide a solution, I chose to only offer attributes. The leaders must own and design their system. Consequently, only the management team can supply the specific targets and goals for measuring individuals. Only through personal involvement will the leader achieve the systemic ownership necessary for long term success

Core Managers

Recent focus on the importance of quality, delivery and other metrics such as safety, has established minimum gates for acceptance as a supplier. Core areas must either exceed Kodak's standards or show the ability to attain this world-class status in the near term through partnering with the LOBs. Given that Core meets the minimum criteria for acceptance, the remaining point of differentiation among suppliers is component cost

The current measurement of performance is simply meeting the AOP. Unfortunately, this metric encourages maintaining the status quo rather than increasing productivity. The strategic role for Core managers is simple: Core managers must reduce their cost-per-actual-part produced, not dollar-per-hour rate or budget.¹⁷ This can be done by either controlling expenses, or increasing productivity *without* capital expenditures. This will increase asset utilization and thus lower costs. The job of each

¹⁷ Dollar per hour rate is a false measure of productivity. Suppose Core has a \$40/HR rate compared to the external rate of \$30/HR. Using dollar/hour rate as a measure, Core looks uncompetitive. However, if Core can produce twice as many parts as the external vendor in an hour, clearly the cost per part is more competitive internally. Consequently, cost-per-part is selected as the appropriate measure

Core manager must be to provide the most production capacity at the lowest possible cost from the current asset base.

Metrics in line with the strategic activities for Core managers would measure:

- Making productivity improvements without capital expenditures
- Decreasing expenses-per-part produced
- Working with LOBs to aid them in achieving lower costs and improved reliability

Office Imaging Material Management

Currently, management uses UMC to determine how successful this group procures the lowest cost goods for Office Imaging. As demonstrated, this criterion can lead to harmful purchasing decisions. Unless Core receives more volume, the company will not be able to realize any of the benefits achieved by increasing Core's productivity. Consistent with leadership's vision is the belief that increasing the utilization of Core benefits Eastman Kodak from a cash flow perspective, reduces costs for Office Imaging in the long run, and provides the intangible strategic benefits

Metrics in line with the strategic activities for Commodity managers would measure:

- Moving externally purchased work to Core as quickly as possible *based on cash flow analysis*¹⁸
- Maintaining the lowest true cost component purchasing for Eastman Kodak through *cash flow analysis*

Office Imaging Product Engineering

Currently, there is little incentive for or managerial emphasis on engineers working with Core. Consistent with the leadership's vision is concurrent engineering and using

¹⁸ Caution must be exercised here. If work is moved in haphazardly or without a firm plan in mind, chaos and ultimate failure of the strategy are almost assured. The process of bringing work inside must occur with due haste to begin realizing the benefits from the cash savings. However, this effort should be coordinated with engineering and Core to provide a smooth, consistent and measured pace for resourcing this work internally.

Core process expertise to reduce cost and improve reliability in the product. As demonstrated, an excellent method for accomplishing this objective is the close interaction between Office Imaging product engineers and Core process engineers. Office Imaging engineers can remove cost and increase productivity by value engineering and possible redesign of components.

In the context of partnering with Core, Office Imaging engineering has very little control over UMC and should not be measured on this basis. While reduced costs can be achieved through material substitution, as documented here, this is a low leverage action; the amount of savings that management is seeking will not be found through material substitution. A better allocation of engineering resources is in helping Core become more productive through redesign of products. A partnership with this goal in mind will undoubtedly reveal cost reductions through material substitution; more importantly, it will lead to the elimination of superfluous parts and creation of more manufacturable designs. This will reduce cycle times. It is with this newly freed effective capacity that Kodak can make money. Money can only be saved, and product costs reduced, if volume is increased either through sales or work is purchased internally to use this free capacity. Since engineers cannot affect the necessary volume to fill freed capacity, they should not be held accountable for the reduction of product cost. However, they are an invaluable source of expertise in working to free capacity in Core and setting up the options for other members of the Kodak team to complete the equation by increasing volume and making the company money.

Metrics in line with the strategic activities for Office Imaging engineering would measure combining engineering talents to analyze processes or redesign components to achieve

- Productivity improvements through partnering with Core
- Material cost reductions through partnering with Core
- Reliability improvements through partnering with Core

These attributes must be supplemented by details to become actual metrics. Simply saying people should make productivity improvements is not enough. Managers and their subordinates at all levels must agree on specific and conditional targets, such as "increasing available capacity by twenty percent this rating period". These attributes provide an outline from which to formulate specific metrics.

Change the Measurement System

People react to their measurements. To espouse a strategy and then measure people contrary to it will have negative results. Additionally, leaders must resist the temptation to simply push financial measures down to the lowest level of the organization. In this process, it is likely that localized optima occur as employees work to increase the profits in their area, often at the expense of the whole organization. This system removes the responsibility for and control of financial success from the senior levels, where it belongs, to the lowest level of worker. In addition to the sub-optimization shown in this document, pushing cost-accounting-based financial measures lower into the organization shows a lack of confidence in the strategy. Rather than believing that partnering will bring long term success, managers speak the words but measure on short term returns that do not allow the partnership to develop. While it is debatable whether financial measurements are ever appropriate at any level except the highest of the organization, it is clear, in this case, that financial measurements based on numbers provided by the accounting system are wrong.

4.2 Leaders Must Set the Course for Change

Change Involves Altering Something

Success will only come through leadership. Design and control of an organization's systems are the domain of the leader. There is a possibility that a manager can be successful by circumventing the system; however, doing this allows the

organization to once again fall victim to the faulty system. It is far better to change the system for the long run. Leaders must decide what should be changed, what to change to and most importantly, how to change. The point here is that to effect change, something must be altered. Doing this is the challenge of the leader --- and what will make a company successful.

EXHIBIT I
Measuring Customer-Driven Manufacturing
Process Improvement in a Multi-Divisional Corporation
by
Jonathan A. Rennert

Submitted to the Departments of Mechanical
Engineering and the Sloan School of Management
in Partial Fulfillment of the Requirements for the Degrees of

Master of Science in Mechanical Engineering
and
Master of Science in Management

Abstract

Many large, vertically-integrated companies have decentralized their internal supply chain, in an attempt to push profitability incentives as close to the factory floor as possible. This has led to a heavy reliance on cost-accounting-based transfer prices to measure efficiency and performance of individual business units. Decentralization has also created barriers to effective design-manufacturing communication when these functions are in different responsibility centers. Some companies find that even with the best of intentions, there is no guarantee that optimization of each link leads to the strongest chain.

This thesis presents a case study of one division within a large corporation partnering with its internal supplier to solve a significant manufacturing problem. Through value engineering of a single component part, the customer division was able to double the throughput potential of the supplier's bottleneck process. The customer organization is compensated through a significant transfer-price reduction on this component part.

However, closer inspection of the accounting data finds two significant barriers to the general implementation of this partnership process-improvement model. First, the potential savings to the corporation are several times larger than the accounting credit to the enabling customer engineer. This suggests that the customer division allocates far fewer resources to internal partnering than would be optimal for the company. Second, and more serious, the role of transfer prices in material procurement may actually prevent the company from realizing these savings at all. The accounting system understates the *potential* value of partnering at the same time it overstates the *actual* benefit.

Ironically, over time the squandering of potential savings from partnership projects justifies the low priority placed on them. To break this cycle, recommendations are made to shift shop-floor performance metrics away from accounting definitions of profitability and toward the process improvement and follow-up activities that drive productivity growth.

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EXHIBIT II

RESULTS OF PROCESS/PRODUCT TEAM ASSEMBLY REVIEW

Part #	Description	Manufacturer	Proposed Change
991677	Wireform AY Lower	External	Switch From E-polished Stainless to Cold-rolled with Ni plate
983340	Upper Wireform Assy	External	Switch From E-polished Stainless to Cold-rolled with Ni plate
975455	Roller AY Registration	External	Switch From E-polished Stainless to Cold-rolled with Ni plate
372730	Shaft Deflector	External	Make Electroless Ni rather than Electrolytic
421025	Trip Shaft AY	External	Make Electroless Ni rather than Electrolytic
367538	Shaft-Pivot Center	External	Make Electroless Ni rather than Electrolytic
922906	Depressor, AY	External	Make Electroless Ni rather than Electrolytic
268868	Drive Roller AY-VT	External	Make Electroless Ni rather than Electrolytic
270310	Idler Pulley AY	External	Make Electroless Ni rather than Electrolytic
371517	Tie-Bar, V.T., Lift	External	Make Electroless Ni rather than Electrolytic
975593	Bracket-support, Front	Kodak Core	Switch from Black Zinc to Yellow Zinc. Why is the piece machined after plating?

Part #	Description	Manufacturer	Proposed Change
983292	Fuser & Transweld	Kodak Core	Potential overplating -- reduced requirement No prescribed thickness of plate - - Could we do it with less?
975912	Support Weldment	Kodak Core	Pieces receive either an Anodize or Chromate followed by a Black powder. Can one of these processes be eliminated? Looks as if we overplated the product
928868	Guide Assembly Inner	External	Stainless Steel now; switch to electroless Ni
950564	Guide AY Outer	External	Stainless Steel now; switch to electroless Ni
975098	Platform & Stud ASSY	External	Possible elimination of second finishing that provides a textured finish. Is this needed texture?
331713	Bracket-lock, Lower	External	Potential to switch from Stainless to Cold-roll with Ni -- Caution, parts are small -- change may not be worth it
721188	Bracket-lock, Upper	External	Potential to switch from Stainless to Cold-roll with Ni -- Caution, parts are small -- change may not be worth it
991373	Feedhead Module ASSY	Kodak Core	Piece is unfinished Aluminum -- use as benchmark to determine if any Aluminum plating is needed inside the copier

EXHIBIT III

COMPARISON OF STAINLESS STEEL AND NICKEL PLATED COLD-ROLLED STEEL

Material Choices

EK 189 Steel, Stainless, AISI Type 416, Cold Finished, Bar: Free Machining

EK 151 Steel, AISI Type 1213 and 1215, Cold Finished, Bar and Ground Bar Free Machining with Nickel, electroless, High Phosphorus, with PTFE (Teflon)

Property	EK 189	EK 151 w/ plating
Modulus of Elasticity	28,000 ksi	29,000 ksi
Hardness	26 HRC	35 HRC
Corrosion Resistance	Good	Excellent
Tensile Strength, Ultimate	85 ksi	75 ksi
Tensile Yield Point	75 ksi	50 ksi

The three primary considerations for these parts are the hardness, modulus of elasticity and corrosion resistance. The new material, plated EK 151, is clearly better than the existing design. Additionally, the forces that these parts are subjected to are negligible. However, they are listed below. Clearly, any engineer can see that either material is sufficient for these needs.

The two shafts analyzed are subjected to the following loadings:

372730	Shaft Deflector	negligible torsion
367538	Shaft-Pivot Center	1 lbf approximately one inch from each end

EXHIBIT IV

ANALYSIS OF ROTATIONAL MACHINING WORK

This analysis has been prepared to determine whether there is a cost saving to Kodak and Office Imaging from internally sourcing all of the Rotational Machining work. It will address four questions

- How much work is currently outsourced?
- What are the Rotational Machining Department's capabilities under several scenarios?
- If it has been determined that Core has the capacity to do this work, will this save the company money?
- How will the accounting system distribute these savings?

How much Office Imaging Rotational Machining work is currently outsourced?

Source: Estimations provided by Office Imaging Commodity Management

Office Imagings' purchase for rotational parts is broken out as follows:

external	\$1,900,000
internal	<u>\$3,000,000</u>
total buy	\$4,900,000

To simplify the analysis, it will be assumed that the material cost is the same for the both external and internal purchases; thus it can be removed from further calculations. As a conservative estimate, material cost is assumed to be 35% of the external purchase price. Adjusting for cost minus material, the total buy becomes:

external	\$1,235,000	(\$1.9MM x 65%)
internal	<u>\$1,950,000</u>	(\$3MM x 65%)
total buy	\$3,185,000	

Number of Parts Purchased Externally:

Total external purchase is 694 unique part numbers

- 50% of these parts are for BIS equipment with an average annual buy of 1250 units per part number
- 50% of these parts are for Copy equipment with an average annual buy of 3000 units per part number

50% of parts Business Information Equipment X 694 part #s X 1250 annual volume = 433,750
50% of parts Office Imaging X 694 part #s X 3000 annual volume = 1,041,000
Total # of Parts Purchased Outside = 1,474,750

Hours of Machine Time:

Average Cycle Time is assumed to be 1 minute per part. This is based upon analysis of a standardized rotational part. This is a commonly accepted number

$$1,474,750 \text{ parts} * 1 \text{ min/part} / 60 \text{ min/HR} = 24,580 \text{ HRS}$$

What are the Rotational Machining Department's capabilities under several scenarios?

The next relevant question is how much work can Rotational Machining handle? The following scenarios have been analyzed to determine the effective Rotational Machining capacity under various conditions. Following the description of the scenarios is the analysis of capacity, budget, and dollar per hour rate for each situation. The calculations for this spreadsheet are provided immediately following the capacity analysis.

Assumptions

- (1) These calculations will assume that Core has the requisite equipment and expertise to perform all work currently purchased outside. In actuality, this is not the case. However, Core has the equipment and expertise to perform a great deal of this work.
- (2) This includes all Office Imaging work currently done outside. If all of this work was moved inside, Kodak would not retain any external rotational vendors. It is assumed that all of this work is eligible for sourcing internally.
- (3) These calculations do not account for external sourcing of other Kodak LOBs or Core groups. The availability of this work is unknown at this time. However, inclusion of this work would make the situation more favorable for Eastman Kodak, Office Imaging and the other LOBs.

Description of Scenarios

- I. Reflects the currently planned volumes of equipment. This is product volumes rather than machine capacity.
- II. Reflects the dollar per hour rate if ALL Office Imaging work were to be moved inside. This would require additional direct labor but NOT capital expenditures. Additionally, some weekend shifts will be required to make this volume.
- III. This is a maximum scenario. Currently, machines are planned to work at only 70% efficiency and only 46 weeks a year. After inspection of the operation and conferring with the area manager, we believe that these machines can be utilized at 80% capacity (6.5 hours productive time for each 8 hour shift). This scenario represents effective capacity if the shop was run seven days a week, 3 shifts a day, 50 weeks a year.

Spread Sheet Calculations

- (1) Current machine capacity is calculated as follows:

MACHINE HOURS =

$$15 \text{ machines} * 46 \text{ wks/yr} * 3 \text{ shifts/day} * 5.5 \text{ days/wk} * 5.5 \text{ productive hours/shift}$$

- 46 weeks represents 2 weeks of shutdown and 4 weeks of operator vacation randomly spaced throughout the year. The 4 week vacation is eliminated in scenario III.
- 5.5 productive hours/shift represents a 70% utilization rate. Scenario III uses an 80% rate.
- 5.5 days per week equals M-F plus 1/2 of Saturday. Scenario III uses 7 days a week.

- (2) Necessary volume is calculated as the difference between current volume (58,000) and available capacity under the scenario
- (3) There are two classes of workers in the Rotational area. Sixteen employees operate two machines simultaneously, nine others operate only one machine at a time. However, this second category includes one more productive hour of work per shift. Productive labor for these two groups was calculated as follows:

Class I worker hours =

$$46 \text{ wks/year} * 5.5 \text{ productive hrs/shift} * 5.5 \text{ days/wk} * 2 \text{ machine} = 2783$$

Class II worker hours =

$$46 \text{ wks/year} * 6.5 \text{ productive hrs/shift} * 5.5 \text{ days/wk} * 1 \text{ machine} = 1644.5$$

It is assumed that labor will be added in the same proportions as the existing workforce. Each new worker will represent a weighted average of new productive hours as follows:

$$\text{New Worker Hours} = (16 \cdot 2783 + 9 \cdot 1644.5) / 25 = 2373.14$$

Each new worker will add 2373 hours of productive labor. Currently, rotational has 59,330 hours of productive labor. As volume exceeds this labor capacity, labor will be added. Necessary number of direct labor workers is calculated as excess volume divided by 2373.

- (4) In scenario III, the increase in machine productivity is to be matched by increased labor productivity. This is reflected by recalculating New Worker Hours using 6.5 productive labor hours per shift for a Class I worker. This calculation is shown below.

$$\text{Class I worker hours} = 46 \text{ wks/year} \cdot 6.5 \text{ productive hours/shift} \cdot 5.5 \text{ days/wk} \cdot 2 \text{ machine} = 3289$$

This will also alter New Worker Hours for scenario III as follows.

$$\text{New Worker Hours} = (16 \cdot 3289 + 9 \cdot 1644.5) / 25 = 2696.98$$

- (5) The price of adding a worker is set at \$50,000 annual. This is an accepted number from the financial community at Kodak. This includes a full benefits package.
- (6) The dollar per hour rate is calculated as Annual Budget/Available Machine Hours.

SCENARIOS	Machine Available (Hours)	Necessary in Volume to Fill Shop (Hours)	Required Increase Labor	Increase in Budget Due To Labor	New Budget	\$/hr Rate
I Current	58,000 HRS	0 HRS	0	\$0	\$3,617,000	\$62.36
II Absorbing All External Work, 70% Efficiency	82,580 HRS	24,580 HRS	10 People	\$500,000	\$4,117,000	\$49.85
III Working 80% Efficiency, 7 Days/wk 50 Wk/Year	102,375 HRS	44,375 HRS	16 People	\$800,000	\$4,417,000	\$43.15

If it has been determined that Core has the capacity to do this work, will this save the company money?

The following sheet utilizes the budget determined in SCENARIO II to show the cash flow impact of moving work into Core. This analysis shows not only how the savings are generated for the company, but also how the accounting system allocates these savings among the LOBs.

1) Determine the *current cash outlay* for Eastman Kodak to purchase their rotational machining needs: (all numbers net of material cost)

Core Rotational Budget: This represents the current total budget for this department, minus material costs. The percentage representation of each customer is represented to the right of the dollar amount.

Total Budget in SCENARIO I	<u>\$3,617,000</u>	100.0%
Office Imaging	\$1,950,000	53.9%
Other LOBs	\$1,667,000	46.1%

Office Imaging External Buy: This represents the total amount of rotational machining work that Office Imaging currently purchases externally that could be performed internally.

Total External Purchase	\$1,900,000
minus 35% material cost	<u>\$ 665,000</u>
External Purchase minus Material	\$1,235,000

Total EK Rotational Parts Cost: This represents the *total current cash* outlay by the company for rotational machining parts

Internal Purchase	\$3,617,000
External Purchase	<u>\$1,235,000</u>
Total Current Cash Outlay	\$4,852,000

NOTE: From this point on, all costs will be net of material costs

2) Determine the new percentages of each customer user if Office Imaging purchased internally all of its work. This will have a significant impact on how the accounting system allocates the savings. The prior analysis in this exhibit shows that all of this external work could be done internally by adding direct labor only. This has been termed Scenario II. This scenario raises the Rotational Machining budget by \$500,000 (10 people @ \$50,000 per person).

Calculating the new percentages requires that the work be represented in machine hours rather than dollar amounts

Core Rotational Budget (Calculated by machine hours)

Current Situation

The same percentage breakdowns presented in the calculation of the budget in dollars (shown in step one) is now applied to the amount of hours required in Scenario I.

Old Office Imaging Work	31,262 HRS	53.9%
Other LOBs	<u>26,738 HRS</u>	46.1%
Total Rotational Hours	58,000 HRS	100.0%

Projected Situation (Moving all New Office Imaging Work Inside)

Other LOBs		26,738 HRS	32.3%
Office Imaging Work			
Old Office Imaging Work	31,262 HRS		
New Office Imaging Work	24,580 HRS		
		<u>55,842 HRS</u>	67.6% Total
Rotational Hours		82,580 HRS	100.0%

New Core Rotational Budget: With the new percentages determined, the new dollar purchases of each customer can be determined by simply multiplying the percentages by the new budget.

Other LOBs	\$1,332,890	32.3%
Total Office Imaging Work	<u>\$2,784,110</u>	67.6%
New Cash Outlay	\$4,117,000	100.0%

3) Since the two cash outlays are now determined, it is obvious that Eastman Kodak can save money by internally sourcing all of Office Imaging's Rotational Machining work.

Eastman Kodak Savings

Old Rotational purchase	\$4,852,000	(from Total EK buy calculation above)
New Rotational purchase	-- <u>\$4,117,000</u>	
Net Savings to EK	\$735,000	

Note that this is an annual saving!

4) Determine how the accounting system reallocates this \$735,000 between Rotational Machining's customers. This is done by first calculating what each customer used to pay to purchase their components and what they now pay for the same purchase

OFFICE IMAGING SAVINGS

Old Office Imaging Total Purchase			
Internal		\$1,950,000	
External		\$1,235,000	
			\$3,185,000
New Office Imaging Total Purchase	--	<u>\$2,784,110</u>	
Net Savings to Office Imaging		\$400,890	annual 55%

OTHER LOBs SAVINGS

Old LOBs Total Purchase		\$1,667,000	
New LOBs Total Purchase	--	<u>\$1,332,890</u>	
Net Savings to Other LOBs		\$334,110	annual 45%

Observing the difference between the cash outlays for each customer provides an interesting insight into how the accounting system will allocate the \$735,000 saved by Eastman Kodak by internally sourcing Office Imaging's work. The saving between the LOBs is distributed *based upon the prior utilization rates*; thus Office Imaging receives 55% of the savings and other LOBs receive 45%. This demonstrates that the savings are distributed *through cost reductions of components that were previously internally purchased and not through a UMC reduction on the new parts purchased internally*

Simply put, the new work has now absorbed some of the burden that other LOBs had to pay to the rotational machining shop. For every dollar brought in (minus material), this new work absorbs 45 cents of burden from other LOBs and 55 cents from Office Imaging. It is crucial for management to understand that the accounting system does not allow all of the savings that Office Imaging generates by sourcing work to be realized on their purchases. However, it is also important to note that if other LOBs were to also internally purchase work, Office Imaging would receive the same proportional savings

Note: This analysis assumes that this shift to internally sourcing happens as one event. If it were to happen piecemeal, the percentages would be recalculated each time and Office Imaging would receive a proportionally larger portion of the savings each time as their share of the Rotational Budget rose. However, for practical purposes, this difference would be minimal from the step function assumption