Organizational Considerations for Advanced Manufacturing Technology

Bruce D. DeRuntz and Roger M. Turner

In the last several decades, the United States has experienced a decline in productivity (U.S. Bureau of Labor Statistics, 2001), while the world has seen a maturation of the global marketplace. Nations have moved manufacturing strategy and process technology issues to the top of management priority lists. The issues surrounding manufacturing technologies and their implementations have assumed greater importance in overall manufacturing strategy. Practitioners and researchers have developed strong interest in how advanced manufacturing technology (AMT) can be used as a competitive tool in the global economy to combat the phenomena of fragmented mass markets, shorter product life cycle, and increased demand for customization (Hottenstein & Casey, 1997). The combination of increased production flexibility and higher efficiency contradicts traditional manufacturing strategy. In traditional thinking, efficiency is possible only in the production of large volumes of standard products, while customization is associated with higher costs (Shepherd, McDermott, & Stock, 2000). Clearly, the impact of AMT is redefining the way multinational corporations are managing manufacturing operations; however, effective implementation of AMT has not occurred as rapidly as the development of technology due to organizational considerations. A measure of the global adoption of AMT is reflected in a research project called the International Manufacturing Strategy Survey, which received responses from 556 manufacturers in 18 countries and found that computer-aided design (CAD), material requirement planning (MRP), local area networks (LAN), and computer numerical control (CNC) machines are now the most popular AMTs used in manufacturing (Sun, 2000).

Defining AMT

While the International Manufacturing Strategy Survey was explicit in identifying AMTs to the respondents, there has been some debate about whether AMT represents only the latest cutting edge technology or is it an adopted terminology that classifies a segment of manufacturing? The answer is the latter. AMT involves new manufacturing techniques and machines combined with information technology, microelectronics, and new organizational practices in the manufacturing process. AMT is a key enabler to help manufacturers meet the productivity, quality, and cost reduction demands of competitive global markets (Industry Canada, 2002). Sun (2000) defined AMT as computer-aided technologies used in manufacturing companies. While Industry Canada's definition is comprehensive and Sun's definition is broad, both of these definitions are accurate in describing the integration of AMTs in the modern manufacturing system known as computer integrated manufacturing (CIM). The Society for Manufacturing Engineers (SME) developed one of the first models to illustrate the relationship of AMT to CIM (Goetsch, 1990). This original model contains one business component and four technical components. The four technical components are planning and controlling, information resource planning, product and process definition, and factory automation. Each of these components contain AMTs that can be classified by their level of integration (Bessant & Haywood, 1988) as illustrated in Table 1.

Benefits of AMT

The benefits of AMT have been widely reported and can be classified as tangible and intangible. The tangible benefits, which are easily quantifiable, include inventory savings, less floor space, improved return on investment (ROI), and reduced unit costs. The intangible benefits, which are difficult to quantify, include an enhanced competitive advantage, increased flexibility, improved product quality, and quick response to customer demand (Ariss, Raghunathan, & Kunnathar, 2000). These benefits may still offer many other improvements with respect to organizational improvements and management/worker satisfaction. For example, the process of implementing AMT might lead to better communication, redesigned workflows, or better integration of work across functional boundaries.

Although operational and organizational benefits are often associated with AMT, all AMTs are not the same and do not provide the same benefits. It is known that innovations come in varying degrees of complexity and design. For example, some innovations are extensions to product offerings or improved processes (incremental), while radical innovations involve the development or application of new technologies into previously un-utilized applications. Innovations also involve changes in the core components without altering a product's overall architecture. Also, advancements can be made by linking together the existing technology and components in a new architecture (Noori, 1997). These individual characteristics of product change or process upgrade affect the level and type of benefits derived.

Table 1. AMTs in the Four Components of a CIM System

Level of Integration	CIM Components and Their AMTs			
	Design and Engineering	Plan and Control	Information Management	Fabrication and Assembly
From standalone to integrated	CAD CAE CAPP	MRP MRPII	LAN WAN Shared DB CIM	NC/CNC CAI/T/T FMS/FAS APL/U ATC Robot AS/RS AGV

Assessment and Planning of a Manufacturing System

The first step in planning for AMT generally occurs when an organization recognizes that current processes and procedures are inadequate to meet their current or future strategic needs. The usual response is to investigate current manufacturing processes and available technologies in an effort to accomplish the perceived needs or improvements. Implementing an appropriate new manufacturing system is, however, not a simple matter of purchasing and installing the technology. Great effort must be expended to ensure that the organizational framework is conducive to the successful adoption of such a system.

Innovative technology invariably leads to new relationships with an organization's external environment. Therefore, firms must evaluate the critical aspects of planning for modified relationships with its customers, system vendors, and materials/parts suppliers. One of the most crucial issues in planning for a new manufacturing system is justifying the investment in the new technology.

The prime motivation for installing AMT is to increase the competitiveness of the firm. Since different firms have varying competitive objectives, their expectations from AMT will also vary. Top management must therefore examine the firm's current competitive position in relation to its desired position before deciding on particular technologies that appear to be suitable for its short-term and long-term goals. If it is seeking savings in human and capital costs, the natural choice will be the technology that promises cost efficiencies. If the expected benefits relate to improved product variety, then the technology that promises product flexibility will be preferred. In many instances, organizations have multiple objectives and the choice of technology should be based on that technology's ability to optimize the possibility of attaining both short-term and long-term objectives.

The Role of AMT

The role of AMT can be broken down into three specific categories: operational, marketing, and strategic (Noori, 1997). In its operational role, AMT is often seen as an instrument for achieving economies of scale in small batch production. For mass production firms, the greater product flexibility provided by AMT could result in economies of scope. In its marketing role, AMT is viewed as providing the basis that enables firms to exploit competitive advantages fostered by the technology. In mass production firms, these are expected to gain a competitive edge through their ability to provide a wide range of products at their usual rates of efficiency. Small batch producers can enhance their process efficiencies while maintaining or improving product flexibility. The strategic role of AMT has been related to improving the firm's ability to cope with environmental uncertainty. It has also been viewed as an important factor in the overall improvement of industrial performance. Many believe that in order for AMT to play a strategic role, a philosophy that integrates the computing environment with the factory control system, the corporate planning system has to evolve.

Prime consideration should be given to the benefits that the firm expects to derive from the implementation of the new technology. Only after this determination can an attempt be made to determine the type of technological innovation that will achieve these desired benefits.

It should be stated that not all types of products are conducive to automated manufacturing. Unlike software-based innovations, hardware-based innovations may be rather product/process dependent. For example, with reference to flexible manufacturing cells, there are those who assert that parts which have similar physical configurations or can be partitioned into distinct product families are prime candidates. This accounts for the proliferation of AMTs in metalworking and assembly. The continuing development of robotics is expected to lead to further development of these and other operations. Also, in spite of the increasing number of AMT adoptions, potential users should be cautioned against making premature decisions to adopt such systems because simple practices such as design for manufacturability may be just as effective and cost much less.

Technological Assessment

In order to understand a firm's technological competitiveness, a periodic technology assessment needs to be performed to chart the deterioration of technology and to benchmark a firm's relative position against a competitor. This entails the computation of the organization's "technology index" (a measure of the capability of the firm versus competitors' capabilities), and the comparison of this index with the state-of-the-art firm in the industry. When the firm's index deviates from the industry index by a prespecified value, a signal indicating the need for technological improvement is triggered. The important factors of such an index should include set-up time, turn-around time, and minimum lot size as key components. Other considerations should be production flow, flexibility of manufacturing facilities and product lines, flexibility of production processes, interdependence of manufacturing segments, and continuity of production. In addition to technical components, the improvements in overall competitiveness and increased responsiveness to market changes should be highly regarded factors in the firm's technological index.

Management Commitment and Organizational Structure

No matter how great the planning or implementation of a process, management's commitment is probably the most key factor of all. This commitment must not be restricted to the support of a concept. Management's commitment should look beyond the technical aspects of a project and to its organizational requirements for a successful implementation.

Training, team building, and the maintaining of employee morale should be seen as its underpinning. A commitment strategy to all personnel should analyze current tasks and skills, anticipate new activities, and determine the fit of skills needed to develop worker involvement or ability and also training programs for appropriate worker selection (Ghani & Jayabalan, 2000). A high level of management commitment should also facilitate the development of a workable strategy that helps eliminate organizational barriers to its implementation of worker delimitation at hierarchical levels and responsibility.

It appears that one of the major barriers to the successful implementation of a new technology is the existence of mechanistic organizational structures. This means that an organizational structure in an AMT firm should be more of an organic nature (Ghani & Jayabalan, 2000). Although the upper levels of management tend to delineate organizational goals based on strategic focus, the importance of a multiskilled workforce cannot be over emphasized. In many instances a reliance on multiskilled workforces and the continued commitment to design has allowed many manufacturers to adopt less complex and less expensive manufacturing techniques. A firm warning should be noted against the "technology first, organization later" approach; strong integration is highly needed. A firm that embraces modernization should first fit the skills of the available personnel into its modernization strategy, while gradually training to upgrade the skills of the employees (Ghani & Jayabalan, 2000).

Process Champion

A process champion is essential to a project success. Projects having a champion are more likely to proceed in an orderly fashion, achieve integration with the wider organization, and meet planned objectives. The roles of the process champion are seen as follows (Hottenstein & Casey, 1997):

1. Creative originator—the source of the idea (not necessarily but "figure head").
2. Entrepreneur—the person who adopts and sells the project.
3. Sponsor—protector and coach.
4. Project manager/overseer—the person who takes charge of planning.

There are also three areas of knowledge and skill required by a champion as shown in the following (Hottenstein & Casey, 1997):

1. Path finding—related to the ability to emphasize the necessity of technological change for future development.
2. Problem solving—related to technical knowledge concerning products and processes in combination with budgeting/planning/monitoring skills.
3. Implementing—requires interpersonal/communication skills.

Although these skills are essential, they are not necessarily sufficient to ensure successful implementation. An organizational structure that supports the work of the champion should be followed here (Hottenstein & Casey, 1997).

Changing Functional Relationships

The flexibility and efficiency obtained in successful AMT operations can lead to substantial strategic marketing advantages. Benefits such as increased market share, reduced prices, improved responsiveness to change in the marketplace, the ability to offer a continuous stream of customized products, faster product innovation, and improvement of the company's image have all been attributed to flexible AMT. New manufacturing technologies should offer many opportunities for innovative marketing strategies. It is believed that the adoption of automated technologies (FMS in particular) allows for a shift in the role of manufacturing from simply supporting marketing to playing a major role in strengthening a company's overall position in a particular market.

In order to take full advantage of the considerable manufacturing and marketing capabilities offered by new manufacturing technologies, there must be a balance between the marketing and manufacturing strategies of the firm. In instances where there are radical changes in manufacturing/process capabilities, innovative marketing strategies are essential. Rapid changes in marketing capabilities or market conditions usually will signal a need for manufacturing strategy changes. In an attempt to develop a shared marketing or manufacturing strategy, companies should determine appropriate order "winners" such as price, delivery, quality, and flexibility for their different markets and needs. For example, AMT with product flexibility built in can relieve the pressure of an increased product diversity as well a fragmented market, while firms with both volume flexibility and mix flexibility incorporated into their AMT can respond better to the threat of unexpected competitors (McClenahen, 2000).

Functional Integration

In addition to facilitating the market or manufacturing interface, the improved process capabilities of an AMT organization can also affect other functional departments of the firm. Of particular relevance to manufacturing is the integration of design and R&D. It has been seen that in the past, the failure to remove organizational barriers between functional areas contributes to integration difficulties that are usually a departmental interfacing problem.

To provide a framework for functional integration, an organizational impact analysis must be completed. This seeks to analyze the importance of the functional departments and/or functions within each department. These usually arise from such analyses that determine the need for vertical or horizontal shifts (Ghani & Jayabalan, 2000), requirements for new departments or new positions within existing departments, changes in the organizational workflow, or required manpower changes in worker qualifications.

To encourage integration between separate functional departments, firms should promote the multifunctional team concept. Other methods to encourage integration include cross training, the formation of autonomous work teams, and the education of personnel in the interfacing departments (Hottenstein & Casey, 1997). The adoption of AMT creates a need for more complex relationships and greater integration within an organization's key environment. It is generally believed that complex projects can only succeed with a greater expenditure of effort in that the combined action of system vendors, consultants, and users are able to capitalize better on the full benefits.

System Vendors

The desired relationship between system vendors and users is a close collaboration over an extended period. Many analysts believe that adopters of such technology lack the technological knowledge to specify the most suitable system for their situation and to operate and maintain the system after installation. In cases where users lack technical knowledge, they have the choice of dealing directly with the vendors or hiring a consultant for assistance. When the users prefer to deal directly with vendors, the vendors should be selected based on technical competence, quality, and dependability, rather than low cost. Users must also recognize that few vendors supply all the components required in any of the new manufacturing technologies and there will most certainly be networking problems in connecting equipment purchased from different suppliers. There will almost certainly be a software problem between the programs written by developers and the hardware to be purchased. Users must be aware that the system vendor will probably require detailed knowledge of business operations in order to design a system that meets the organization's needs. Unless potential users are prepared to provide such information, the solution offered by the vendor might not meet their requirements.

Given the complex nature of interfacing the hardware with the software developers, many potential users should use a consultant. It should be noted that in order for the user-consultant relationship to be beneficial, it is suggested that that the consultant analyze the requirements and resources of the organization. The consultant should be allowed to make suggestions for the development of the internal structure as well as the structure of production to facilitate reduced start-up problems.

Customers and Suppliers

The adoption of AMT has direct implications for the relationship with customers in at least two areas. First, the adoption of AMT requires the firm to shift its manufacturing emphasis from a product orientation to a service orientation. This means that firms should foster tighter links with customers, with the emphasis being on achieving quick response to customer demand. To achieve this, customers should be allowed to participate in product development. Second, the adoption of AMT production should allow the manufacturer to reduce set-up time and produce in smaller lot sizes. Customer response to such capabilities might be to adopt a just-in-time (JIT) approach, thus increasing the number of orders.

As for the relation with suppliers, it is suggested that manufacturing firms work towards a relationship of interdependence with suppliers. Since an AMT is more conducive to JIT, it is believed that AMT users should encourage flexibility in their suppliers. This requires the sharing of sensitive data between producer and supplier (Brandt, 1998).

Economic and Strategic Benefits of AMT

The experience of plants adopting AMT indicates that major economic benefits of AMT include the following (Shepherd et al., 2000):

- Decreased lead times
- Reduced delivery times
- Reduced set-up costs
- Reduced set-up times
- Reduced transportation costs
- Reduced investment in stock
- Reduction in batch sizes
- Improved quality
- Improved reliability
- Improved dependability

Once the expected benefits are determined and the technology required to reap these benefits has been chosen, the firm needs to consider the economic justification for adopting such technology. The major considerations at this stage are the quantification of costs and benefits. While the costs are generally quantifiable, the benefits are often very difficult to quantify. In particular, while major strategic benefits such as early entry to market, perceived market leadership, and improved flexibility are extremely important for the growth and survival of the firm, they are not readily convertible into cash values or numbers. Organizations often seek to justify AMT adoption by showing that the number of people required to operate the production process will decrease. This practice might not be universally applicable due to the fact that the labor cost factor no longer constitutes a large part of manufacturing operations (Ariss et al., 2000).

Budgeting and Assessment Procedures

An issue in justifying investment in AMT has been the inappropriateness of the techniques of financial and accounting analysis in determining the tangible and intangible benefits that accrue from the adoption of AMT. The adoption of AMT usually depresses short-term profits. Since many AMT projects may take several years to install fully, there is a greater danger in setting only short-term financial goals. The payback period appears to be the main criterion used for the economic justification of such projects. A payback period of 1 to 5 years is the generally accepted amount of time to recover the cost of such projects. However, some eastern industrialized giants such as the Japanese use the payback method to serve more as a performance measure than as a rigid financial criterion.

The consensus with respect to accounting for AMT falls squarely on the side of adopting absorption costing, since it is widely accepted that the variable cost component will be reduced substantially while overhead costs rise. There are those who suggest that while firms may continue to use traditional factors in formal financial appraisal of their projects, these factors might not be the main objectives of that particular implementation (Ariss et al., 2000).

Summary and Conclusion

The key to successful AMT planning and implementation appears to be the choice of an appropriate manufacturing system and the attainment of an organizational infrastructure that will offer maximum support to the chosen system. To achieve the desired benefits from AMTs, marketing and manufacturing must work together to ensure that the marketing strategy reflects the manufacturing capabilities of the new technology. Closer working relationships among all other functions of the organization are also required if the firm is to achieve its innovation objectives.

Economic justification of AMT presents significant problems, since many of the touted benefits are difficult to quantify. However, in some instances strategic considerations may override pure financial considerations. This will allow projects with significant tangible and intangible benefits to overcome the rigid payback criterion that has caused the dismissal of many new manufacturing projects at the pre-installation phase.

Bruce DeRuntz is an assistant professor in the Department of Technology at Southern Illinois University, Carbondale and an Epsilon Pi Tau member-at-large.

Roger Turner is an industrial technology student in the Department of Technology at Southern Illinois University, Carbondale.

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21st Century Manufacturing Supervisors and Their Historical Roots

Douglas R. Hotek

This article provides a perspective of the past and present roles of the manufacturing supervisor with a specific focus on new skills requirements.[1] Within the structure of manufacturing management, the supervisor plays a key role in implementing today's complex automated manufacturing technologies. The supervisor is at the bottom of the management pyramid—the one with upfront responsibility for machines, equipment, and tools, and for those who use them to produce a product. In the past, men who held the position were undisputed "bosses of the shop." Today's companies refer to supervisors by different job titles, and although women make up a significant portion of the profession, it is not uncommon to hear employees refer to their supervisors as foremen (Walker & Guest, 1952; Walker, Guest, & Turner, 1956). Some refer to the position as *first-level* supervisor (Marcus & Segal, 1989). But the term team leader has recently come into use with the trend toward a teaming philosophy for workers.

Because many manufacturing firms use automation technologies in their competitive strategy (Skinner, 1996), production employees must know the meaning of the latest acronyms such as CAD-CAM, CIM, FMS, JIT, MRP/MRP II, SPC, SDWT, and TQM (defined later in this article), and they must be technologically literate in them. These complex requirements in employee-technology relationships have made an impact on the role of supervision. It has changed from that of directing and controlling employees to that of effectively leading the improvement of employee performance (Markland, Vickery, & Davis, 1998; Polakoff, 1990; Skinner, 1996; Stevenson, 1999).

This new leadership role for supervisors can best be understood in a historical context of evolving manufacturing technologies, workforce characteristics, and skills used. This is presented in two parts. The first is a historical perspective of the supervisor's job and how it has changed during the 20th century. The second section describes the supervisor's job in the context of modern-day complexities.

Historical Perspective

In the early part of the 20th century, the Industrial Revolution was well on its way to creating a highly profitable system of mass production. Factories had become significantly larger in contrast to the relatively small job shops of the late 1800s. Production emphasized very large lot sizes. As opposed to single structures, most factories were made up of several buildings. The "American System" (Marcus & Segal, 1989, p. 72) of manufacturing now stressed precision and exactness in production so that parts could be interchanged easily during assembly. The early 20th century factories were characterized by large-scale production machine tools for such processes as sheet metal stamping, grinding, milling, and complex systems of organized mechanical assembly processes utilizing specialized jigs and fixtures. However, on the downside was the working environment. Many rotating shafts, pulleys, and belts used for drive mechanisms in these production machines of the early 20th century were fully exposed and in proximity to the worker who, by the way, was expected to work longer and harder than what is expected today. Worker fatigue and these types of dangerous conditions were undoubtedly a significant safety factor to be considered in those days (Khol & Mraz, 1997; Marcus & Segal, 1989; Williams, 1987).

At the turn of the century, the face of manufacturing in the United States was almost universally White and male. This was because highly skilled machinists and mechanics were initially needed to operate machinery and perform assembly processes. Minorities and women were hard-pressed to gain access to apprenticeships in these relatively high-paying jobs. However, industrialists such as Henry Ford and efficiency experts such as Frederick W. Taylor revamped ways in which production jobs were performed. Jobs that required highly skilled worker performance were simplified. Complex tasks were broken down into repetitively small sequential steps that could be documented and measured. These simpler tasks were then able to be performed by lesser skilled workers (Marcus & Segal, 1989; Williams, 1987).

Some men who excelled at their jobs and mastered many different tasks were promoted to foremen (supervisors) with responsibilities for performing and overseeing the day-to-day production tasks on the shop floor. The early 20th century foreman was the undisputed boss of the shop, with considerable authority to make decisions regarding the work of his men. He was responsible for increased volume and capacity and lowered unit and labor costs. He was trained in the practice of *scientific management* (Taylor, 1947) to methodically measure, monitor, direct, and control the manufacturing system. However, to stimulate productivity in his workers and influence efficiency in the way in which materials flowed through his shop, he at times used supervisory methods that would be thought of as backward and abusive today. The supervisor of the early 20th century sometimes revived his tired workers with "stimulants furnished for each shift, such as a good belt of whiskey" (Grosson, 1998, p. 98). To punish and/or put fear into his insubordinates, he at times resorted to the use of threats and actual physical violence (Child & Partridge, 1982; National Industrial Conference Board, 1967; Patten, 1968). "So I hit him on the jaw. He knew who was boss now. He picked himself up and walked back to his job laying tracks" (Parker & Kleemeier, 1951, p. 1).

Forces for Change

With corporate growth and prosperity, brought on by an accelerated Industrial Revolution, came a stronger push by workers to be ensured a better quality of work life. Workers united, forming bargaining units to help guarantee fair wages and better working conditions. The formation of these labor unions consequently transferred much of the factory foreman's authority up to higher levels of management. Disagreements concerning shop-floor issues escalated to the plant manager, who now controlled what was previously within the worker-supervisor relationship. Formalized negotiations, something for which the typical supervisor was not trained and therefore not capable of executing, became more technical in nature between corporate management and labor union representatives. Thus with unions an integral part of the manufacturing environment, some discretionary powers of the supervisor began to wane. Prospective new-hires were now to be selected from the prescribed union list. All disciplinary actions, firings, suspensions, etc., had to follow the letter of the law as indicated in the union contract. Most company layoffs became controlled by union seniority and not by productivity standards. In addition, and what may have been most disheartening for the first-level supervisor, was that labor unions were now beginning to win major concessions in wage increases, job security, and working conditions—something the first-level supervisor had tried to do for years but had not succeeded in doing. These increased limitations on the first-level supervisor continued to refine and narrow the scope of the supervisor's job responsibilities (Kerr, Hill, & Broedling, 1986; Young, 1983).

The Great Depression and 1930s disappeared as manufacturing began working to support the efforts of World War II. In 1940, 28% of the machine tools in use were less than 10 years old. By 1945, 62% were less than 10 years old, the quickest advancement in capital investment known to have occurred in any developed country to this date. The rapid introduction of new technologies into manufacturing made World War II a different kind of war from its predecessor and was undoubtedly responsible for the outcome of that war. With research generated by defense needs, new machine tools were developed that could cut, shape, and form metal faster, with greater precision, and at lower cost. Materials and processes used in the assembly of auto and aerospace products continued to advance as well (Benes, 1998).

World War II likewise changed the face of the workforce of the middle 20th century. While men fought on the battlefront, women filled the millions of civilian and defense positions created as the United States shifted to wartime production. In 1942, women were recruited to work in the factories. "War gave women access to skilled higher-paying industrial jobs . . . " (Baxandall & Gordon, 1995, p. 245). As the war ended, most women gave up their wartime jobs to the men coming home from the war (Amott & Matthaei, 1991). Undoubtedly, the introduction of women in the workforce and the better educated, better organized worker home from the war left a lasting impact on supervisory practices in American industry (Fair, 1957).

By the middle of the century the job of the supervisor continued to be that of foreman, the overseer, director, and controller of employees. However, most training schemes for supervisors included considerable emphasis on human relations techniques, especially in the handling of women workers (Allen, 1957). Studies by Walker and Guest (1952) and by Walker et al. (1956) uncovered particular human relations skills in the successful supervisor. Their studies found that the best foremen were those who, in addition to directing and controlling shop operations, practiced good human relations with their wage employees. They treated employees as individuals, established personal relationships with employees apart from the job relationships, taught and promoted employees, acted as a shock absorber between employees and either the pressures implicit in the process or pressures coming from managers, stood up for employees in face of those pressures, consulted employees, and delegated responsibility to them.

World War II was the greatest factor in shaping the middle-of-the-century factory. The war's impact greatly affected developments in manufacturing technology, workforce characteristics, and supervisory methods. Technology developments resulted in newer, more precise, and more efficient machine tools. The workforce changed from predominantly male to predominantly female, and back again. With the introduction of working women and a war-experienced workforce, supervisors became more humanistic. They used less autocratic tactics of bullying and intimidating employees and showed more respect with a human relations perspective.

Manufacturing Supervision Today

By the late 20th century, supervisory practices had evolved significantly and were largely influenced by changes in manufacturing technology, organizational strategy, and workforce characteristics. Yet, today's manufacturing organizations composed of advanced automation and unique workforce characteristics call for further reformation of supervision.

This section, first, focuses on new developments in the area of information technology. Second, examples of contemporary organizational changes are discussed. Then, the characteristics of the modern-day workforce are considered. Out of these flow a series of recommendations for practices of modern supervision.

Manufacturing Systems and Information Technology

To be successful in today's complex work environments, most supervisors become technologically literate in many of the following.

Computer-aided design (CAD) is the use of computer software and hardware in interactive engineering drawing and storage of designs for manufacturing. Designers use CAD software to complete the layout, geometric dimensions, projections, rotations, magnifications, and cross-section views of a part and its relationship with other parts. The software allows designers to design, build, and test (in a virtual sense) production prototypes under given parameters as three-dimensional computerized objects. It compiles parts and quantity lists for a product, outlines fabrication and assembly procedures, and transmits the final design directly to production machinery such as milling and rolling machines (Goetsch, 1992; Markert, 1997; Markland et al., 1998; Stevenson, 1999; Turban, McLean, & Wetherbe, 1996).

Computer-aided manufacturing (CAM) software uses the digital output from a CAD system to directly control programs in production equipment such as robotics and numerical control machining centers. When CAD is feeding information to CAM, the combined system is referred to as CAD-CAM. CAD-CAM encompasses the computer-aided techniques that facilitate planning, operation, and control of a manufacturing facility. Such techniques include computer-aided process planning, computer-generated work drawings and standards, MRP II, capacity requirements planning, and shop floor control that are direct responsibilities of the supervisor (Goetsch, 1992; Markert, 1997; Markland et al., 1998; Stevenson, 1999; Turban et al., 1996).

Computer-integrated manufacturing (CIM) is a term that originated in the 1960s, a concept in American industry that encompasses a diverse collection of manufacturing technologies in use today and implies a system where all components necessary for production of the product are integrated. This includes the initial stages of planning and design through the stages of purchasing, production, packaging, shipping, and order fulfillment. CIM is not a specific hard technology per se. It is more of a management technology that involves strategic efforts to combine all available technologies such as CAD-CAM, MRP/MRP II, JIT, and other automated systems to manage and control an entire enterprise (Markert, 1997). If another factor were to be included, it would relate to the human elements between supervisor and wage employees. According to Markland et al. (1998), "many implementations of new technology, including CIM have failed because responsible parties (such as supervisors) failed to prepare the workforce to accept, support, and be able to use the new technology" (p. 322).

Flexible manufacturing systems (FMS) are fully automated, computer-controlled manufacturing systems that offer substantial advantages in comparison to a conventional job shop. An FMS is a set of machines linked by an automated materials handling system—all under central computer control. Flexible machining centers (called cells) can produce a variety (or family) of parts with a simple change of software. Instead of using special-purpose machines and tooling to perform a single operation, FMS may use computerized machines that can be quickly reprogrammed to do a variety of things, which could be from machining several different types of product to performing multiple operations on a single piece of work. This is especially important for manufacturing small lot sizes of products and those that undergo rapid changes in specifications (Markert, 1997; Volti, 2001).

Materials requirements planning (MRP) is a calculation technique that deals with production inventories and scheduling. It is used for planning future manufacturing lots and purchase orders according to what is required to complete a master production schedule. MRP provides the benefit of accurately forecasting the demand for like items in different products that are interdependent, which is generally the case in a just-in-time manufacturing system. For instance, a company may make three types of widgets that all use the same type of screws, bolts, and nuts. Thus, the demand for the bolts, for example, depends on the shipment schedule of all three types of widgets. MRP is typically computerized because of complex interrelationships between products and their subparts, and the often need to change plans when delivery dates or order quantities are changed (Markert, 1997; Turban et al., 1996).

Manufacturing resource planning (MRP II) is an application software arrangement used by the line organization. Essentially, MRP II creates a closed-loop management system that integrates the regular MRP with all other major functional areas of the organization such as forecasting and sales, design engineering, purchasing and receiving, production activity planning and maintenance, and distribution planning and cost accounting. Furthermore, it coordinates activities toward the goals of a JIT system, producing the right product at the right time (Markert, 1997; Turban et al., 1996).

Statistical process control (SPC) is a quality-control method that provides information helpful in the reduction of defective parts or products by statistically monitoring manufacturing processes, typically through the use of computerized charts and graphs. To manufacture products within specifications, processes producing the parts need to be stable and predictable. A process is considered to be under control when SPC charts show that variability from one product to the other is stable and predictable. If and when a process becomes unstable and about to go out of control, SPC charts will show evidence of such in far enough time so that adjustments can be made to the process before defects are produced (Deming, 1994; Grant & Leavenworth, 1988; Juran, 1988).

Organizational Changes

Changes in the manufacturing environment and in technology induce organizations to change the manner in which they operate. It has long been recognized that there are strong relationships among the environment, technology, and organizational structure. The following are examples of organizational changes that also call for reformation of first-level supervision.

Total quality management (TQM) is an integrative management approach that emphasizes continuous process and system improvement as a means to achieve customer satisfaction and long-term company success. Simply stated, TQM utilizes the strengths and expertise of everyone in the company as well as scientific methods for problem analysis and decision making. Quality is the concern and responsibility for everyone in the organization and is built into every product and business process. TQM is based on the premise that customers (internal, external, or both) are the focus of all activities of an organization, and relies on all members of the organization to continuously improve everything they make and do as well as the culture in which they work. Most important, TQM is a philosophy for long-term, never-ending commitment to improvement, not a temporary program (Ahire, Landeros, & Golhar, 1995; Deming, 1994; Summers, 1997).

Just-in-time (JIT) is a complete inventory control and production scheduling system that attempts to reduce costs and improve work flow by scheduling parts and materials to arrive at a manufacturing work station precisely at a time when they are needed. Such a system saves space, reduces inventories, and minimizes waste, and by doing so saves considerable capital. JIT utilizes a pull system for moving goods (where control of materials and parts movement is established in reverse of the work flow, from the last work station to previous stations) and several other technologies and management techniques that enable production to move as fast as possible without disruption. The major components of a JIT system are few but reliable suppliers, small lot sizes, low inventories, high-quality materials, fixed production rates and standardized outputs, extensive preventive maintenance and quick repairs, quick machine setups, and moderately utilized capacity. Perhaps the most significant elements to a successful JIT system are multiskilled employees and participative supervision that encourage continuous innovation and improvements (Markland et al., 1998; Stevenson, 1999; Turban et al., 1996).

Self-directed work teams (SDWTs) are a functional group of employees (usually between 8 and 15 members) who share responsibilities for a particular unit of production. Technically, the team consists of individuals who are trained, empowered (with authority), and held accountable to make decisions regarding the quality, cost, and scheduling requirements of their production unit and for the safety of their production processes (Torres & Spiegel, 1990). Each member of a SDWT possesses a variety of technical skills and is encouraged to develop new ones to increase the job flexibility and value of the SDWT (R. Koenig, R. Schnack, & R. Marconi, personal communication with respective vice president of operations, director of manufacturing, and production manager, Norand Corporation, Cedar Rapids, IA, August 10, 1995).

Workforce Characteristics

Changes in the characteristics of today's workforce obviously affect the job of the supervisor. According to Rue and Byars (1996), one of the more prevalent changes in today's workforce that affect the supervisor's job is the transformation of its demographics. The following are examples of this phenomenon.

Compared to the 1980s, Kutcher (1991) predicted that the workforce in the 2000s would grow more slowly. Gendell and Siegel (1992) expected older members of the workforce to take early retirement. In contrast, Redwood (1990) stated that women—especially women under 40—would enter the workforce at an accelerated rate. A recent report by the U.S. Department of Labor (1999) validates these forecasts. The report shows that women are working more while men are working less. What is most characteristic of the shrinking workforce is the age of workers. Although young people are a substantial part of the workforce, there is a disproportionate amount of wage employees under age 35. At the lowest age levels this reduction is already upon us. Overall, wage employees are getting much older very rapidly. Thus, there are fewer qualified people to fill wage employee positions, the type of condition that can make for a labor shortage.

The U.S. Department of Labor (1999) also reported that minority groups of all types are becoming a larger proportion of the workforce. In fact, due to a need for skilled labor, immigration plays the largest role in the growth of the United States. Some state governments (Workforce Resource Bureau, 2001) are preparing to reverse their trend of a declining workforce population. They see great potential in attracting immigrants and refugees from Hispanic and/or Latino countries of origin and have set strategic planning goals to welcome and accommodate these newcomers (Iowa Governor's Strategic Planning Council, 2000). As a result, in the year 2000, the U.S. Bureau of the Census counted 82,473 Hispanic and/or Latino residents in Iowa, which is a 152.6% increase from a 1990 count of 32,647 residents from the same countries of origin (Iowa State University, 2001). Certainly, the supervisor plays a positive role for those immigrants who choose employment in the manufacturing sector, especially in the challenge of leading non-English-speaking workers and/or those with poor English language skills.

Perhaps the most significant change in the shape of the workforce is that workers are now expected to fulfill jobs that require more than a high school education (Carnevale, 1991; Redwood, 1990; U.S. Department of Labor, 1999). In today's world of manufacturing, unlike other sectors in the economy, the work of wage employees is becoming increasingly complex as they find themselves having to continuously upgrade their skills to fit the latest manufacturing technologies (Carnevale, 1991; Dean, Dean, & Rebalsky, 1996). For example, compared to their day-to-day operations of the past, employees are now using less manual skills and more intellectual skills as required for operating automated machinery and processes. Their skills have also become more versatile in the variety of manufacturing technologies they apply (Markland et al., 1998; Stevenson, 1999). According to Carnevale (1991), Douglas (1997), and Gupta and Ash (1994), employees are being told less by their supervisors of what to do, as well as when, where, and how to do it, and are expected to autonomously make more decisions as members of self-directed work teams. Researchers agree with two of Deming's (1994) long-standing opinions regarding trends in employee performance: (a) Performance outcomes are being greatly influenced in breadth and depth by increased sophistication of manufacturing and organizational systems, and (b) employees are being empowered to make less reactive and more proactive job-related decisions.

Even in the modern age of automation, the highly diverse, highly skilled, highly motivated, productive employee is still manufacturing's greatest asset. The person best able to make the most efficient and effective use of this asset is the well-trained, knowledgeable supervisor.

Supervisor Characteristics

Historically, supervision has been viewed as a process concerned with accomplishing work through other people, and this concept is still valid. If asked what it is that a supervisor actually does today, most people would still probably respond with an answer that implies that a supervisor oversees the work of wage employees (Berliner, 1979; Deming, 1994; Drucker, 1993). It has been well established that an important skill of a supervisor is to appraise and improve the performance of his or her employees. However, manufacturing has become so technology dependent that the impact of technology on productivity and on employees cannot be ignored. Supervisors are still responsible for ensuring that employees accomplish their work. Yet, more and more employees are using technology to do their work, and technology is becoming increasingly sophisticated and increasingly complex. In a symbiotic relationship, the employee depends on technology and technology depends on the employee (Dean, 1995; Rothwell, 1996; Rummler & Brache, 1995).

Supervisors must be able to bring out the best from both employee and technology, and learn to make optimum use of the employee-technology relationship. To do so supervisors must understand technology as a concept, be familiar with the latest developments in manufacturing technology, appreciate the impact of technology on the employee's work, be familiar with employee-technology relationship problems and know how to deal with them, and be prepared to deal with the rapid and continual changes associated with modern manufacturing technology (Goetsch, 1992; Petersen, 1989). In short, the modern supervisor should be a technically oriented team coach (Deeprose, 1995).

Research Gaps

We know what the human resource, academic, and management authors think supervisors should do. However, what is missing from most of the extant literature is perspective of the line organization—what *they* think supervisors should actually be doing on the production floor. Ahire et al. (1995), Crutchfield (1998), and Douglas (1997) implied that further research is needed in identifying the leadership elements required of supervisors and their roles and responsibilities in a highly technical and complex manufacturing organization. With respect to the job of supervisor in today's work team environment, Gupta and Ash (1994) stated:

> Although many operators and mechanics welcomed the promise of input into the plant's work, lower level supervisors felt extremely threatened by the changes. Of all the employees at [the company], these supervisors are experiencing the most uncertainty about the effect the work teams would have on their work and livelihood. They were told their jobs would change drastically, but no one seemed able to articulate how. (p. 198)

Skinner (1996), referring to supervision of highly skilled employees and the use of modern manufacturing technologies as a competitive advantage, wrote:

> One conclusion seems clear: we are now in a totally new industrial era in which the performance required for competitive success is orders of magnitude greater than in the past. But in the face of these heightened requirements, hard-pressed production managers appear to be trying for competitive parity principally by concentrating on adopting the latest tactical controls and planning techniques . . . [but] . . . typical industrial managers do not seem to know what to do differently . . . the urgent need [is] to improve performance. (p. 16)

There are many textbooks and other literature on what seems to make the modern supervisor a good supervisor, and most agree that the supervisor plays a key role in managing today's manufacturing operations. However, there is very little sound research in what people in the line organization believe supervisors actually do that is most important.

The evolutionary role of the manufacturing supervisor has gone from autocratic boss to human relations overseer to technical team coach. Now, when employee performance must be enhanced to accommodate organizational changes and ever-increasing sophisticated manufacturing technologies, supervisors need to do more than simply train their employees. If supervisors knew *everything* about today's complex organizational systems and automated manufacturing technologies, they could tell their employees what to do, how to do it, and when to do it. They could get by with the traditional supervisory skills of bossing and controlling employees, making all of the decisions. But when supervising a diverse group of self-directed and well-educated employees who are highly skilled in modern manufacturing technologies, such an approach would be a mistake. Hence, there is a declining need for directive supervision.

However, contrary to a vision of factories run by robots, successful manufacturing systems today depend more than ever on the skills of the first-level supervisor. An increase in breadth and depth of employee performance both on the factory floor and in business decision making has called for a transformation of skills used by supervisors. Studies by Crutchfield (1998), Douglas (1997), and Hynds (1997) show that in order for supervisors to make the transformation, from that of directing and controlling employees to that of leading and improving employee performance, it is important for them to obtain unique leadership skills. Many believe the primary skills of a supervisor today are in managing what Rummler and Brache (1995) referred to as the "human performance system" (p. 71). Supervisors need skills in applying *performance technology* (Hotek & White, 1999), a more complete and continuous approach to improving the system in which they and their employees work.

Douglas R. Hotek is a professor of Technology Education in the Department of Industrial Technology at the University of Northern Iowa, Cedar Falls. He is a member of Pi Chapter of Epsilon Pi Tau.

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Notes

[1] Because I focus on the skills of the supervisor that are changing, more traditional skills that fall in the category of people skills and business skills are not given much attention. However, these skills are still integral and necessary for effective supervision.