Digital Integration and the Lean Manufacturing Practices of U.S. Printing Firms

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A Research Monograph of the Printing Industry Center at RIT

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R·I·T Printing Industry Center

An Alfred P. Sloan Foundation Center

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Executive Summary

Technology plays a critical role in reducing the costs of business and manufacturing processes. However, the acquisition of new technology in the absence of a disciplined approach to process analysis and sound strategic planning can sometimes lead in the wrong direction—to increased costs and eventual failure. Many large companies have the resources necessary to take a rigorous approach to process re-engineering. They take a sober view of the problems they intend to solve and develop a clear set of goals for improvement. They then concentrate their energy on changing their business and manufacturing processes to continuously reduce or eliminate costs that do not contribute to the value of the products and services they sell.

Smaller firms must accomplish the same objectives, but do not have the necessary resources to do it on their own. It is more likely that these companies will take a less coordinated approach to improving productivity. They will acquire new equipment piece by piece, justifying each investment individually. They will expect these investments to integrate with other capital equipment that they already have or plan to acquire in the future. They will look to suppliers who offer work cell level solutions that deliver quick return on investment and integrate efficiently with one another.

Although the smaller companies are less likely to take a comprehensive approach to manufacturing cost reduction than the larger companies, they still stand to benefit from a working knowledge of how lean manufacturing practices and computer integration can be put to work in a print-manufacturing context.

The analysis of the results of a survey returned by 103 printing firms reveals a number of key findings in three areas of inquiry:

1. Current problems facing the industry:

- Delays due to lack of information are experienced throughout the production process, but the percentage of jobs delayed decreases steadily as work moves downstream. On average, the chance that a job will be delayed somewhere in production is greater than 60% for both smaller and larger companies in our survey.
- The majority of firms of all sizes claim that there is some redundancy within their information systems.
- Firms of all sizes have realized the greatest increases in productivity during the past three years by improving production yields at each step in the process. The least significant cost reductions are due to reductions in plant inventories.
- More than 20% of jobs overall need to be expedited to meet delivery deadlines.
- The majority of firms report average run lengths below 10,000 pieces. For smaller firms, 43% of jobs fall between 1,500 and 4,999 pieces. For larger firms, 30% of jobs fall between 5,000 and 9,000 pieces.

2. Current industry practice versus best practice:

- Less than 25% of smaller firms have a chief information officer, whereas nearly 60% of larger firms do.

- The most common computer-based systems among firms of all sizes are management information systems and scheduling systems. Very few (5%) of smaller firms and less than 20% of larger firms have ERP (Enterprise Resource Planning) systems.

- Approximately 7% of smaller firms and 33% of larger firms have achieved ISO certification.

- When choosing suppliers, on-time delivery is the most important factor. Location is least important.

- Firms of all sizes believe that there is a gap between what they know about CIM (Computer Integrated Manufacturing), lean manufacturing, competitive benchmarking, quality control/assurance, and specific technologies like JDF, and the importance of these factors to their future profitability.

- Larger firms place a greater emphasis on measurement and monitoring of waste; smaller firms place a greater emphasis on monitoring of on-time delivery.

3. Perceptions of the promise of new technology and management strategies:

- More than 80% of smaller firms and nearly 90% of larger firms acknowledge the importance of CIM to their future profitability. More than 60% of larger firms believe that CIM is very important or essential to their future.

- Firms of all sizes place a high value on improved information for the sales force.

- Smaller firms are more interested in improved information about competitive pricing and capabilities than larger firms.

- Only 25% of smaller firms have established cost reduction goals, while more than 65% of larger firms have.

- Prepress is seen as the area of greatest opportunity for cost reduction in the future.

- Firms of all sizes believe that both new technology and smarter management will contribute to improved operating efficiencies in the future.

- Cost reductions are the most important future improvement sought by firms of all sizes.

Introduction

The printing industry is in the midst of a transformation that can best be understood with reference to the metaphor of the "perfect storm." Four forces—digitization, standardization, the rise of the Internet, and globalization leading to increased competition—have combined to create the storm. The storm is destroying many companies in its path. Other companies are learning how to ride through it and harness its awesome power to their best advantage.

Technology can play a critical role in reducing the costs of business and manufacturing processes. But the acquisition of new technology in the absence of a disciplined approach to process analysis and sound strategic planning can sometimes lead in the wrong direction—to increased costs and eventual failure. Technology also enables competition where none existed before. When work can be handed off as quickly to a colleague in Hong Kong, Barbados, or Bangalore as it can to a co-worker sitting in an adjacent cubicle in Chicago or New York, the fundamental rules of the game change irreversibly.

This paper is a mid-course status-report on the progress of the industry and on the proactive measures that some companies are taking to battle the storm. These companies have several characteristics in common. They all take a sober view of the situation they are in and develop a clear understanding of the limits of their control. They then concentrate their energy on changing their business and manufacturing processes to continuously reduce or eliminate costs that do not contribute to the value of the products and services they sell. They also continually look for opportunities to develop new products and services that leverage the capabilities of new technology.

In July 2003, the Printing Industry Center at RIT sent a survey on manufacturing operations to its panel of printing companies. The objectives of this research were threefold:

1. To refine the understanding of the manufacturing-related problems currently facing the industry.
2. To assess current industry approaches to improving operating efficiencies in light of benchmarks established by leading companies.
3. To determine how managers view new technology and new management techniques designed to improve productivity.

One hundred three firms completed the survey. The survey results are reported in the Appendix. The responses to the survey inform the discussion to follow.

DIGITIZING GUTENBERG

The digital revolution began with the use of primitive digital technologies such as punch cards and paper tape in the typesetting industry. Each discrete function that had historically been performed using non-digital technology was eventually replaced by digital technology—that is, technology that at some point in its operation manipulated symbolic representations of objects or information in digital form.

At first, digital technology was designed to closely emulate the non-digital technology that it replaced. The focus was on the inner workings of discrete work cells, rather than on the connections between them. Digital technology brought with it the advantages of 100 percent repeatable representation and execution of work. In most cases digital technology also increased the productivity of an operation as a function of labor. Variability was still a problem, because the output of digital systems was still in physical form. (Digital scanners and typesetters still produced film and paper that had to be wet processed.) Digital technology replaced craftsmanship with robotics, a critical first step toward the creation of an automated production system.

In the mid 1990s, the first commercial computer-to-plate devices for conventional printing presses and the first direct digital production color printing presses were introduced to the market. These new devices completed the digitization of discrete components in the print production process, moving the transformation of digital information into physical form as far downstream in the production process as possible.

The last wet chemical process in the extended print communications workflow to be replaced by digital technology is creative photography. The price/performance of digital cameras and supporting infrastructure now favor the rapid transition of commercial photography to digital. This trend is accelerated by the ability to retrofit most existing medium and large format film cameras with digital backs.

Digitize then Connect

Once each step in the extended process has been digitized, attention next turns to the connections between production steps and the design of efficient workflows. The mere fact that each step in the production process is digital does not guarantee anything beyond localized speed, uniformity, and repeatability. The net efficiency of a production system is determined by the constraints in the system (Goldratt, 1990). Wherever the digital output of one device must be "handled" by a human operator to be prepared for input into another device, a potential system constraint exists. The summation of these interfaces between production steps account for a significant share of the cost of production.

In the 2002 Printing Industry Center research monograph, *Design to Production: The Critical Interface*, the significant effort expended in the preparation of customer-submitted file sets for production was described (Cost, 2002). Since then, the accelerated adoption of PDF as an interchange standard has been noted. This is enabled by three factors: 1) the maturation of the PDF format in its ability to represent the intent of the designer to the level of detail required; 2) the simplification of PDF creation; and 3) the proliferation of automated prepress systems that input PDF at the front end.

STANDARDS AND STANDARD PRACTICE

One of the realities of life in the computer age is that the exponential improvement of digital technology following Gordon Moore's 1965 prediction (Moore, 1965) trumps almost every other factor in determining the adoption of standards. While computer scientists engage in lively debate about the relative merits of representing or processing digital information, the industry improves the technology at such a rapid rate as to render these arguments as pointless as a debate about how many angels can fit on the head of a pin. Brute force ultimately rules in a world of ever-increasing power at ever-decreasing cost.

One consequence of this is that the debate over the best approach to solving a problem is less important than the political mechanism for reaching consensus. Who, after all, cares how ugly or poorly designed Microsoft Word may be underneath the polished surface of the computer screen? The only thing that matters is that we all use it. So complete is the victory of Microsoft Word as the standard package for exchange of editable text-intensive documents that one seriously questions the mental health of a colleague who attaches a WordPerfect file to an email. Pity the poor soul who tries to argue that WordPerfect is actually a more elegantly designed piece of software.

The simple truth is that standard practice rarely coincides with best practice. There are two reasons why this is true. First, any given engineering problem can be solved in many different ways. In the mechanical realm, external factors such as gravity, friction, and leverage, limit the number of practical solutions to a problem. In the digital realm, no such limitations exist. This explains why, for example, the first version of what later evolved into JDF could be in the format of a PostScript file. The fact that PostScript was never intended as a vehicle for representing the kind of hierarchically organized information associated with an electronic job ticket did not prevent the original CIP3 designers from forcing it into that role. By disguising the job ticket as PostScript, the information could ride along with a PostScript stream and not disrupt established workflows.

The second reason why standard practice rarely coincides with best practice is rooted in the human attributes of adaptability and habit. Humans adapt quickly to arbitrary requirements, developing habits that enable them to work effectively with the tools at hand. This leads to a resistance to innovations that promise incremental improvements in exchange for disruptions in routine practice. Thus, tool sets become fixed and work habits become entrenched. This poses an interesting dilemma for software manufacturers who emerge as the winners in each category. How do they sell the new and improved version of software to a population for whom familiarity with the current version is the most important factor in preserving the monopoly? The answer is to add features that will entice the user base to upgrade without significantly altering the core product.

This presents a difficult challenge to efforts to build computer-integrated systems. The first requirement for such systems is stable and clearly defined inputs and outputs at the component level. What is needed is a set of black boxes that can be used as the building blocks for the integrated system. Changes to the inner workings of the black box are not a problem as long as the inputs and outputs remain constant.

This explains, among other things, why PDF is such a critical element as an interchange format between design and production, and why it is essential that PDF reach maturity and then freeze before the industry can fully embrace it as a standard. (The same can be said for JDF, which will be addressed separately below).

Without PDF, the native file format of each design application must serve as the interchange format. As software manufacturers add features to design applications (essential to keeping their businesses alive), the file formats must change to allow for the representation of the new features. Every new upgrade of every application therefore forces a change at the front end of the production process. Printers must have the latest versions of all of the relevant design software and maintain the expertise in-house to operate it.

PDF has the potential to eliminate all of this complexity. First, it must prove that it can effectively represent all of the nuances of design intent that may be expressed by any designer using any application program. VIGC, a partner of the Printing Industry Center, has conducted an extensive set of evaluative tests of PDF. Some anomalies may occur in the generation of PDF not because of inherent problems with PDF, but because of weaknesses in the applications responsible for generating the PDF files (VIGC, 2003). Independent research conducted in the RIT School of Print Media has determined that, if properly configured, PDF is capable of representing the full range of graphical features available to a designer working with standard graphic arts design tools such as Quark XPress or Adobe InDesign. The results of this work will be published in 2004.

As a proposed interchange format, JDF faces a challenge similar to that of PDF. JDF is a necessary complement to PDF. Whereas PDF represents the exact graphical content of a document as a set of ordered layouts or pages, JDF is intended as an electronic job ticket that contains all other relevant information about the job necessary for its manufacture and delivery. Theoretically, this should include every possible piece of meta-information that might be needed at any point downstream in the production process. If JDF achieves its promise, a PDF/JDF file pair will comprise a complete self-documenting package that compliant production systems will be able to process and convert into a finished manufacturing/distribution run.

Because it is impossible to anticipate all of the various kinds of specialized information that will be required by each of the myriad applications that JDF will cover, the designers have made provision for user-defined extensions. This provision is accompanied by a strongly worded caution (CIP4, 2000):

> If you or your technology vendors extend JDF, please do so with caution. The success of JDF depends on the ability of MIS systems and JDF-enabled devices to write, read, parse, and use JDF. Extensions are custom integration applications and great care needs to be made to ensure that extensions made for one system or device will not jam the JDF workflow or other JDF enabled systems and devices. If they use extensions to JDF, your technology providers should be able to provide you with a fully validated JDF schema and documentation that includes the use of their extensions. Extensions that are not documented, or that may not be disclosed to third parties for integration purposes, should be viewed skeptically.

This caution reveals a fundamental dilemma for a huge standard that is intended for use across a vast range of applications. It is impossible for the standard itself to anticipate every future need, thus the provision for extensions. This must be accompanied by a complex system for validating extensions to preserve the integrity of the standard. Fortunately, JDF extensions must be rigorously defined in XML. This imposes a discipline on the extension-making process. However, once the possibility of user extensions is allowed, there is no practical way to prevent individuals from creating proprietary variations and then building closed systems that depend on them.

THE CHANGING COMPETITIVE ENVIRONMENT

The walls in the front lobby of most commercial printing companies are covered with awards and certificates of all kinds. These are prominently displayed as an implied guarantee to customers that they are doing business with a company that has a track record of quality. But what do most of these awards really mean?

For the most part, awards are the result of a competition where samples of jobs are submitted for judging by panels of experts. The physical appearance of each entry is the sole criterion for judgment in many such competitions. No other information about the entries is available to the judges. For example, was the job delivered on time? Was the customer pleased with the service? Did the product deliver the anticipated value to the customer? Was the job profitable for the printer? How profitable was the job? Did the job lead to an expansion of business opportunity?

The point of all of these questions is not to diminish the importance of print and product quality. In most cases today, high product quality is assumed. All printed products must be of high quality. As a point of competition, quality was once a measure of the prowess of a company's craftsmanship. Every move of every craftsman in the company contributed to the overall quality of the final product. When reproduction copy was photographed with process cameras, films were assembled on light tables, and the sharpness of razor blades and steadiness of hands could all be detected in the finished product, a contest that focused on print quality was meaningful. This is not longer true.

Today product quality is more a direct function of design than of production. Contests that focus solely on the appearance and physical characteristics of the entries, without reference to any of the invisible characteristics mentioned above, meaningless. Limited to these criteria, it is possible that a winner could have failed in all the important invisible dimensions and that a loser could have succeeded in the same. The "loser" could have been delivered on time, delighted the customer, and returned more than was anticipated on the customer's investment. The "winner" could have been a disaster in all the same dimensions—except for the fact that the winner appeared better to a panel of "experts" who were given nothing beyond the physical sample itself as a basis for judgment.

The printing competitions that generate thousands of awards that grace the lobbies of printing companies throughout the U.S. are relics of the age of craftsmanship. Most printing companies know this, but awards make for good decor in a place where customers begin to form their opinions of a company. A front lobby devoid of awards would sow the seeds of doubt about the wisdom of doing business with the company even in the mind of this skeptical author.

The above argument is not intended to suggest that the industry abandon print contests. The awards undoubtedly help companies market their services, and are therefore considered to be worth the time and effort. However, the idea of quality that is implied by contests masks a number of far more important contributors to the quality of most of the products of the industry. Everyone in the printing business knows that product quality alone is not sufficient for success. Good service is also critical. But quality and service are viewed as independent requirements. One must produce high quality products. One must also provide customers with excellent service. But what if product quality and service are not independent? Furthermore, what if the success of a product is inversely related to quality?

All of this points to a common misunderstanding among print service providers about the real value of the products and services they offer their customers. This misunderstanding is rooted in the long history and rich culture of the industry. The myopic focus on the material attributes of the manufactured product is a natural consequence of craft-based thinking. However, printed products that are primarily channels of communication between organizations and populations find their ultimate value in the effectiveness of the communication. The value of a catalog, for example, is a direct function of the volume and distribution of sales that it generates. The physical attributes of the product are only part of the value formula.

Manufacturing and Service

Because the printing industry produces physical products, it must involve manufacturing, though it is only recently that the industry began to use the term "manufacturing" to describe what it does. This is further complicated by the profound changes that have been taking place in manufacturing in general. Fifty years ago, the mass production of most products was largely accomplished in factories modeled on the Ford production system. There was no place for craftsmanship in a factory of this kind. Workers were trained to perform simple repetitive tasks that did not require special skills or training. Problems encountered on the factory floor were solved by methods of brute force. Defective parts that did not fit were simply discarded.

Before the digital age, print production had almost nothing in common with classic Ford system mass manufacturing operations. The printing industry relied on a highly skilled workforce that knew how to mass-produce custom products using a sequence of complex craft operations appropriate for each job. There was no process-engineering department in a printing plant. All of the process knowledge resided in the minds of the craft workers. The most important management functions were scheduling and enforcement of production quotas. Management rarely presumed to second-guess the techniques that were employed in each department. These were the exclusive domains of the master craftsmen. The industry had been organized this way for half a millennium.

In this context, the use of the word "manufacturing" to describe the printing industry was a provocative statement when it was first uttered. (In the late 1990s, R.R. Donnelley, under the leadership of William L. Davis, began to explicitly describe its printing operations as manufacturing. The term was intended to be disruptive when spoken to the employees, customers, and stockholders of the company.) Even today, managers of printing companies who describe print production in these terms are often met with skepticism and hostility. Manufacturing neither respects nor needs craftsmanship. Craftsmen rightly perceive a threat to their power and livelihood when they hear the word.

Printing companies have wrestled with the problem of reconciling the demands of their customer for ever-improved service with the need to build efficient manufacturing processes. If the service side of the equation dominates the thinking of management, the manufacturing operation may not be organized very well. If, alternatively, management focuses on building the most rational and efficient manufacturing operations, they are often forced into a "product-out" mindset that sends the sales force out into the world to sell machine time. If the Sphinx were still alive today, perhaps his riddle would go something like this: How do you provide the best service to your customers while keeping the cylinders always turning? This is the riddle that the printing industry must answer.

IMPROVING THE MANUFACTURING PROCESS WITH COMPUTER INTEGRATED MANUFACTURING (CIM)

The term Computer Integrated Manufacturing was originally defined by the Society of Manufacturing Engineers (Rehg & Kraebber, 2000, p. 22):

> CIM is the integration of the total manufacturing enterprise through the use of integrated systems and data communications coupled with new managerial philosophies that improve organizational and personnel efficiency.

This definition is so abstract and generic that it is difficult to imagine how it might apply to the specific circumstances of the printing industry. Rehg and Kraebber (2000, p. 23) further elaborate on the definition of CIM:

> CIM is a new way to do business that includes a commitment to total enterprise quality, continuous improvement, customer satisfaction, use of a single computer database for all product information that is the basis for manufacturing and production decisions in every department, removal of communication barriers among all departments, and the integration of enterprise resources.

The notion of a "single computer database for all product information that is the basis for manufacturing and production decisions in every department" sounds more like the definition of an enterprise resource planning (ERP) system, given the approach to CIM that is currently being promoted by the leading vendors to the printing industry. When companies such as MAN Roland, Heidelberg, Creo, and others use the term "CIM," they restrict the meaning of the term to the integration of the various pieces of the manufacturing process. The central organizing principle is the Job Definition Format (JDF) developed by the CIP4 consortium.

Application of CIM to Job-Based Manufacturing

In the original CIM literature, various taxonomies are suggested for organizing the different types of manufacturing. In one common taxonomy, the realm of manufacturing is divided into two broad categories.

- **Flow-Based Manufacturing**
  In flow-based manufacturing, "specialized resources perform limited tasks with great precision and speed" (Anupindi, Chopra, Deshmukh, Van Mieghem & Zemel, 1999, p. 12). It can be further divided into discrete flow and continuous flow manufacturing operations. Discrete flow operations produce products like computers and automobiles. Continuous flow operations produce products like gasoline, steel, and chemicals. A good example of a flow-based manufacturing operation that is related to the printing industry is a plant that converts raw potatoes into crated bags of potato chips. In this example, the preparation and cooking of the chips is closer to a continuous flow process, and the bagging, boxing, and palletizing operations more resemble discrete flow operations.

- **Job-Based Manufacturing**
  The production of the decorated potato chip bags takes place in another type of manufacturing operation. This is closer to the ideal of job-based manufacturing, where the resources of the manufacturing company are organized and operated to perform discrete manufacturing operations that result in the production of a job. Each job moves through the plant from department to department, where discrete operations are

performed and value (or non value-added cost) is added to the job. The path that a job takes through the plant is programmed into the job itself and documented on the job ticket or job jacket. The job ticket is the organizing principle for work performed in the plant.

Job-based manufacturing depends on the job ticket to carry all of the knowledge about the nature of the final product. If this information were to be stored redundantly apart from the job ticket, there would arise the possibility of anomalies that would then have to be resolved. The apparatus for resolving anomalies adds further complexity and introduces its own set of problems. Thus, the single most important aspect of a job-based manufacturing system is the architecture of the job ticket.

The ideal job ticket contains all of the necessary information required to manufacture and deliver the job. This must include information or pointers to information about the customer, the business agreement, the exact description of the product down to the last detail, the delivery plan, etc.

A commercial printing plant is the quintessential job shop. The plant houses a wide range of capabilities that can be configured appropriately for each new job that comes through. The goal of the manager of a job shop is to try to attract the right mix of work into the plant to keep all of the machinery busy all of the time. This goal has become increasingly elusive, as customers demand faster and faster delivery of product. Commercial printing plant managers faced with the inevitable bottlenecks that threaten on-time delivery to their customers are tempted to add capacity in key bottleneck areas. To justify these investments, they then try to fill the capacity of the new equipment by attracting more business. This additional business also demands capacity from other equipment in the plant, and new bottlenecks arise. To eliminate these, the hapless manager is forced to try to eliminate the new bottlenecks by acquiring additional equipment, or risk losing customers because of missed deadlines.

This cycle repeats, and very often, even though the total volume of business increases, the profitability of the company suffers because of rising overcapacity. The desperate manager will then often try to fill excess capacity by pricing work below cost. As one manager told the author during a recent interview, “If the machine isn’t running, I’m losing money anyway. Pricing below cost may sound like a bad idea, but it slows down the rate at which I lose money.”

Eli Goldratt (1990) developed a theoretical explanation of this problem in a book entitled *The Theory of Constraints*. Dr. Goldratt’s basic idea is that the total throughput of a manufacturing system hinges on the bottlenecks in the plant, and that only by taking a global view of the entire operation is it possible to minimize the impact of the bottlenecks on overall throughput. The theory is easy to grasp, but difficult to implement, especially as the complexity of the operation increases. The central insight of the theory is that optimization of a production system to maximize the profitability of individual jobs or the productivity of specific operations does not necessarily result in increased throughput and greater overall profitability.[1]

This approach to scheduling is very sophisticated. However, optimization does not guarantee achieving full utilization of all of the capacity in the plant. It simply optimizes the profitability possible given all of the factors in play. Even with global optimization, the act of reducing turn-around time to meet rising customer demands may inevitably lead to increased overcapacity and lower productivity.

Is JDF the “Ticket”?

The promise of JDF is fairly simple. A JDF file attached to a print job has the capacity to carry all of the information about the print job that may be needed at any point during its planning, production, scheduling, or distribution. A JDF file can replace all other sources of information about a job necessary to its successful completion. In order for JDF to work, the relevant information must be written into the file by those systems and applications that possess it, and the information in the JDF file must be read and acted upon by other systems and applications where it is meaningful.

A simple example will serve to illustrate the function of JDF within a manufacturing process. When an imposition program processes a PDF of a book, producing imposed signatures to be sent to the CTP device, the software calculates the ink coverage color by color for each signature. This information is written into the JDF file. When the job gets to press, the press control system reads the JDF file, extracts the ink coverage information, and presets all of the ink keys on the press. This eliminates the need for separate plate scanning and expedites the press make-ready process.

The above is the best initial example of how JDF works because it is conceptually easy to grasp and because it has already been implemented by the major prepress manufacturers such as Creo, and by press manufacturers such as MAN Roland and Heidelberg. These manufacturers have concentrated on putting JDF to work as a way of expediting the setup of machines that perform discrete operations in the job shop. Without JDF, it would be necessary to build custom interfaces between systems. Strictly speaking, there is nothing preventing Creo and MAN Roland, for example, from developing a proprietary method of communicating the ink coverage information from the Creo plate-setting system to the MAN Roland press to automate the ink key presets. But this would have to be done separately for every combination of prepress system and press that the two manufacturers make, and then again if Creo and Heidelberg wished to connect up their systems.

JDF is best seen as an "information bus" that can travel from any system to any other system providing a standardized structure for information sharing among systems. When the bus arrives, a compliant system can interrogate the contents and extract the information that is needed. The user interface can be as simple and elegant as the manufacturers want to make it. (Perhaps just double-clicking on an icon of the "JDF bus" that appears with a job would be the easiest user interface imaginable. Click on the bus and your system consumes the JDF file and sets itself up accordingly.)

JDF provides an important piece of the CIM puzzle that the industry is in the process of assembling. The entire puzzle, however, goes far beyond the scope of JDF. Some of the original goals of CIM, when they were first articulated back in the 1970s, will only be realized with the full implementation of ERP. JDF is best seen for what it is, an electronic job ticket that has the capacity, if used properly, to provide all of the necessary meta-information about a job needed for its successful manufacture and delivery. The good news is that JDF is useful as soon as two systems that need to exchange information with each other have the capability of using it. The bus, to return to the simple metaphor for JDF, need only carry a single passenger to begin to have value.

During the past two years, an increasing number of JDF-enabled applications have been introduced to the market. It is expected that many more JDF applications will be announced in the spring of 2004 at the Drupa trade show in Düsseldorf. Most of these applications promise to reduce setup times on discrete pieces of equipment by using the information in a JDF file to perform setups automatically. A JDF-enabled folding machine, for example, will be able to set itself up based on the folding geometry contained in the JDF file that accompanies the job.

Lean Manufacturing: The Necessary Foundation for CIM

In the CIM literature there are a number of recommended approaches to implementation that are variations on the same general theme. Implementation is a multi-step process that requires a disciplined strategy sanctioned by top management. According to Rehg and Kraebber in Computer-Integrated Manufacturing (2000, p. 30), successful implementation of CIM proceeds in three steps:

1. Assessment of enterprise in three areas: technology, human resources, systems
2. Simplification
3. Implementation with performance measures.

The simplification step is a critical antecedent to implementation of CIM. Trying to integrate and automate existing processes before making a rigorous effort to simplify them is the wrong approach. Process simplification seeks to minimize "cost-added activity." This is sometimes called "non value-added activity."

Non value-added activity is any activity that does not directly increase the value of a product or service. Non value-added activities include such things as moving material from place to place, storing materials in inventories, etc. The RIT Center for Excellence in Lean Enterprise identifies seven different kinds of non value-added activity:

1. Transportation: movement of material in the plant
2. Inventory: anything of value waiting in process
3. Motion: excess movement of people
4. Waiting: idle operators or machines
5. Overproduction: producing more product at each step than is needed downstream
6. Over-processing: performing extra processing steps that don't add value
7. Defects: materials spoiled in process.

Lean manufacturing takes a disciplined approach to the identification and reduction of these seven types of non value-added activity. The first step is to create a detailed flowchart of the current state using a technique called "value stream mapping." The techniques for creating a value stream map are described in detail in Rother and Shook's publication (1999) and will not be discussed here. A completed value stream map identifies where the cost-added activities exist in a production system, and where the largest opportunities for cost reduction might be. The value stream map also provides a baseline from which a desired future state map can be derived.

The motivation to invest the time and resources required to create an accurate value stream map of the current state of any manufacturing process must come from a strong conviction that cost-added activities can be reduced by a significant enough amount to warrant the effort. It is difficult to imagine that a company that does not have goals for cost reduction will be motivated to take the formalized approach to cost reduction implied by value stream mapping.

SUMMARY

Sustainable competitive performance of the printing industry is dependent on the ability to continuously improve the efficiencies of the relevant manufacturing processes. The new approaches are broad (lean and CIM) but rely on specific new enabling technologies such as PDF and JDF. The purpose of this research is to determine current industry knowledge and practice and to assess the opportunities for new technologies and practices to reduce the costs and improve the profitability of print manufacturing operations.

[1] This theory serves as the basis for a dynamic scheduling program called PrintFlow available from PrintCafe.

Research Questions

The research questions emerged as large and small companies were studied to develop a composite set of benchmarks representing current best practice. These benchmarks then guided the formulation of survey questions for the research panel. The research addresses three broad questions related to how the printing industry is responding to the need to offer improved service to its customers while simultaneously improving manufacturing productivity:

1. What are the manufacturing-related problems facing the industry and what are the opportunities for improvement?

2. How does current industry practice compare with best practice?

3. How do managers perceive the promise of new technology and management approaches to solving these problems?

EXAMPLES OF CURRENT INDUSTRY BEST PRACTICE

The industry has made the greatest strides toward full implementation of CIM in manufacturing facilities that produce a narrow range of standardized products. Perhaps the best example in North America is the R. R. Donnelley plant in Roanoke, Virginia. Dedicated to book production, the plant has realized significant gains in productivity through the use of the Internet for customer interaction, the standardization of the prepress process around a PDF workflow, computer-to-plate, rigorous process monitoring and control, a Six Sigma continuous improvement program, and lean manufacturing to reduce cycle times.

In a recent Fortune Magazine profile of the plant (Bylinsky, 2003), the result of these combined strategies was described as follows:

> With these new digital techniques, the Roanoke plant produces 75% of its titles in two weeks or less, compared with four to six weeks for a four-color book in a traditional plant. A shorter period for make-ready allows the plant to devote more time to production. Overall, Roanoke has increased throughput 20% without having to buy an additional press or another binding line—a saving of $15 million.

Donnelley has taken the same disciplined approach to continuous improvement in their service-oriented businesses, such as Donnelley Logistics, with great success. A description of the methodology they have used to apply Six Sigma to logistics operations can be found in *Measurable Change: Harnessing the Power of Six Sigma in a Logistics Environment* (Moszkowicz, 2002).

Another company that has made great strides in streamlining their print manufacturing operations is Thomson Legal and Regulatory (TLR) in Eagan, MN, a suburb of Minneapolis. TLR is a division of The Thomson Corporation, a $7 billion company. In 2001 TLR had total annual revenues of $2.8 billion, with $700 million in operating profits.

West is a business within TLR that serves the legal profession with print, CD-ROM, and Web information products. Forty percent of the West's revenues are from print, 52% are from the Internet, 4% are from CD-ROM, and the balance is from other services. In 2002, they saw a 13% volume decline in print sales. To fill the manufacturing capacity vacated, TLR's printing facility produces printed products for other divisions of The Thomson Corporation, such as Thomson Learning. The growth in volume of external work has kept the printing plant operating at nearly full capacity.

TLR is a fully vertically integrated company. Everything from market research through delivery of the final product is accomplished in house. The company has only one significant competitor: Reed Elsevier plc. The majority of annual print sales are in the form of subscription fulfillment. This means that nearly 85% of the books and other print products produced by the company are shipped directly out of the plant to the end customer. The balance of products are produced and held in inventory in anticipation of future sales.

TLR's manufacturing facility is one of the largest printing plants in the world. The manufacturing, distribution, and warehouse operations occupy 1.3 million square feet of space. The plant produces approximately 61 billion pages per year on web offset, sheet-fed offset, and digital (Océ and Xerox) machines. The plant consumes 42,000 tons of paper each year. All parts of the final products are made within the plant with no outsourcing.

Prepress on most products is simple because the product mix is limited and the company has control over the entire process from editorial to shipping. They have been able to engineer a comprehensive standardized workflow for most of the products they produce. Everything comes into the plant from the publishing side in the form of PostScript. PostScript pages are imposed and plated and the plates are then inspected for defects and sent to press. The error rate in prepress is extremely low. Spoilage percentages in the offset pressroom have been steadily declining but seem to be flattening out at just around 10%. This may seem high in a single color application; however, the average run length in the plant is extremely short. They may be approaching the limits of the printing processes to reduce make-ready times.

TLR went live with SAP (ERP) in the summer of 2001. They had prepared the ground for three years. The first six months were a time of great tribulation, where gaps between and among functions appeared and were fixed.

By the beginning of 2002, the advantages of SAP started to show up in their productivity numbers. This year has brought significant improvements in productivity across all manufacturing processes, much of it attributed to the new capabilities enabled by SAP.

Until recently, the printing plant has produced a large variety of multicolor printed products in addition to the core products of single-color books. The plant was providing the services of a general commercial printer for the larger company. The management team made a major strategic decision this past year to eliminate most of this commercial printing and concentrate the company's energy on its core products. The managers all expressed great enthusiasm for the idea. The great variety of products they produced in the past may have been "an interesting challenge," but a lot of expensive craftwork went into their production and they were not profitable jobs as a result. The consensus among the leadership of the company is that the migration away from "jack of all trades" general commercial work is the right strategic direction for the company.

A third company that is considered to be among the most advanced practitioners of integrated manufacturing is Van Genechten Biermans n.v., one of the largest European packaging converters specializing in offset lithographic printed folding cartons. Van Genechten Biermans has plants in Europe, Asia, and North America. Total sales worldwide exceed $1 billion. The company is privately held. The corporate headquarters and central manufacturing plant in Europe are in Turnhout, Belgium.

The manufacturing operation is highly automated. They collect and keep production and cost data on all sub-processes. This data is rigorously analyzed and used to inform the continuous improvement programs in the plant. Information management throughout the company is state-of-the-art. Robots perform a good percentage of the manual labor in the plant. Materials are transported throughout the plant on computer-controlled, optically guided carts. Everything needed at each production step in the plant is delivered robotically just in time.

The most impressive aspect of the operation is its extreme orderliness and economy. Every movement of people and materials that the author observed during a tour of the plant appeared to be deliberately engineered to reduce non value-added activity to an absolute minimum.

All three of these operations focus on a limited range of products for a clearly defined customer base. In the case of Donnelley Roanoke and Van Genechten Biermans, their respective customer bases of book publishers and consumer product companies are external. For Thomson Legal and Regulatory, the customer base is internal. In all three cases, the manufacturing operations are optimized for specific types of products. In the case of TLR, the company recently decided to cease manufacturing products that did not fit with what they considered to be their core manufacturing competencies.

These three companies have taken formalized approaches to building rational manufacturing processes. These approaches include all of the following:

- **Use of process performance metrics**
  The best practitioners measure and monitor every relevant process variable. They have a quantitative understanding of productivity at each point in the process. They know how much labor is expended at each step and how much waste is generated. They monitor these numbers over time and are able to detect the effects of changes they make to the processes. They also strive to reduce the amount of labor required to collect this data.

- **The drive toward Six Sigma quality**
  Six-sigma represents an ideal of quality close to perfection or zero defects. In a print manufacturing operation, the complete process may involve dozens of discrete steps, each of which contributes to the final product. Six-sigma is a disciplined process aimed at reducing the number of defects that occur at each step in the process. Process performance metrics are the essential starting point. There is no mystery to Six-sigma. There are only two essential ingredients to the discipline. First, the current performance of a process must be known. For example, what percentage of plates currently delivered from the CTP system are defective? Second, the root causes of the defects must be discovered. Once these two things are known, corrective action can be taken and the results monitored. The drive toward zero defects is continuous and relentless.

- **Lean manufacturing**
  Whereas Six Sigma concentrates on defect reduction at each point in the manufacturing process, lean manufacturing is concerned with improving the entire production process as a coordinated whole. The disciplined approach to the implementation of lean manufacturing seeks to identify unnecessary cost-added activity in a manufacturing process, and then to re-engineer the process to reduce this activity.

- **Custom software development**
  The largest companies all possess significant software development capabilities. They are able to design and build or procure custom software to integrate existing systems or provide custom interfaces to their customers. Smaller companies must depend on outside vendors to supply them with all of the necessary software they will need to run their operations.

- **Enterprise Resource Planning (ERP)**
  This most expensive and difficult effort to integrate all business and manufacturing functions with software provided by a single vendor such as SAP or Oracle is only available to the largest companies with the deepest pockets. The initial cost to implement ERP includes the cost of the software itself, the careful analysis of business processes that must be undertaken before the software can be customized, the customization of the software,

the integration of the software with other systems such as E-commerce and Customer Relationship Management (CRM) systems, and the training of the workforce to use the system. Once all of these elements are in place, the organization can "go live" with the new system, after which a massive and lengthy follow-up effort is needed to fine-tune the system.

- **Computer Integrated Manufacturing (CIM)**
  This term, when originally used in the 1970s, had a very broad meaning. The concept of CIM theoretically included most of the features of ERP described above. In a sense, CIM and ERP aspire to accomplish overlapping goals.[2] This leads to some degree of confusion. We will explore this problem in more detail below.

THREE BROAD AREAS OF INQUIRY

The following research questions guided the development of a survey instrument that was sent to our research panel. The questions are organized into three broad areas of inquiry.

1. **What are the manufacturing-related problems facing the industry and what are the opportunities for improvement?**

    - What percentage of jobs are delayed in each department because of missing or wrong information originating at other points in the operation?
    - To what extent do companies have redundant digital information residing in more than one location or computer system?
    - What percentage of work needs to be expedited in the production process to meet delivery deadlines?
    - What kinds of improvements do companies believe are important to future profitability?

2. **How does current industry practice compare with best practice?**

    - How do companies manage their information systems and assets?
    - What kinds of computer-based systems do companies currently employ?
    - What percentage of companies have ISO 9001 certification?
    - What specific measures have companies been taking during the past three years to increase productivity?
    - How have these measures actually contributed to productivity?
    - How familiar are printing industry managers with such concepts as CIM, lean manufacturing, competitive benchmarking, and continuous quality improvement?
    - How important do they believe these will be to the future profitability of their businesses?
    - What do companies measure and monitor and how often?
    - What percentage of employees are formally trained in statistical process control, quality assurance, root-cause analysis, and process re-engineering methodologies?
    - Who among the workforce are involved in the redesign of workflows to achieve higher productivity?

3. **How do managers perceive the promise of new technology and management approaches to solving these problems?**

   - How important do managers believe CIM, lean manufacturing, competitive benchmarking, and continuous quality improvement methodologies will be to the future profitability of their businesses?

   - What are the perceived needs for improved access to information both within the organization and between the organization and its customers and suppliers?

   - Do companies have established cost reduction goals for the future, and if so, what are their goals?

   - What do companies think is the magnitude of the opportunity for improved efficiencies department by department?

   - How important do they believe the acquisition of new technology will be in improving operating efficiencies?

   - How important do they think changes in management practice will be in improving operating efficiencies?

METHOD

The survey was designed to address all of the research questions using an approach that attempted to balance the research goals with what was assumed to be the natural time limitations among the panel members. As with all surveys of this kind, increasing the demand for information from the participants has a negative impact on the yield.

The 22 survey questions, included along with the raw survey results in the Appendix, were carefully crafted and edited by the authors of this paper with input from several representatives of Printing Industry Center partner companies. The survey was distributed electronically to the research panel in July 2003. The survey was sent to approximately 600 companies and returned by 103 of them. The sampling error is approximately ±10% at 95% confidence.

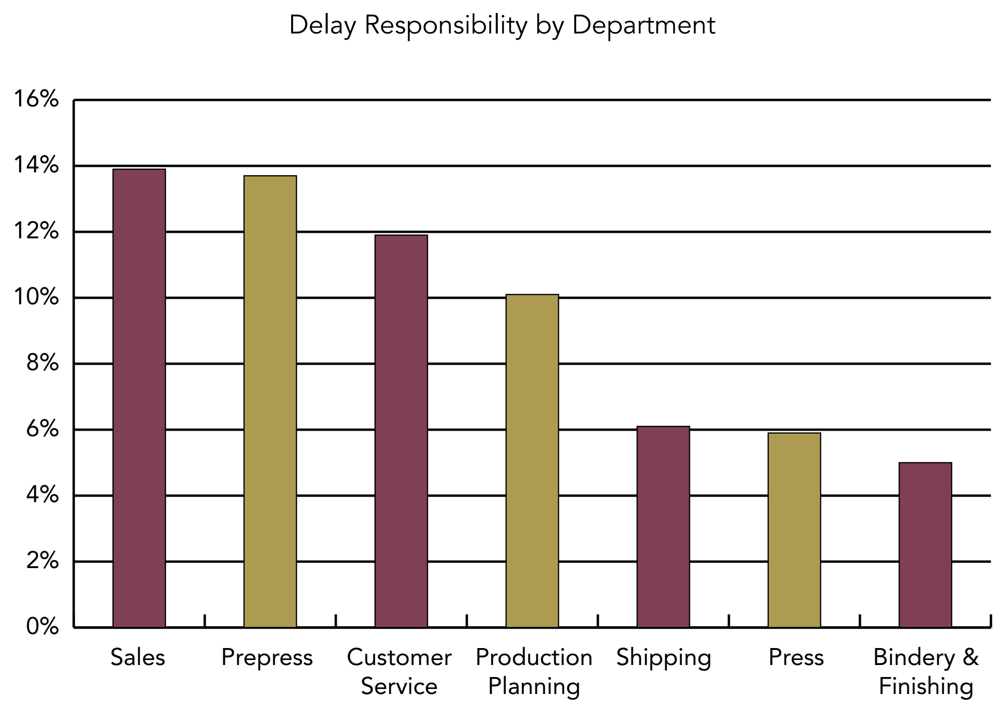
[2]An ambitious vision for CIM was articulated in the 1980s in a book entitled *A New CIM Model: A Blueprint for the Computer Integrated Manufacturing Enterprise*, published by the Society of Manufacturing Engineers. (Thacker, King & Ploskonka, 1989, p. 6) The authors write, “Imagine that you have the ability to create an enterprise system capable of sensing and analyzing current and future customer needs, that these needs in turn are communicated within the system to areas where ideas for new products, manufacturing processes, and facilities are reviewed, estimated, designed, analyzed, simulated, and documented. After validating the product process and facility designs, the system then releases them into a control environment. In the control environment, appropriate plans, controls, standards, and schedules are placed on the designs. The control environment releases the designs and their associated controls to the production environment, where the system tracks and reports back real and estimated performance, time, and costs. You know instantaneously whether or not you are making a profit.”

Results

In the following section the results of the survey are reported; they are organized according to the three broad research questions that guided the creation of the survey. The responses were divided into two groups according to company size. The smaller companies were those with up to 49 employees. The larger companies were those with 50 or more employees. In some cases the responses between the two groups were not statistically different. In others there is a clear statistical difference between the responses of the smaller and larger groups, and these differences will be reported here. A complete breakdown of all question responses by size of firm is included in the Appendix.

Question 1. What are the manufacturing-related problems facing the industry and what are the opportunities for improvement?

1a. What percent of your jobs are delayed in the following departments because of missing or wrong information originating at other points in the operation?



Department	Under 50 Employees	50+ Employees
Sales	12.4%	14.4%
Prepress	12.9%	10.4%
Shipping	4.9%	7.7%

Overall, the sales and prepress departments are the greatest contributors to delay. When comparing large and small companies, larger companies reported more delay in the sales department, while smaller companies reported more delay in the prepress department. While still ranking fairly low, larger companies had greater issues with their shipping department, which may reflect the impact of organizational inefficiencies. As jobs move downstream in the process, the percentage of jobs that are delayed because of missing or wrong information decreases. Less than 6% of jobs are delayed on press or in the bindery because of missing or wrong information. Nonetheless, with a greater than 10% chance of delay in four departments, the overall chance that a job will be delayed somewhere in the process is quite high.

These survey results argue strongly for CIM approaches to productivity improvements. Respondents generally stated that they needed better information at every step of the process and that work was often held up in the plant because of bad or missing information.

1b. Redundant information is defined as the same information that resides in more than one location in your computer systems. How would you characterize your information systems?

Response	Percent
No redundancy	38.6%
Some redundancy	51.8%
Much redundancy	6.0%
Not connected and no redundancy	3.6%

Redundancy was a common theme for respondents, with a combined 57.8% reporting at least some redundancy, and smaller and larger companies reporting similar results. A greater percentage of small companies reported "no redundancy" whatsoever, perhaps reflecting the fact the smaller companies generally use fewer computer-based systems than larger companies.

1c. To what extent did these activities actually contribute to increased productivity?
Responses to this question ranged from 1 to 4, indicating the following: 1="don't know," 2="not important," 3="moderately important," and 4="very important."

Category	Rating
Reduced overproduction by improving yields at each step in the process	3.7
Increased the productivity via better organization of the workplace	3.5
Reduced downtime by better matching the throughputs of production processes	3.5
Reduced material waste	3.4
Streamlined production by reducing processing steps	3.4
Reduced the value of inventories throughout the plant	3.3

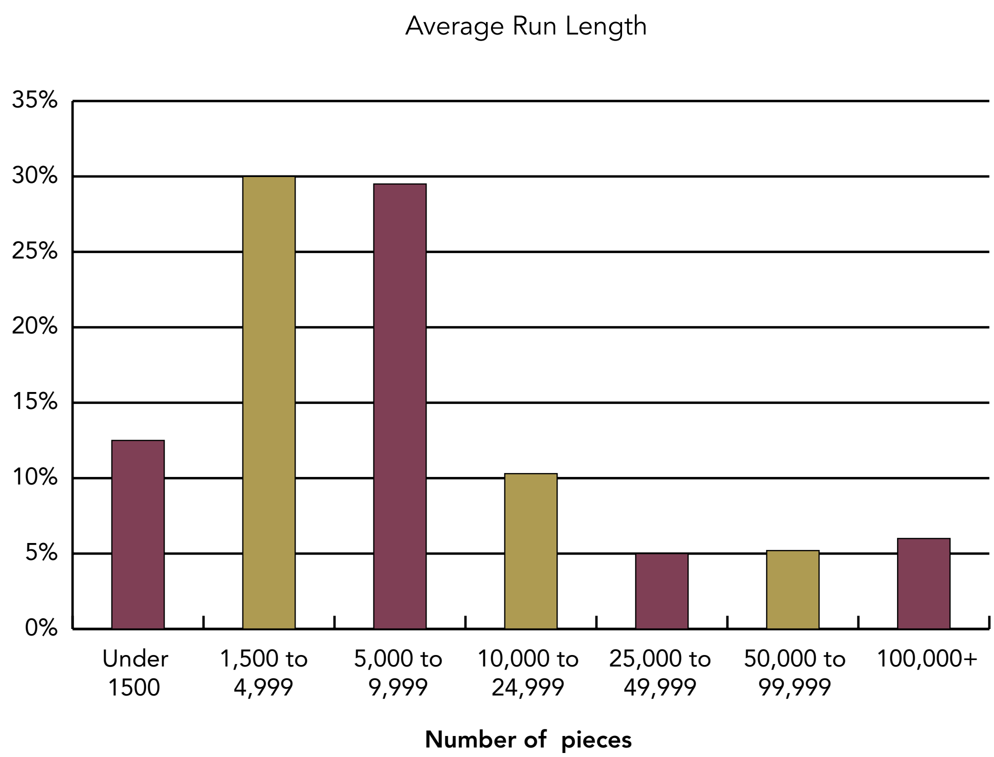
Reduced overproduction by improving yields at each step of the process proved to be the most worthwhile measure overall for both smaller and larger companies. All of these measures received mean ratings between moderately important and very important by small and large companies alike.

1d. On average, what percentage of jobs in your plant need to be expedited to meet delivery deadlines?

Percentage of Jobs	Percent
0-5%	14.8%
6-10%	19.6%
11-20%	26.5%
21-30%	17.7%
Over 30%	21.4%
Mean	21.9%

The mean value is 21.9%, with a standard deviation of 16.3%. Nearly 40% of respondents reported that more than 20% of their jobs are expedited. Differences between responses to this question by smaller and larger companies are not statistically significant.

1e. What is your average run length?



Company Size	Under 1,500	1,500-4,999	5,000-9,999	10,000-24,999	25,000-49,999	50,000-99,999	100,000+
Under 50 employees	19.6%	42.9%	28.6%	3.6%	0%	1.8%	3.6%
50+ employees	4.7%	16.3%	30.2%	16.3%	9.3%	11.6%	11.6%

Overall, close to 60% of runs fall between 1,500 and 9,999 pieces. Larger companies generally reported greater average run lengths than smaller ones. The demand for shorter runs is encouraged by the improved ability of the industry to comply. The reduction of setup costs is the primary reason why the industry is able to comply. Print buyers have always wanted to get as close to the print-on-demand ideal as they could. Having to maintain inventories of finished goods has always been the bane of the print buyer's existence. In the past, the economies of scale offered by long runs and the relatively long lifespan of printed products made this the lesser of two evils. The relative contribution of machine setup to cost has been steadily rising as average run lengths have declined. The reduction of machine setup times is the most tangible selling point for JDF initially. Time-consuming setups have always been one of the prime contributors of non value-added activity in a manufacturing operation.

From this perspective, CIM can be clearly seen as an important technology to the future of the industry. Print buyers have always wanted what CIM promises to deliver. Only by integrating and automating the production process to eliminate the setup costs that dictate the practical lower limits to short run jobs can companies deliver on this promise.

Question 2. How does current industry practice compare with best practice?

2a. Does your organization have a Chief Information Officer for managing all of your information systems?

Sixty-three percent of firms reported that they do not have a chief information officer (37% indicated they do have a CIO). There is a statistically significant difference between smaller and larger companies: 22.8% of small companies report having a CIO versus 58.1% of companies with 50 or more employees.

2b. Which of the following computer-based systems does your company employ?

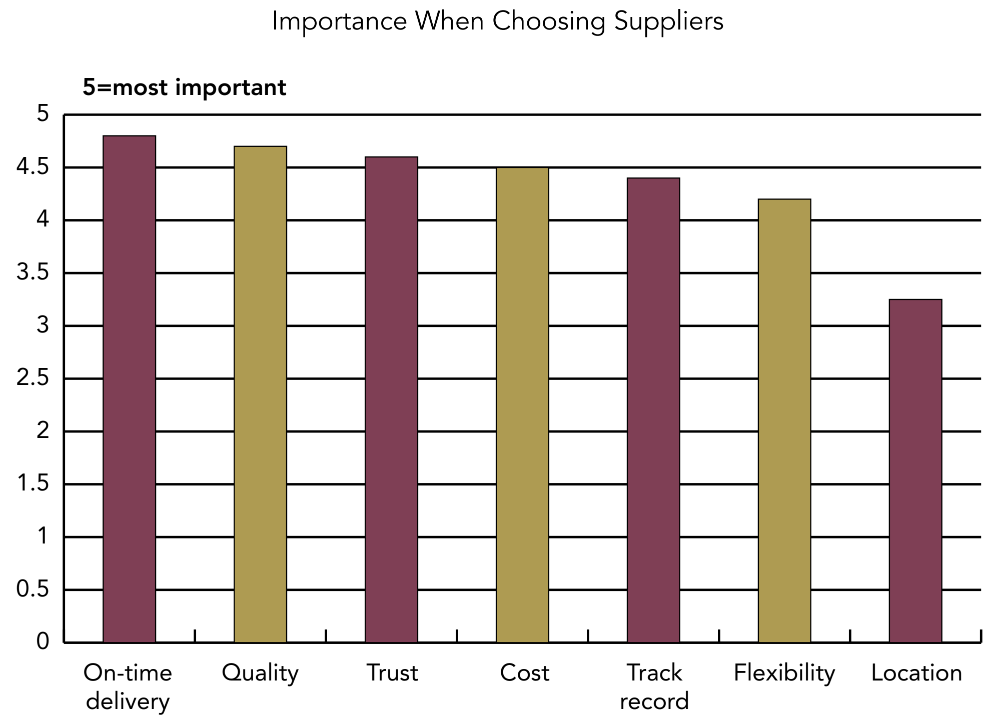
Category	Percent	Under 50 employees	50+ employees
MIS	59.1%	50.0%	86.0%
Scheduling	46.1%	40.0%	65.1%
Production planning	44.3%	38.3%	62.8%
Real-time production monitoring	36.5%	21.7%	62.8%
Internet-based order entry	28.7%		
ERP	10.4%	5.0%	18.6%

Overall, the only computer-based system that is used by the majority of respondents is an MIS system. Larger companies generally employ more computer-based systems and the differences between smaller and larger companies are statistically significant for all systems except Internet-based order entry. The greatest statistical variance between larger and smaller printers is in the use of computerized production planning systems.

2c. Does your company have ISO 9001:2000 certification?

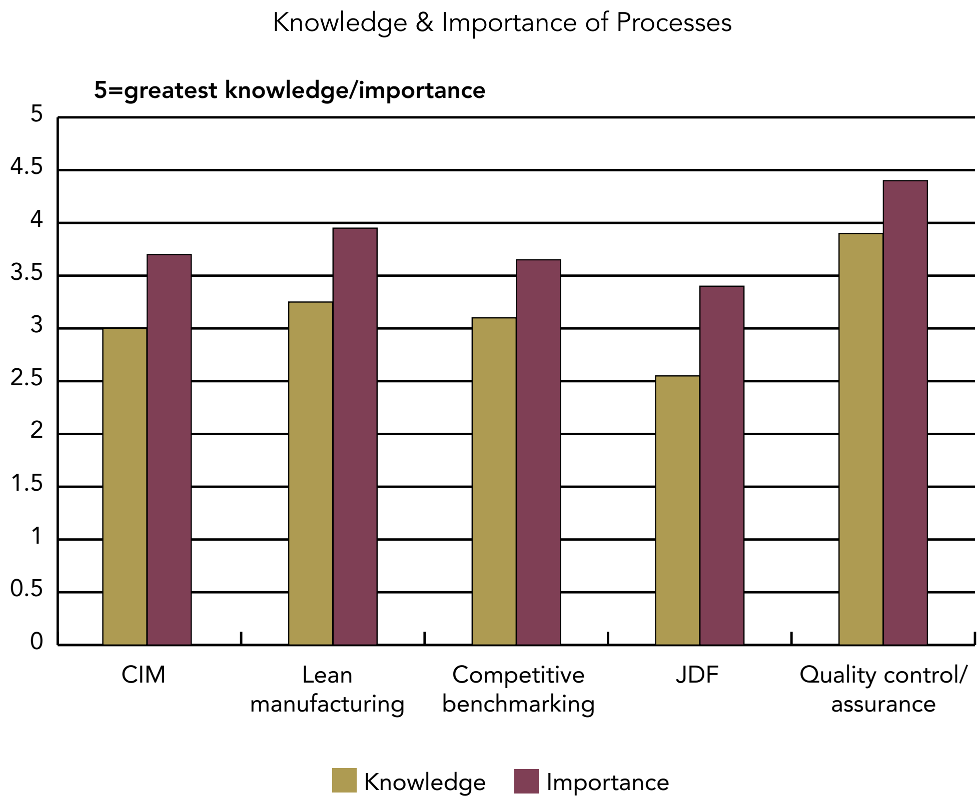
Most companies do not have ISO certification (81% indicated “No”; 19% indicated “Yes”). A much greater percentage of larger companies have gained certification (33.3% versus 7.0%).

2d. When considering suppliers, how important are the following factors?



On-time delivery and quality are the most important factors to both groups. Location is the least important factor.

2e. Rate all of the following items and concepts in terms of your management team's level of knowledge and how important they are to the future profitability of your business.



In every instance, companies ranked their knowledge below how important they believe the respective measure to be. Very little variance was seen between the responses of smaller and larger companies. The survey respondents know most about quality control/assurance, and they believe that it is the most important of the five factors to future profitability. This is not surprising. Quality is the one factor that their customers see. The four other factors are internal to the manufacturing operation and are hidden from customers. For all five factors, a need for more knowledge is indicated based on the gap between what they know and how important they believe each factor to be to future profitability.

2f. How often do you measure/monitor the following in your plant?

To Measure	Never	Monthly	Weekly	Daily	Per job
Paper waste	15.0%	22.0%	6.0%	6.0%	51%
On-time delivery	10.9%	18.8%	10.9%	23.8%	35.6%
Plate remakes	12.0%	23.0%	5.0%	17.0%	43.0%
Press productivity	7.1%	27.3%	16.2%	21.2%	28.3%
Ink waste	47.5%	17.8%	10.9%	4.0%	19.8%
Value of total plant inventory	11.6%	74.7%	7.4%	6.3%	0%

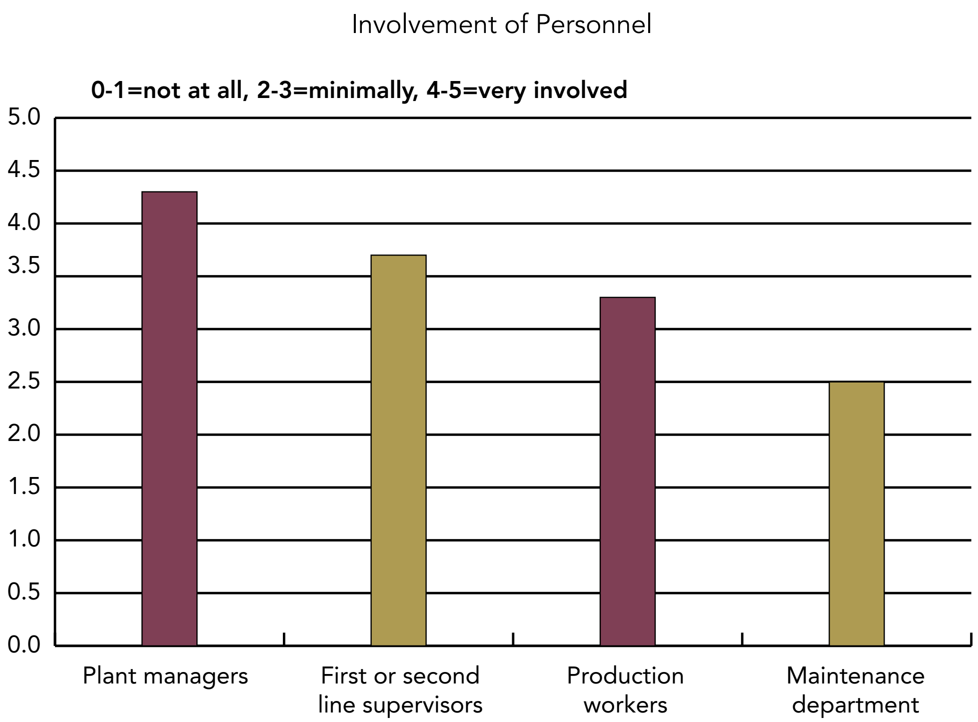
There were some differences between the segments. Paper waste is monitored most intensely by larger companies. Smaller companies gave the most attention to on-time delivery, which ranked third for larger companies. On the whole, larger companies monitored all of the categories aside from on-time delivery more closely. However, the results between smaller and larger firms revealed no statistically significant difference.

2g. Approximately what percent of your production employees have had formal training in the following areas?

	None	Some	Most	All
Statistical process control	49.5%	44.8%	2.9%	2.9%
Under 50 employees	67.2%	29.3%	3.4%	0%
50+ employees	27.9%	65.1%	0%	7.0%
Quality assurance	26.7%	41.0%	20.0%	12.4%
Root-cause analysis	50.0%	37.3%	8.8%	3.9%

Only a few companies train most of their employees on any of the key measures. Larger companies train a greater percentage of employees overall. Quality assurance was highest area of training overall. When comparing firm size, the differences are only significant for statistical process control.

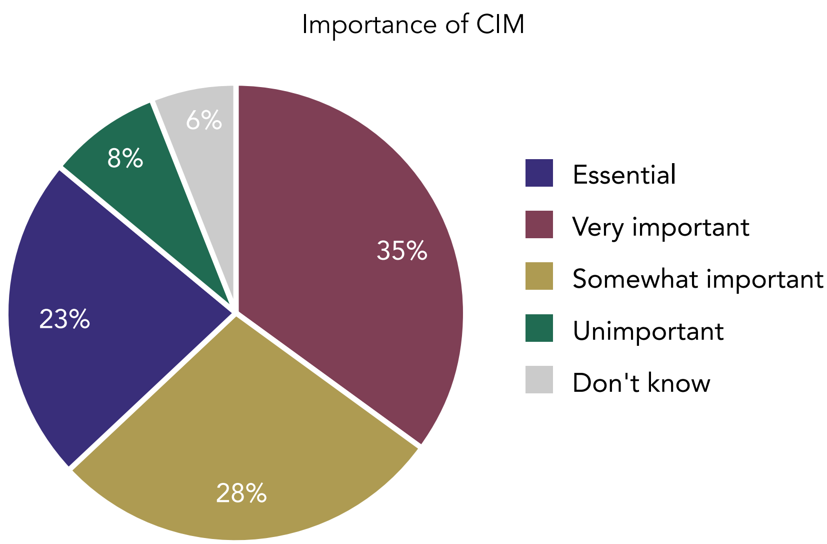
2h. How involved are the following groups/personnel in redesigning workflows to achieve higher productivity?



Overall, plant managers and first/second line supervisors were the most involved. Both segments followed an identical order. Plant managers were involved at an especially high level with larger companies, while production workers were more involved at smaller companies.

Question 3. How do managers perceive the promise of new technology and management approaches to solving these problems?

3a. How important do you believe CIM will be to the future profitability of your business?



Company Size	Not important	Somewhat important	Very important	Essential	Don't know
Under 50 employees	12.1%	32.8%	36.2%	13.8%	5.2%
50+ employees	2.3%	25.6%	32.6%	30.2%	9.3%

We defined CIM for our panel as follows: The Society of Manufacturing Engineers defines Computer Integrated Manufacturing (CIM) as "the integration of the total manufacturing enterprise through the use of integrated systems and data communications coupled with new managerial philosophies that improve organizational and personnel efficiency." Over half of respondents reported that CIM is either essential or very important. Once again, we see that larger companies assign more importance to breakthrough technologies such as CIM. A combined 62.8% of companies with 50+ employees felt CIM would be very important or essential, while only 50% of small companies shared the same viewpoint. The differences between responses of smaller and larger companies are marginally significant.

3b. How important are each of the following to the future of your business?
Responses to this question ranged from 1 to 5, with a "1" indicating "not important" and a "5" indicating "very important."

Importance of improvement	Mean Score
Improved sales access to competitive pricing information	4.4
Improved prepress access to customer image assets	4.2
Improved sales access to scheduling information	4.2
Improved sales access to pricing information	4.2
Improved estimating access to supplier information	4.1
Improved sales access to production capabilities	4.1
Automated equipment setup enabled by CIM technologies and standards	4.0
Improved ales access to competitive production capabilities	4.0
Improved production planning access to suppliers information	4.0
Improved customer service access to sales agreements	3.9
Improved customer access to production capabilities	3.8
Improved customer access to scheduling information	3.5
Improved customer access to pricing information	3.4

Improvements relevant to sales proved to be most important overall. Four of the top six rated categories of information improvement involve obtaining better information for the sales force. The most desired information improvement is in the area of competitive pricing. Improved sales access to competitive production capabilities also had the greatest level of variance between small and large companies, with small companies believing that it is significantly more important to their business. Smaller companies also ranked improved sales access to production capabilities higher than larger companies, while larger companies valued improved prepress access to customer image assets significantly more than smaller companies. This is an important finding. Smaller firms place a higher value on improved intelligence about competitors than larger firms do. This is an indication that smaller firms feel themselves under greater competitive pressure than larger firms.

All of the 13 improvements suggested in the question received a rating of 3.4 or higher. All but one of the suggested improvements support improved decision-making within the company and among the company's customers. The respondents believe that automated equipment setup will also be an important improvement, giving it a rating above 4.

3c. Do you have an established goal for cost reductions for the future?

Most companies do not have cost reduction goals (56% indicated "No"; 44% indicated "Yes"). 65.1% of larger companies have established cost reduction goals, as opposed to 25.0% of smaller companies.

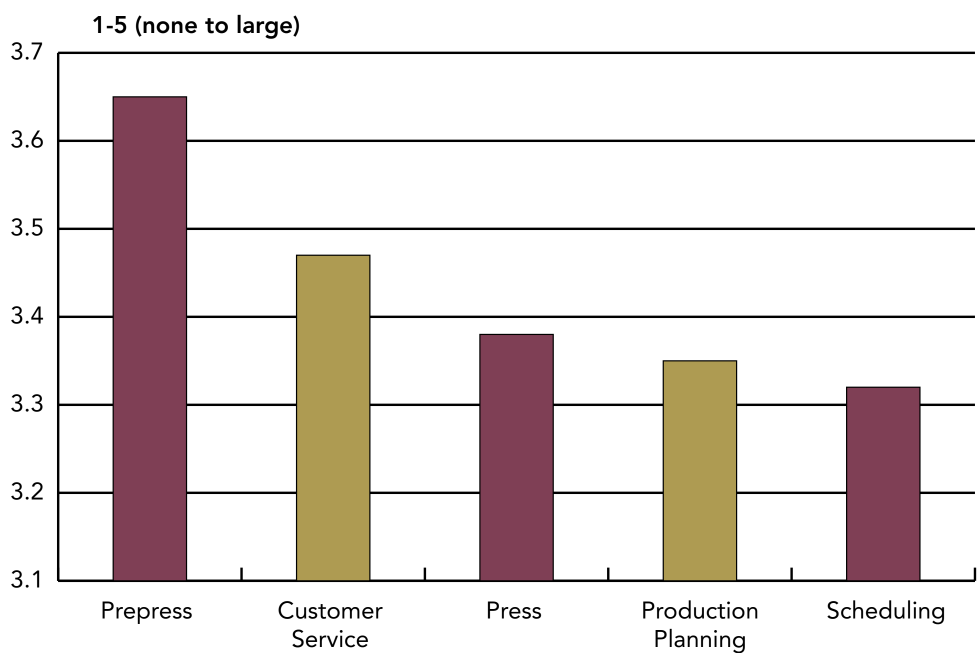
If so, what is your cost reduction goal for the next year?

Mean Value	8.3%
Standard Deviation	5.4%

Cost reduction goals ranged from 0 to 20 percent with three distinct modes at 5%, 10%, and 15%. The standard deviation is 5.4%. There is not a statistically significant difference between the goal size reported by small companies and large companies.

3d. What do you believe is the magnitude of the opportunity for improved efficiencies in the following areas in your plant? (Responses ranged from 1 to 5, indicating "no opportunity" to "large opportunity").

Magnitude of Opportunity for Improved Efficiencies



Both larger and smaller companies believe that prepress presents the greatest opportunity for improved efficiencies and the differences between the responses of smaller and larger companies to this question are marginally significant. Smaller companies see slightly more opportunity in prepress and larger companies see slightly more opportunity in finishing.

3e. How important will the acquisition of new technologies be in helping your company improve operating efficiencies?

Response	Percent
Not Important	1.0%
Not That Important	9.6%
Somewhat Important	36.5%
Very Important	52.9%

Most respondents (89.4%) felt that the acquisition of new technologies will be either somewhat or very important. Larger companies are somewhat more likely to put emphasis on the acquisition of new technologies. The difference in responses between larger and smaller companies is not, however, statistically significant.

3f. How important will changes in management practice be in helping your company improve operating efficiencies?

Response	Percent
Not Important	1.9%
Not That Important	5.8%
Somewhat Important	41.3%
Very Important	51.0%

Small and large companies alike believe that this is an important issue. 95.3% of those in larger companies believe that changes in management practices are either “somewhat important” or “very important.”

The responses to the two previous questions indicate that the majority of large and small companies believe that new technology and smarter management will contribute to improved operating efficiencies in the future.

3g. During the past three years, which of the following measures has your company taken to increase productivity?

Response	Percent
Better organization of the workplace	78.5%
Reduced material waste	70.1%
Reduced inventories	55.1%
Better matching of throughputs/production processes	51.1%
Reduced processing steps	50.5%
Improved yields at each step	34.6%

Better organization of the workplace and the reduction of material waste are the most frequent measures taken. Larger companies have put a greater effort into reducing material waste than smaller firms (86% versus 58%). The most frequent measure taken by both smaller and larger companies has been "increasing the productivity of employees through better organization of the workplace."

3h. Rate the importance of the following improvements to the future of your business (5 is very important, 1 is not important).

Improvement	Mean Response
Reduce costs	4.6
Improve accuracy & timeliness of communication with customers	4.3
Develop innovative products & services	4.3
Shorten lead times & increase on-time delivery	4.2
Improve product quality	4.0

Reducing costs rated highest among both smaller and larger groups. Improving the accuracy and timeliness of communication with customers ranked second for smaller companies, while developing innovative products and services placed second for larger companies. The differences between the responses of smaller and larger companies to this question are not statistically significant.

Discussion

SUMMARY OF FINDINGS

The analysis of the results of our survey reveals a number of key findings in three areas of inquiry:

1. Current problems facing the industry:

- Delays due to lack of information are experienced throughout the production process, but the percentage of jobs delayed decreases steadily as work moves downstream. On average, the chance that a job will be delayed somewhere in this process is greater than 60% for both smaller and larger companies in the survey.

- The majority of firms of all sizes claim that there is some redundancy within their information systems.

- Firms of all sizes have realized the greatest increases in productivity during the past three years by improving production yields at each step in the process. The least significant cost reductions are due to reductions in plant inventories.

- More than 20% of jobs overall need to be expedited to meet delivery deadlines.

- The majority of firms report average run lengths below 10,000 pieces. For smaller firms, 43% of jobs fall between 1,500 and 4,999 pieces. For larger firms, 30% of jobs fall between 5,000 and 9,000 pieces.

2. Current industry practice versus best practice:

- Less than 25% of smaller firms have a chief information officer, whereas nearly 60% of larger firms do.

- The most common computer-based systems among firms of all sizes are management information systems and scheduling systems. Very few (5%) of smaller firms and less than 20% of larger firms have ERP systems.

- Approximately 7% of smaller firms and 33% of larger firms have achieved ISO certification.

- On-time delivery is the most important factor to choice of suppliers. Location is least important.

- Firms of all sizes believe that there is a gap between what they know about CIM, lean manufacturing, competitive benchmarking, quality control/assurance, and specific technologies like JDF, and the importance of these factors to their future profitability.

- Larger firms place a greater emphasis on measurement and monitoring of waste and smaller firms place a greater emphasis on monitoring of on-time delivery.

3. Perceptions of the promise of new technology and management strategies:

- More than 80% of smaller firms and nearly 90% of larger firms acknowledge the importance of CIM to their future profitability. More than 60% of larger firms believe that CIM is very important or essential to their future.

- Firms of all sizes place a high value on improved information for the sales force.

- Smaller firms are more interested in improved information about competitive pricing and capabilities than larger firms.

- Only 25% of smaller firms have established cost reduction goals. More than 65% of larger firms have.

- Prepress is seen as the area of greatest opportunity for cost reduction in the future.

- Firms of all sizes believe that both new technology and smarter management will contribute to improved operating efficiencies in the future.

- Cost reductions are the most important future improvement sought by firms of all sizes.

WE KNOW CIM IS IMPORTANT, BUT HOW DO WE GET THERE?

The companies who responded to the survey understand the importance of CIM in its broadest definition to the future of their businesses. However, they don't have a clearly defined approach to implementation. They place a high degree of confidence in new technology, but also realize that technology alone is not sufficient. Integrated manufacturing systems must be designed and built by people who have a solid understanding of the capabilities of the various available technologies and a clear vision for what they want to enable their companies to do. Respondents stated that they do not know as much as the need to know about the tools and techniques for implementing CIM.

One of the most important principles repeated throughout the CIM literature is the need to simplify a process before attempting to integrate and automate it. This presents a challenge to general commercial printing companies that attempt to serve the diverse and expanding needs of a large customer base. This problem is further exacerbated by the imperative for print communications to be aggressively innovative. Differentiation is considered by designers to be one of the keys to improving the power of the pieces they design. Format, texture, folding geometry, and finishing options are all important variables to the effectiveness of the final product. For these reasons, general commercial printing still involves a significant amount of craftwork (creative work) that is difficult to imagine automating.

THE INDUSTRY AT THE CROSSROADS: IMPLICATIONS OF FINDINGS

Many companies, especially smaller companies, are struggling to reconcile two critical needs that are equally important to their long-term prosperity but that often work against one another. They must offer their customers continuously improving and innovative services while simultaneously improving the efficiencies of the underlying manufacturing operations. It is relatively easy to place the prime emphasis on one of these two efforts, and let the other side of the business follow.

If a company places the prime emphasis on service and neglects to take a disciplined approach to improving manufacturing efficiencies, the business will not be sustainable long term. In our interviews with managers of printing companies, we often hear a variation on a common theme expressed by the owner of one particular company: "We do anything and everything necessary to take care of our customers." In this particular case, the manufacturing operation reflects this service-at-all-costs philosophy. The factory is organized with large buffers in front of and behind all of the major manufacturing operations. The workforce is conditioned to respond to quick changes in the production schedule that reflect the frequent need to expedite work for customers who have come to rely on the company to make up for shortfalls due to their own poor planning processes. The scheduling board shows a lot of back-and-forth movement over time as jobs jockey for position in the queues.

A lot of effort is expended in the plant re-arranging queues of work in progress. The values of inventories relative to sales volumes in the plant have been rising slowly.

This company realizes that in addition to its commitment to service, it must also strive to continuously improve its manufacturing efficiencies. It has embarked on a lean manufacturing program intended to systematically improve the efficiencies of its manufacturing operations. The prime motivator for this company is the knowledge that long-term pricing trends for the commodity products that it manufactures are negative, and that if costs are not reduced at the same or better rate, margins will decline and the business will not survive.

The lean manufacturing approach to continuous improvement of manufacturing efficiencies has the advantage of being applicable to companies of any size from the smallest to the largest. Lean provides a set of mechanisms for analysis and action that are rooted in common sense.

Although the smaller companies in our survey indicated by their responses that they were less likely to take a comprehensive approach to manufacturing cost reduction than the larger companies, they still stand to benefit immensely from a working knowledge of how lean manufacturing practices can be put to work in a print-manufacturing context.

Because of the way the suppliers are rolling out CIM technology, small companies that seek to increase efficiencies by reducing the amount of time spent setting up machines and re-keying information will be able to buy pieces of CIM a-la carte.

The primary challenge for the industry is to relentlessly seek to improve the efficiencies of manufacturing and distribution and to disengage the services offered to customers from the exigencies of their manufacturing processes. Large companies have the resources and the special knowledge needed to launch and sustain process re-engineering efforts that will eventually yield results such as those demonstrated at Roanoke. Smaller commercial printing companies servicing narrower geographic areas offering a greater diversity of products and services with more generalized manufacturing facilities will not follow the same path.

It is more likely that these companies will take a less coordinated approach to improving productivity. They will acquire new equipment piece by piece, justifying each investment individually. They will expect these investments to integrate with other capital equipment that they already have or plan to acquire in the future. Since many of the smallest companies do not have an articulated business strategy or established goals for future cost reductions, they rely heavily on management intuition to guide their investments. Most of these decisions appear to be inspired by a desire to offer better services to their customers rather than to lower the costs of manufacturing.

One saving grace for smaller companies has been the significant cost savings that new front-end technology has been delivering over the past decade. Replacing a traditional film-based workflow with a CTP workflow has dramatically reduced the labor required to prepare (produce the tooling for) a given unit of work. These savings are partially counteracted by demand pressures that push relentlessly for shorter runs at lower prices.

Although not a subject of this paper, another factor that may advantage some smaller companies is the absence of labor organization. This has enabled small non-union companies to more easily re-deploy the workforce to optimize the efficiencies of the new workflows.

Meanwhile, Outside the Storm Rages

Imagine that ten years have passed, and we are looking back at the past decade from the year 2013. It is probable that digitization, data interchange standards, the Internet, and globalization will have precipitated such a radical restructuring of the industry that we will not believe that it once could have been as it is today. We can see the evidence all around us that this is what is happening.

The same technological foundation that enables integration and automation of manufacturing operations also enables globalization. Before the digital age, printing companies primarily served local markets. The elimination of the need for face-to-face contact and place-to-place transportation of physical assets neutralize the gravitational forces that have kept the industry local for half a millennium. Today, digital work uploaded to a network server in New York can be picked up moments later in Hong Kong. Large companies such as R. R. Donnelley are moving aggressively to globalize their operations. For the most part they are accomplishing this by building their own facilities in Asia, Latin America, the Caribbean, and other places where labor is inexpensive.

Digitization, data interchange standards, and the Internet enable the separation of business and manufacturing processes that traditionally have been performed by single companies often organized under one roof. This is no longer necessary. With unambiguous interfaces enabled by digital technology and universal data interchange standards such as PDF and JDF, work can easily pass among organizations that each add specialized value to the final product/service.

How exactly this will ultimately play out over the next decade is beyond the scope of this paper. However, it is not difficult to spot some clear trends and predict some eventualities that these trends imply.

First, it is likely that the trend toward offshoring of business processes that is underway in other businesses, and in the largest commercial printing companies, will begin to look attractive to smaller companies as the services become more accessible, reliable, and secure. Today, only large companies can afford the investments required to gain access to inexpensive services in India and elsewhere. But as the overseas service providers gain experience and learn how to package and market themselves to smaller US players, the overheads will come down and US companies will be able to buy these services "off the shelf."

Thus it is not difficult to envision a future where many business process functions currently performed in house will be sent offshore. In ten years time it is unlikely that this will be thought of as "sending work offshore." Rather, we will simply think of it as passing the work through filters that are available on our desktops. The actual work may take place in Madras or in Kansas City. It won't matter.

Although the technology for globalization is accessible to all companies regardless of size, the cultural barriers are formidable for smaller companies that do not have the resources to build their own facilities overseas. In the next few years we expect to see services arise that will enable smaller companies to globalize without leaving home. This is already happening with many general business services employed by companies of all sizes.[3] The trend will continue with specialized services designed to serve the needs of print service providers. These will include such labor-intensive operations as database creation and maintenance, preflighting, proofreading, and print production.

As for manufacturing, PDF/JDF file sets can be sent anywhere. Today, there is a strong incentive to move manufacturing to places like China where the lower labor costs dramatically impact the final price. Companies like Phoenix Color currently sell printing in the US market and have it manufactured by partner companies in Hong Kong and China. The quality of the work is as good as the best commercial printing in the US.

In the next decade the rising cost of labor in China and other developing countries combined with the greater efficiencies enabled by CIM technology will reduce the cost differentials that currently favor overseas manufacturing. However, regardless of where in the world the manufacturing takes place, the perfect storm of digitization, data interchange standards, the Internet, and globalization, will transform print production into a fungible commodity on a global scale. All the printing contest awards in the world will not stop this trend.

The manufacturing companies that will have the best competitive position in this new economic order will be large and multinational. Smaller companies will need to concentrate their efforts on building innovative and comprehensive services that leverage off-the-shelf digital technology, and cultivating new business relationships where face-to-face contact with customers is a critical piece of the value proposition. We predict that many of the smaller companies will move upstream in the process to capture more of the creative end of the value stream for themselves. Technology-based barriers that made this kind of movement difficult in the past are disappearing. These companies will become increasingly dependent on external services and manufacturing capabilities enabled by digital technology and globalization. They will finally escape the limitations imposed on their ability to offer the most creative and valuable solutions to their customers by the relentless imperative to keep the cylinders turning.

[3] An excellent working paper on the growing trend toward offshoring of services is *Went for Cost, Stayed for Quality?: Moving the Back Office to India*, by Rafiq Dossani and Martin Kenney (Dossani and Kenney, 2003). The Alfred P. Sloan Foundation provides funding for this work. A PDF of the working paper is available for review from the Printing Industry Center.

References

Anupindi, R., Chopra, S., Deshmukh, S. D., Van Mieghem, J. A., & Zemel, E. (1999). *Managing business process flows*. Upper Saddle River, NJ: Prentice Hall.

Bylinski, G. (2003, September 1). Elite factories: Two of America's best have found new life using digital tech. *Fortune*, 148(4), 154-159.

CIP4. (2000, March 14). *Job definition format: An open, multi-vendor solution*. Retrieved November 13, 2003, from http://www.cip4.org/documents/jdf_overview/jdf_wp.pdf

Cost, F. (2002). *Design to production: The critical interface*. Rochester, NY: RIT Printing Industry Center.

Goldratt, E. M. (1990). *The theory of constraints*. Croton-on-Hudson, NY: North River Press.

Moore, G. E. (1965, April 19). Cramming more components onto integrated circuits. *Electronics,138*, 114-117.

Moszkowicz, G. (2002, August 1). *Measurable change: Harnessing the power of six sigma in a logistics environment*. Retrieved November 13, 2003 from http://www.donnelleylogistics.com/articles/RRD-101.pdf

Rehg, J. A., & Kraebber, H. W. (2000). *Computer- integrated manufacturing* (2nd ed.). Upper Saddle River, NJ: Prentice Hall.

Romano, F. J. (2003). *An investigation into printing industry demographics*. Rochester, NY: RIT Printing Industry Center.

Rother, M., & Shook, J. (1999). *Learning to see: Value stream mapping to create value and eliminate muda*. Brookline, MA: The Lean Enterprise Institute.

Thacker, R. M., & King, R. E. (Ed.). (1989). *A new CIM model: A blueprint for the computer integrated manufacturing enterprise*. Dearborn, MI: Society of Manufacturing Engineers.

Turbide, D. A. (1991). *Computers in manufacturing*. New York, NY: Industrial Press, Inc.

VICG. (2003). *PDF study*. Turnhout, Belgium: The Flemish Innovation Center for Graphic Communications.

Womack, J. P., & Jones, T. D. (2003). *Lean thinking: Banish waste and create wealth in your corporation* (2nd ed.). Free Press.

Appendix

A survey of the Printing Industry Center at RIT Research Affiliates (printer panel) was conducted in Summer 2003. The table below reports the summary data for all respondents. The responses are listed in the order in which they were asked, with the valid results reported. The results are broken into two additional groups, with "small companies" indicating those with under 50 employees, and "large companies" involving those with 50 or more employees. Out of 107 respondents, 103 indicated their company size, with 60 firms having fewer than 50 employees. In the large and small company columns, the results highlighted have a significance of p=.10 or better.

Appendix

Questions	Total n=107	Small companies n=60	Large companies n=43
1. Does your company have a Chief Financial Office responsible for managing all of your information?			
Yes	37.0%	22.8%	58.1%
No	63.0%	77.2%	41.9%
2. The Society of Manufacturing Engineers defines Computer Integrated Manufacturing (CIM) as "the integration of the total manufacturing enterprise through the use of integrated systems and data communications coupled with new managerial philosophies that improve organizational and personal efficiency." How important do you believe CIM will be to the future profitability of your business?			
Essential	20.8%	13.8%	30.2%
Very important	34.7%	36.2%	32.6%
Somewhat important	29.7%	32.8%	25.6%
Unimportant	7.9%	12.1%	2.3%
Don't know	6.9%	5.2%	9.3%
3. How important are each of the following to your business? (Scale: 1-5, 5 indicates the highest importance)			
Improved customer access to pricing information	3.41	3.42	3.38
Improved customer access to scheduling information	3.45	3.37	3.53
Improved customer access to production capabilities	3.83	3.80	3.91
Improved sales access to pricing information	4.19	4.18	4.20
Improved sales access to scheduling information	4.21	4.24	4.16
Improved sales access to production capabilities	4.08	4.15	3.90
Improved sales access to competitive pricing information	4.41	4.47	4.28
Improved sales access to competitive production capabilities	3.98	4.17	3.77
Improved customer service access to sales agreements	3.86	3.80	3.91
Improved estimating access to suppliers information	4.11	4.03	4.21
Improved production planning access to suppliers information	3.95	3.85	4.09
Improved prepress access to customer image assets	4.22	4.11	4.29
Automated equipment setup enabled by CIM technologies and standards such as JDF	4.04	4.11	3.98

Questions	Total n=107	Small companies n=60	Large companies n=43
4. What percent of jobs produced by your company are delayed in the following departments because of missing or wrong information originating at other points in the operation?			
Sales	13.8%	12.4%	14.4%
Customer service department	11.8%	10.9%	12.4%
Production planning/scheduling	10.1%	10.0%	10.3%
Prepress department	13.6%	12.9%	10.4%
Press department	5.8%	6.3%	4.9%
Bindery and finishing	5.0%	5.4%	4.5%
Shipping department	6.2%	4.9%	7.7%
5. Which of the following computer-based systems does your company employ? (Percent yes)			
Production planning system	44.3%	38.3%	62.8%
Scheduling system	46.1%	40.0%	65.1%
Real-time production monitoring system	36.5%	21.7%	62.8%
Management information system	59.1%	50.0%	86.0%
Enterprise resource planning (ERP) system	10.4%	5.0%	18.6%
Internet-based order entry system	28.7%	26.7%	34.9%
6. Redundant information is defined as the same information that resides in more than one location in your computer systems. How would you characterize your information systems?			
We have a single centralized database serving all of our systems with little or no redundancy	38.6%	42.9%	35.3%
We have some redundant information residing in two or more unconnected databases	51.8%	46.9%	55.9%
Most of our computer systems are not connected and much of our information is redundant	6.0%	8.2%	2.9%
Most of our computer systems are not connected and very little of our information is redundant	3.6%	2.0%	5.9%
7. Does your company have ISO 9001:2000 certification?			
Yes	19.0%	7.0%	33.3%
No	81.0%	93.0%	66.7%

Questions	Total n=107	Small companies n=60	Large companies n=43
8. Do you have an established cost reduction goal for the future?			
Yes	44.0%	25.0%	65.1%
No	56.0%	75.0%	34.9%
9. If so, what is your cost reduction goal for next year?			
Mean value	8.3%	8.7%	8.1%
10. What do you believe is the magnitude of the opportunity for improved efficiencies in the following areas in your plant? (Scale: 1-5, none to large)			
Customer service	3.47	3.59	3.33
Production planning	3.36	3.46	3.26
Scheduling	3.33	3.33	3.34
Prepress	3.65	3.72	3.53
Press	3.38	3.38	3.37
Finishing	3.39	3.33	3.47
11. How important will the acquisition of new technologies be in helping your company improve operating efficiencies?			
Very important	52.9%	52.1%	53.9%
Somewhat important	36.5%	34.4%	39.5%
Not that important	9.6%	11.9%	7.0%
Not important	1.0%	1.7%	0%
12. How important will changes in management practice be in helping your company improve operation efficiencies?			
Very important	51.0%	44.4%	53.8%
Somewhat important	41.3%	45.8%	39.5%
Not that important	5.8%	9.2%	2.3%
Not important	1.9%	1.7%	2.2%
13. During the past three years, which of the following measures have your company taken to increase productivity? (check all that apply)			
Increase the productivity of employees through better organization of the workplace	78.5%	76.7%	81.4%
Reduce or eliminate machine downtime or worker idleness by better matching the throughputs of production processes	51.1%	46.7%	58.1%

Questions	Total n=107	Small companies n=60	Large companies n=43
Reduce overproduction by improving yields at each step of the process	34.6%	30.0%	41.9%
Simplify production of printed products by reducing the number of processing steps	50.5%	50.0%	51.2%
Reduce material waste	70.1%	58.3%	86.0%
Reduce the value of inventories throughout the plant	55.1%	51.7%	60.5%
14. To what extent did these activities actually contribute to increased productivity? (Scale 1-5, 5 indicates the greatest contribution)			
Increase the productivity of employees through better organization of the workplace	3.51	3.61	3.36
Reduce or eliminate machine downtime or worker idleness by better matching the throughputs of production processes	3.45	3.59	3.23
Reduce overproduction by improving yields at each step of the process	3.68	3.63	3.76
Simplify production of printed products by reducing the number of processing steps	3.35	3.41	3.24
Reduce material waste	3.40	3.36	3.43
Reduce the value of inventories throughout the plant	3.33	3.18	3.46
15. On average, what percentage of jobs are expedited or "jump the schedule" to meet delivery deadlines?			
Mean percentage	21.9%	21.7%	22.2%
16. When considering your choice of suppliers, how important are the following factors? (Scale: 1-5, 5 indicates the highest importance)			
Cost	4.46	4.48	4.44
Quality	4.78	4.78	4.79
On-time delivery	4.82	4.79	4.84
Track record	4.45	4.38	4.51
Location	3.27	3.25	3.29
Flexibility	4.18	4.05	4.28
Trust	4.63	4.57	4.70
17. Rate the importance of the following improvements to the future of your business (Scale: 1-5, 5 indicates "very important")			
Shorten lead times and improve on-time delivery	4.20	4.15	4.24
Improve product quality	4.04	4.04	4.04

Questions	Total n=107	Small companies n=60	Large companies n=43
Improve accuracy and timeliness of communication with our customers	4.31	4.33	4.28
Reduce costs	4.63	4.59	4.67
Develop innovative products and services	4.26	4.11	4.42
18. Rate all of the following terms and concepts in terms of your management team's level of knowledge and how important they are to your future profitability of your business. (Scale: 1-5, 5 indicates the highest level of knowledge or importance)			
Knowledge			
Computer integrated manufacturing	3.01	2.98	3.05
Lean manufacturing	3.25	3.14	3.43
Competitive benchmarking	3.13	3.07	3.27
Job Definition Format (JDF)	2.58	2.35	2.83
Quality control/assurance	3.88	3.73	4.07
Importance			
Computer integrated manufacturing	3.69	3.49	3.91
Lean manufacturing	3.94	3.69	4.21
Competitive benchmarking	3.71	3.62	3.95
Job Definition Format (JDF)	3.32	3.11	3.54
Quality control/assurance	4.39	4.36	4.42
19. How often do you measure/monitor the following in your plant?			
Paper waste			
Per job	51.0%	45.6%	58.1%
Daily	6.0%	5.3%	7.0%
Weekly	6.0%	7.0%	4.7%
Monthly	22.0%	20.9%	22.8%
Never	15.0%	19.3%	9.3%

Questions	Total n=107	Small companies n=60	Large companies n=43
Ink waste			
Per job	19.8%	13.8%	27.9%
Daily	4.0%	3.4%	4.7%
Weekly	10.9%	8.6%	14.0%
Monthly	17.8%	17.2%	18.6%
Never	47.5%	56.9%	34.9%
Plate remakes			
Per job	43.0%	38.6%	48.8%
Daily	17.0%	17.5%	16.3%
Weekly	5.0%	3.5%	7.0%
Monthly	23.0%	24.6%	20.9%
Never	12.0%	15.8%	7.0%
Press productivity			
Per job	28.3%	26.8%	30.2%
Daily	21.2%	21.4%	20.9%
Weekly	16.2%	14.3%	18.6%
Monthly	27.3%	30.4%	23.3%
Never	7.1%	7.0%	7.1%
On-time delivery			
Per job	35.6%	39.7%	30.2%
Daily	23.8%	20.7%	27.9%
Weekly	10.9%	10.3%	11.6%
Monthly	18.8%	17.2%	20.9%
Never	10.9%	12.1%	9.3%

Questions	Total n=107	Small companies n=60	Large companies n=43
Value of total plant inventory			
Per job	0%	0%	0%
Daily	6.3%	7.3%	5.0%
Weekly	7.4%	3.6%	12.5%
Monthly	74.7%	69.1%	82.5%
Never	11.6%	20.0%	0%
20. What is your average run length?			
Under 5,000 pieces	42.7%	62.5%	21.0%
5,000 to 9,999 pieces	29.1%	28.6%	30.2%
10,000 to 24,999 pieces	10.7%	3.6%	16.3%
25,000 to 49,999 pieces	4.9%	0%	9.3%
50,000 to 99,999 pieces	5.8%	1.8%	11.6%
100,000 or more pieces	6.8%	3.6%	11.6%
21. Approximately what percent of your production employees have had formal training in the following areas?			
Statistical process control			
All	2.9%	0%	7.0%
Most	2.9%	3.4%	0%
Some	44.8%	29.3%	65.1%
None	49.5%	67.2%	27.9%
Quality assurance			
All	12.4%	12.0%	13.6%
Most	20.0%	13.8%	25.6%
Some	41.0%	39.7%	44.2%
None	26.7%	34.5%	16.3%

Questions	Total n=107	Small companies n=60	Large companies n=43
Root-cause analysis or similar process reengineer methodologies			
All	3.9%	3.6%	4.7%
Most	8.8%	5.5%	11.6%
Some	37.3%	25.5%	53.5%
None	50.0%	65.5%	30.2%
22. How involved are the following groups/personnel in redesigning workflows to achieve higher productivity?			
Production workers	3.30	3.45	3.05
First or second line supervisors	3.71	3.70	3.73
Plant managers	4.29	4.07	4.45
Maintenance department	2.49	2.30	2.71

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