Achieving Competitive Advantages of Advanced Manufacturing Technology

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World-class Manufacturing

Change is an essential business trait. Manufacturing, in particular, is transforming at an unprecedented pace. Profound changes driven by increasingly unpredictable, dynamic and fiercely competitive markets, rapidly expanding manufacturing capabilities worldwide, increasingly available inexpensive microelectronics-based technologies, and development of complementary and overlapping organizational practices greatly complicate business[1,2]. While computing technology permits increased automation of a wide range of operations, world-class manufacturing (WCM) practices such as total quality management (TQM), just-in-time (JIT), *kaizen*, and employee empowerment possess great potential for increasing the importance of manufacturing. Adopting effective management practices, capable of keeping pace with the changing technological environment, is particularly important to success in global markets. WCM requires continuous improvement because world standards constantly change.

Naturally, global competitors such as Ford, GE, Motorola, Toyota, and Xerox focus on being world-class manufacturers. However, small companies or focused factories owned by a large company are often better positioned to make the quantum leaps required to become a world-class manufacturer[3]. Fostering a WCM culture in an old plant, saddled with outdated methods, systems and attitudes, is indeed difficult[4]. However, to remain competitive in today's global economy, progressive management must integrate manufacturing and computing technologies and divest itself of old patterns of thinking that restrict manufacturing to a narrow concept of efficiency[1]. Reversing the historical trend towards segmentation and specialization requires substantial commitment.

World-class manufacturers identify and understand customers' needs all along the value chain[5]. A WCM mind-set emphasizes dedication to higher quality levels, greater flexibility, reducing manufacturing cycle times, and lowering costs. Manufacturers employing advanced manufacturing technology (AMT) are often more flexible than their traditional counterparts since AMT

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permits the integration of product design and production processes. Consequently, this synergistic effect facilitates achievement of WCM objectives by allowing more rapid product development with fewer flaws and at lower costs.

Despite obvious advantages, sparse research exists concerning achieving AMT competitive advantages. This article considers issues of managerial and strategic importance associated with the acquisition and implementation of AMT. In particular, this article addresses requirements for achieving AMT competitive advantages; our study concludes that properly addressing managerial issues greatly increases the probability of remaining competitive and successfully reaping the benefits of AMT. Furthermore, our findings indicate that AMT is a strategic decision with long-term ramifications; therefore, strategic planning plays a significant role.

Being the best in the world at manufacturing an obsolete product does not make an organization world-class. Increasingly turbulent task environments, characterized by truncated product life cycles and segmented consumer markets, require world-class manufacturers to be flexible enough to satisfy changing market demands. Before presenting issues of managerial and strategic concern, the next section details the evolution of manufacturing systems. To incorporate AMT organizationally, management must be cognizant of the requirements for successful AMT implementation. The third and fourth sections are based on the principle that managers do things right and leaders do the right things. Hence, section three provides managerial requirements for successfully achieving AMT competitive advantages. Assuming management understands the "how" of doing things right and incorporates the necessary corporate cultural changes to embrace AMT, manufacturing strategic planning can lead the organization towards "what" are the right things to pursue. However, rarely in practice do companies formulate a manufacturing strategy. Nonetheless, strategic planning is key to successful AMT implementation. Therefore, strategic planning is given substantial consideration in the fourth section. The fifth and final section provides concluding remarks.

Evolving Manufacturing Systems

There are three types of manufacturing systems: craft shops; dedicated manufacturing systems (DMS); and advanced manufacturing technology-based systems (AMT). This classification is compatible with Doll and Vonderembse's work[1]. Their research is based on Thompson's conceptualization of long-linked versus intensive technologies. Using their classification scheme, DMS are considered long-linked industrial systems employing hard automation whereas AMT are post-industrial enterprises employing flexible resources.

There are many distinctions between craft shops and DMS. While craft shops employ skilled artisans who use various hand tools, DMS deploy special-purpose machinery operated by unskilled manual labourers. In a craft shop, workers are organized into task-oriented work groups. Work is

functionally specialized and usually a single task is assigned to a worker in a DMS. In a craft shop, performance measures are based on customs and the work is evaluated by other craftsmen. DMS are controlled through a hierarchical structure. In addition to the above characteristics, DMS are product-oriented, concerned with efficiency and productivity. An information system controls task execution and co-ordinates sequential activities within a DMS.

Numerous definitions of AMT exist. For example, Youssef defines AMT as "a group of integrated hardware-based and software-based technologies, which if properly implemented, monitored, and evaluated, will lead to improving the efficiency and effectiveness of the firm in manufacturing a product or providing a service"[6]. This work, however, provides a more global definition that combines the work of Zairi[7], and Zammuto and O'Connor[8]. AMT, defined broadly, is a total socio-technical system where the adopted methodology defines the incorporated level of technology. AMT employs a family of technologies that includes computer-aided design (CAD), computer-aided manufacturing (CAM), flexible manufacturing systems (FMS), manufacturing resource planning (MRP II), automated material handling systems, robotics, computer-numerically controlled (CNC) machines, computer-integrated manufacturing (CIM) systems, optimized production technology (OPT), and just-in-time (JIT). Although AMT places great emphasis on the use of technological innovation, management's role is significant since AMT systems require continual review and readjustment.

To a large extent, DMS and AMT use similar technologies but have different missions. Manufacturing's mission, when deploying DMS, is strictly to execute operational plans in support of the firm's strategic objectives. However, information technology has altered the underlying assumptions of manufacturing by making AMT possible. While the mission of AMT is still evolving, significant focus is on economies of scope and information flow rather than material flow. AMT enterprises are customer-oriented, concerned with time to market and responsiveness. Consequently, from a management perspective, the critical feature of the progression from DMS to AMT is not so much more complex manufacturing machinery, but rather the greater levels of integration of the social, work and control systems. AMT uses an array of flexible resources that are monitored by an extensive information system. In addition, large numbers of self-organizing and self-directed work groups exist. Performance is evaluated based on multiple and global measures and control consists of direct and continuous feedback from operations. Table I gives a brief description of each of the aforementioned manufacturing systems.

Businesses once thought of automation as a mechanism for achieving economies of scale by using DMS to improve process efficiency, lower costs, and produce acceptable quality products. Historically, DMS have justified themselves through mass production of a standard product on dedicated machinery and often operate in environments of low uncertainty created by stable market demands. Products produced are of low differentiation and are

	Manufacturing system		
	AMT	DMS	Craft
Orientation	Customer	Product	Skill
Work group	Self-organizing, self-directed	Individual	Task-organized
Work unit	Multiple tasks	Single task	Product
Focus	Market responsiveness	Efficiency, productivity	Workmanship
Control	Direct, continuous feedback	Hierarchical	Peers
Skill level	Semi-skilled	Unskilled	Skilled
Tools/ machinery	Flexible	Special purpose	Hand tools

Table I. Manufacturing System Components

typically marketed based on low cost. Many global markets are no longer capable of being supported by DMS because of turbulent market conditions; hence, DMS are experiencing a competitiveness crisis.

AMT permits strategic options such as quality-based differentiation, rapid market responsiveness fostered by product design and product mix flexibility, and greater process control. Computer-based technologies, such as those associated with AMT, are increasingly being viewed as decisive weapons in attaining a competitive edge in today's hazardous business environment. Although AMT implementation is a much more complex and difficult undertaking than DMS, manufacturers must strategically employ AMT to enjoy a new era of prosperity. With AMT, manufacturers no longer emphasize the passive supportive role of production, but rather its ability to facilitate enterprise-wide integration. This integration of computer-based control systems and manufacturing processes creates production systems that are more flexible, reliable, and productive than DMS. How successful AMT is depends primarily on selecting and managing projects that enhance organizational capabilities, rather than on measuring and controlling costs[9].

A survey conducted of US manufacturing executives found that 81.2 per cent believed AMT was either essential or very important as a competitive weapon for US industry[10]. Approximately 66 per cent felt AMT was an important cornerstone of world-class manufacturing. However, only 33 per cent believed their companies have long-term strategies for implementing AMT. The top five obstacles to more rapid adoption of AMT, as stated by these executives, are:

(1) lack of necessary funding;

(2) lack of in-house technical expertise;

(3) failure of top management to grasp the benefits of AMT;

(4) inadequate planning or lack of vision; and

(5) inadequate cost-justification methods.

The next two sections address the issues of AMT benefits and inadequate planning respectively, by examining the requirements for achieving AMT competitive advantages and strategic planning.

Requirements for Achieving AMT Competitive Advantages

Albert Einstein believed problem solving requires different thinking from that which created the problems. Top management's reluctance to admit their own culpability for existing problems presents a barrier to organizational improvements such as AMT adoption[11]. This section considers operational requirements while the next section explores strategic concerns. Operational requirements such as those discussed in this section focus on improving AMT implementation; strategic competitive advantages concentrate on how to consistently beat the competition using AMT[12].

For practical purposes, customers exchange money for organizational services; in turn, organizations exchange money for employee services (see Figure 1). AMT improves competitiveness by enhancing this exchange process by lowering costs, improving quality and providing greater flexibility. As discussed in the next section, AMT requires the existence of a long-term strategic plan. But before addressing long-term concerns, operational requirements for achieving AMT competitive advantages are discussed.

Long-term Financial Health Requires Balancing Product and Process Innovation

Maintaining a proper balance between product and process innovation is necessary for companies to use AMT as an offensive competitive weapon. By facilitating the design and production of superior products, this balance maintains the organization's long-term financial health. Maintaining a short-term perspective tends to delay AMT implementation. According to the Council on Competitiveness, US firms currently invest only 21 per cent of their R&D budgets in long-term projects, while Japanese and European firms spend nearly 50 per cent and more than 60 per cent respectively on long-term projects[13]. Another survey, conducted of 250 top manufacturing executives, indicates that the US is still perceived as the product innovation world leader (see Figure 2)[14]. However, a study conducted by Ernst & Young and the American Quality Foundation International shows that US businesses fall well short of Japan and Germany in terms of translating customer expectations into the design of new products and services[15]. This study reveals that only 22 per cent of US businesses always or almost always (at least 90 per cent of the time) translate customer expectations into new products and services while

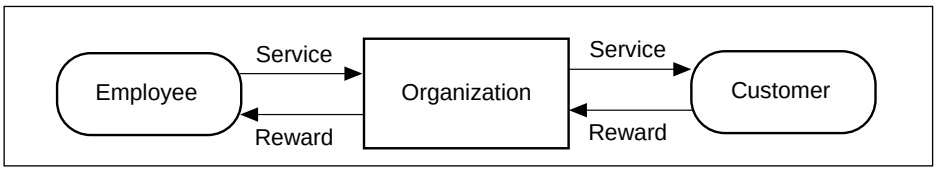

Figure 1.
AMT Facilitates Exchange Process

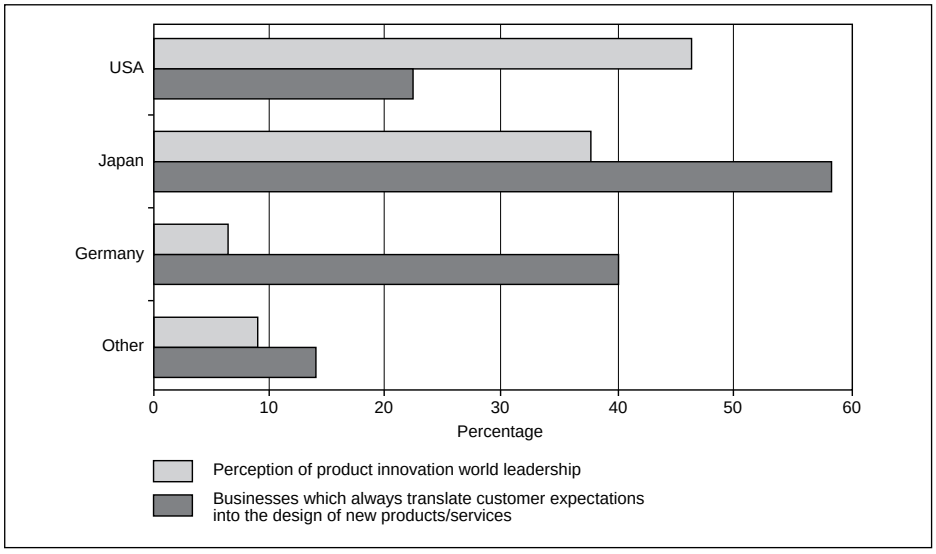

Figure 2.
Product Innovation

only 14 per cent of Canadian firms do so. In Japan and Germany, 58 per cent and 40 per cent respectively of all businesses almost always integrate customer expectations into the early product and service development stages.

Each of the 250 executives mentioned above were asked the following four questions:

(1) What proportion of your firm's annual sales is invested in research and development (R&D)?

(2) What type of innovation is most needed in your industry?

(3) What type of innovation is most needed in your company?

(4) Assuming R&D is currently being pursued by your company, does R&D tend to focus on new product innovation, existing product innovation or manufacturing process innovation?

Forty-three per cent of the firms surveyed spend only 3 per cent of annual sales on R&D, and 20 per cent spend nothing at all. Figure 3 summarizes the survey results. Clearly firms spend most R&D funds on product innovation. One long-term repercussion is *competence destroying*[16]. As demonstrated by these studies, there needs to be greater investment in process innovation.

AMT Champions Are Required to Overcome Organizational Inertia

Organizational inertia is a principal obstacle to AMT implementation. An AMT champion provides the impetus for change. In fact, an effective champion appears absolutely necessary to AMT success[17]. There are three leadership roles, defined by Leavitt, that illustrate the necessary skills to be an effective champion[18]. These roles are that of pathfinder, problem olver, and implementor. Through these roles, a champion facilitates the

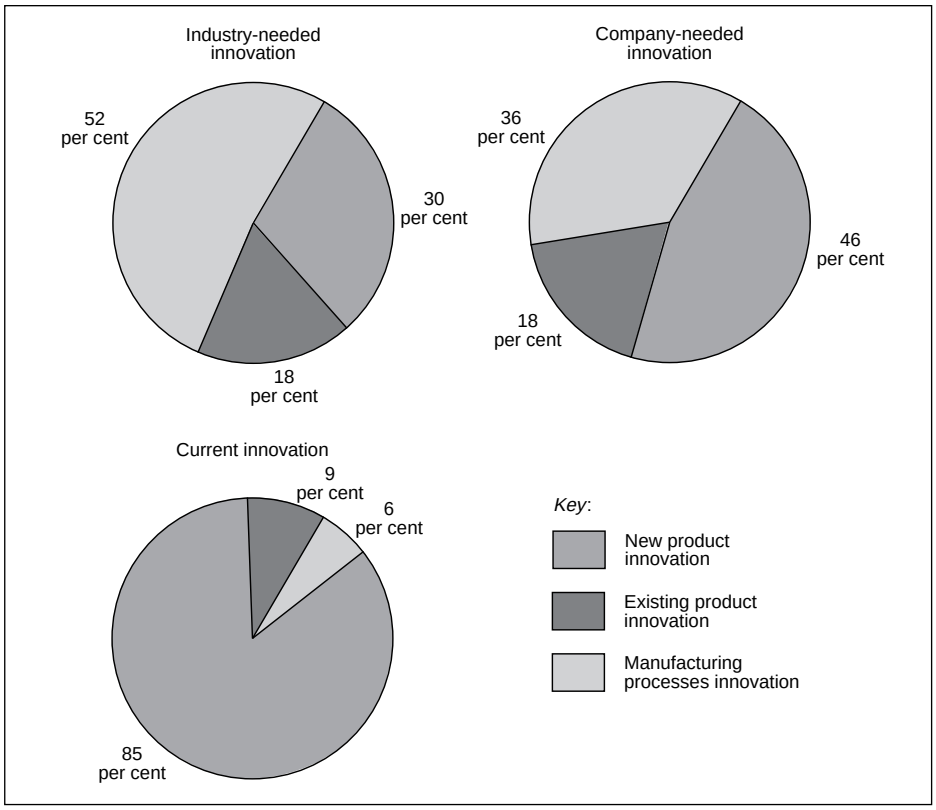

Figure 3.
Innovation Spending Percentages

conversion process. The *pathfinder* wholeheartedly believes in an AMT vision and promotes it throughout the firm. Analytical and technical skills are necessary for the role of *problem solver*. Through this role, an effective champion successfully identifies problems, develops and analyses alternatives, implements the best processes, and monitors results to ensure that the AMT project proceeds unimpeded. The *implementor* motivates and persuades individuals to pursue AMT objectives. This role translates the vision into reality. Together, these three roles provide solid leadership necessary for building trust, acceptance, and commitment to AMT projects.

World-class Operations Require Time-based Competitiveness

Boston Consulting Group industry studies show that companies which are twice as responsive to customer demands expand at five times the industry average with prices 20 per cent higher. For example, the difference between being first and second in new pharmaceutical market entry often results in profitability differences of four to eight times. In the computer industry, estimates show that one company lost 35 per cent in profits by marketing its laser printer 90 days late[13].

In an effort to create competitive advantages, many progressive firms are substantially decreasing their manufacturing cycle times. For example, Honeywell Inc.'s IAC decreased their manufacturing cycle time by 89 per cent, Edy's Grand Ice Cream by 67 per cent, Unisys Corp.'s Government Systems Group by 75 per cent, Exxon Chemicals by 74 per cent, Westinghouse NSD by 75 per cent, Johnson and Johnson by 50 per cent and Fisher-Rosemount by 62 per cent[19]. Keeping in mind that time is equivalent to money, productivity, quality, and even innovation, these reductions represent tremendous savings[20].

Often firms become more time-based competitive by identifying sources of waste and inefficiency – streamlining current production processes. While providing many initial benefits, this approach has diminishing returns after threefold improvements. Reconsidering business processes achieves much more dramatic results, as shown by Allen-Bradley's electronic manufacturing strategy one (EMS 1). Allen-Bradley notes that EMS 1 reduced total product introduction time from as long as three years to as little as five months. Also, products move through this CIM system in as quickly as one day, as contrasted with several weeks when using the manual batch-assembly process[21].

AMT Often Implicitly Requires an Organic Bi-modal Organization

Superimposing AMT on rigid mechanistic organizational structures impedes creation of AMT competitive advantages and often results in implementation failure. New organizational structures are necessary to allow for greater employee participation and subsequent empowerment. Consequently, a potential constraint on AMT adoption is management's resistance to sharing power with subordinates. How extensive resistance to organizational changes is depends upon the breadth and depth of the AMT project. Bi-modal organizations recognize that management is widely shared. Bi-modal organizations broach three types of tension: centralization versus decentralization, stability versus change, and uniformity versus diversity[22]. Decentralization fosters creative initiatives and rapid responsiveness while centralization provides cohesion by charting a strategic direction within which initiatives are pursued. Stability is achieved by articulating a clear strategic vision and strategic statement while an extensive reliance on team building, team problem solving and subsequent disbandment encourages flexibility. A strong commitment to the strategic vision provides uniformity while the manufacturing strategic statement allows the organization to pursue a set of AMT proposals congruent with skills cultivated from the diverse background of the company's employees. Bi-modal organizations recognize that employees are versatile, adaptable and flexible if properly trained. By distributing good management throughout the organization, organic bi-modal firms inhibit crisis management, and increase productivity and flexibility. On the other hand, mechanistic enterprises typically can only improve productivity and never fully realize flexibility benefits.

Exploiting complementarities requires co-ordination among separate functional areas. There is an increasing tendency for world-class manufacturers to introduce new products and new processes simultaneously[23-25]. Startup is particularly problematic when skills are inadequate[26]. Actively selecting and implementing courses of action that are complementary, not only at the level of manufacturing but rather in terms of the entire organization, creates competitive advantages. However, exploiting such an extensive system of complementarities requires a multi-disciplinary team to provide substantial co-ordination. CAD-CAM is an example of such a complementary technology. Schlumberger Well Services, a major supplier of oil-field equipment, using complementary advanced manufacturing technologies (e.g. CAD-CAM) is now able to process 300 engineering change notices compared to only 100 prior to AMT implementation[27]. More importantly, the change cycle has decreased from six weeks to less than one week. Consequently, by functionally integrating both product innovation and AMT, organizations create powerful competitive advantages.

Preventing accidental impacts requires an organizational perspective. Developing technical changes independently of organizational changes increases dramatically the probability of accidental impacts[28]. Anticipating changes in organizational structure, job design, communication patterns, and interorganizational relationships minimizes the probability of AMT failure. However, no matter how well managed AMT project implementation is, accidental impacts occasionally do arise and surprise both system designers and managers[28]. Accidental impacts typically occur when designers view their job technically, as opposed to organizationally. Guiding implementation by a technical perspective, system designers are neither ready for such impacts nor able to explain why they occur, regardless of whether they are favourable or unfavourable. Managing social impacts before making irreversible technical choices requires an organizational perspective. Since not all consequences are anticipated, monitoring projects for unintended side effects aids in keeping AMT projects on course.

Strategic Restructuring Requires Trust and Co-operation

To facilitate the physical, psychological, and cultural changes resulting from a strategic restructuring, management must build trust and co-operation. Planned restructuring coupled with attitude changes is vital to AMT success. Change involves considerable interaction and co-operation to alter the organization's decision-making, co-ordination, and control systems. Companies exhibiting adversarial relationships between various organizational entities rely heavily on formalized job designs and experience substantial organizational risk regardless of the project pursued[29]. On the other hand, management that has internalized the concepts of trust and co-operation allows employees to learn from their mistakes. A good example of trust is item number six of Edy's Grand Ice Cream's company philosophy which states, "Mistakes are opportunities for organizational learning[19]". Edy's workers refer to this

as failing forward. Management must trust employees enough to allow them to fail forward. A good example illustrating the benefits of co-operation is Martin Marietta Aero & Naval Systems' multi-disciplinary teams. Each project is spearheaded by a team, enabling Martin Marietta to bid 20 per cent to 30 per cent lower on some jobs thanks to cost reduction and manufacturing efficiency improvements[30].

Cumulative Advantage Requires Fast Organizational Learning

Emerging innovations have complementarities, making previous experiences relevant to new learning situations[2]. Past cumulated learning creates advantages by magnifying initial differences in innovation adoption. Past success in introducing AMT particularly seems to have benefits. Cumulative advantages accrue to fast learners since innovations that lead directly to lower unit costs also generate other benefits such as the ability to automate and respond flexibly and quickly to changing market demands. As the speed of change and the knowledge intensity of production increases, the effect of differences in knowledge becomes potent. Although cumulative advantages are not necessarily permanent, they can be long-lasting, particularly if competing organizations have greater degrees of inertia.

Flexibility and Integration Requires Teamwork

Flexibility is people driven. Flexibility requires more than the acquisition of financial and physical resources; it requires teamwork. Managers understandably have difficulty initially with team building. A manager builds a team, yet a manager works every day with individuals[31]. Nevertheless, team building is very important to AMT success. Teams operating in an AMT environment encounter change daily. Moreover, change is the only constant. Managers expecting perfection only set up teams for failure. A constantly changing definition of perfection demotivates team members. However, properly conducting team building tends to create environments in which employees have greater morale, productivity, and pride. Teams tend to break down organizational barriers, resulting in a more flexible enterprise. Some companies extensively use self-directed teams. For example, all workers at Edy's Grand Ice Cream and John Crane Belfab are members of self-directed teams. Unisys Corp.'s Government Systems Group, Marlow Industries Inc., and Johnson & Johnson have 75 per cent, 50 per cent and 24 per cent of their workers respectively as members of self-directed teams[19].

Continual and Rapid Improvement Requires Education and Training

Previously, training consisted of one-time investments that concentrated on shallow process knowledge designed to provide workers skills required to perform isolated tasks; education for practical purposes was non-existent. Automating routine tasks effectively increases the complexity of the remaining jobs. Thus, AMT requires greater technical, conceptual, analytical and problem-solving skills. In fact, the most important variable cost associated with

AMT may well be training and education costs[9]. However, these costs are well spent since education and training provides direction so employees do not drift into pursuits counter to organizational goals.

Knowledge conquers fear. Education and training provide employees with the knowledge of how to learn to operate within an AMT environment. With AMT, employee skills move from being behavioural and experienced-based to attitudinal, cognitive, and social[32]. Education and training provides the groundwork for social subsystem adjustments and must be customized and timely. Allen-Bradley, a subsidiary of Rockwell International Corp., believes training is so critical that it created, with the help of the Milwaukee School of Engineering, a novel educational partnership[33]. This programme teaches basic mathematics skills and familiarizes employees with circuit technology. Other firms are just as serious about training. For example, Exxon Chemical Co. invests 20 days annually for employee training and education.

Productivity Requires Automation to Empower People

The president of UAW local 1853 states, "Technology, by itself, offers a limited competitive advantage, but when leveraged by the power of people's minds, the result can be a winning execution as well as a process of continuous improvement"[34]. AMT should leverage employee knowledge, creativity, and initiative. Increasing productivity is the objective, not replacing employees. After purchasing and installing automation, management's job does not end; rather it just begins. AMT requires continuous management just like any resource. However, leaving control of technology strictly to technicians often results in isolated tasks being optimized.

Kenneth Van Winkle, the manager of furniture manufacturing systems at Kimball International Inc., is responsible for CIM implementations in 20 manufacturing plants. Concerning Kimball's CIM operations, he states, "Whereas some companies have replaced people with robots, we have empowered people with information … To us, the most important elements of CIM are the business processes that you develop. They are what drives the whole people process"[10]. AMT projects often positively impact employees, particularly if personnel and machines are utilized in a complementary manner. The implementation of an AMT project should use machines to enhance task consistency and efficiency while utilizing workers' decision-making flexibility to improve productivity.

Change Requires Supportive Performance Measurement and Reward Systems

During AMT implementation, organizational policies designed to protect and insulate existing systems provide incentives for resistance to change. AMT expands job functions, creating new roles, but often performance measures and rewards do not change. Historically, time-contingent pay reflected the lack of employee discretion; previously, employees were mainly rewarded for attendance[35]. AMT, on the other hand, values co-operation rather than competition. Furthermore, AMT projects place great demands on

the organization since jobs that are not eliminated are often greatly enhanced and enlarged. Consequently, workers must be more responsible, co-operative and skilled, particularly in decision making[36]. To motivate employees properly to be multi-functional, flexible and interdependent, new compensation programmes need to be implemented that reflect the increased complexity and heterogeneous nature of new jobs. Furthermore, a firm must design rewards for pursuing long term plans; otherwise employees concentrate on short-term performance since the compensation system explicitly ignores long-term issues.

Automation Requires Fewer Management Levels

Taylor's principles of scientific management essentially reduce tasks to mindless repetition, preventing workers from making intellectual contributions. Rather than empowering workers, layer upon layer of management supervises production. This division between management and labour is the result of years of socialization in the belief that managers know it all and workers do it all.

AMT pushes decision making to lower levels, often making middle management obsolete. Middle managers who do remain become a resource for training and coaching employees rather than directing and controlling them. Consequently, reintroducing common sense requires dismantling institutionalized labour-management practices. The trend toward decoupling and downsizing further reduces the need for management layers. It is not unusual for firms to go from seven, eight, or even nine levels of management to as few as four or five[37]. For example, Unisys Corp.'s Government Systems Group reduced five management levels to three. In fact, not only are most organizations downsizing, decoupling, and disaggregating, the search for flexibility is producing a whole new organizational form that looks more like a network than a pyramidal hierarchy.

Understanding and organizationally internalizing the requirements for achieving AMT competitive advantages is essential for successfully deploying AMT. Creating an environment conducive to utilizing AMT fully requires a manufacturing strategy to be formulated. Next, the role of strategy in achieving AMT competitive advantages is considered.

The Role of Strategy

The principles of total quality management (TQM) need not only be applied to manufacturing; unquestionably, scrutinizing strategic planning using TQM principles is invaluable. This research models the strategic planning process as a six-phase procedure. Each phase transforms inputs into outputs; consequently, phases naturally have suppliers, customers (both internal and external), and products. The definition of quality varies substantially from phase to phase. Capturing the competitive advantages of AMT requires an understanding of the unique characteristics of each phase, particularly from a TQM perspective. The goal of the strategy formulation process is to create synergy. Moreover, AMT creates synergy if properly implemented.

Consequently, strategically planning AMT implementation is key to achieving AMT competitive advantages.

Strategic development consists of enterprise-level, corporate-level, business-level and functional-level strategies[38]. Enterprise-level strategies concentrate on the organization's interaction with its sociocultural environment whereas diversified firms or businesses pursuing growth through diversification create corporate-level strategies. Firms competing in a single domain construct business-level strategies while functional-level strategies specify how available resources are to facilitate overall business success. The proposed strategic formulation process primarily concentrates on business- and functional-level strategies. The procedure consists of vision foundation, strategic intention, environmental assessment, manufacturing design, operational delivery, and post-audit feedback. The last five phases comprise a cycle that essentially is a variant of plan-do-check-act (PDCA). As shown in Figure 4, strategic intention, environmental assessment and manufacturing design constitute the plan facet of PDCA. Operational delivery and post-audit feedback correspond to do and check respectively. The process of cycling through the strategic formulation process coincides with the act of PDCA.

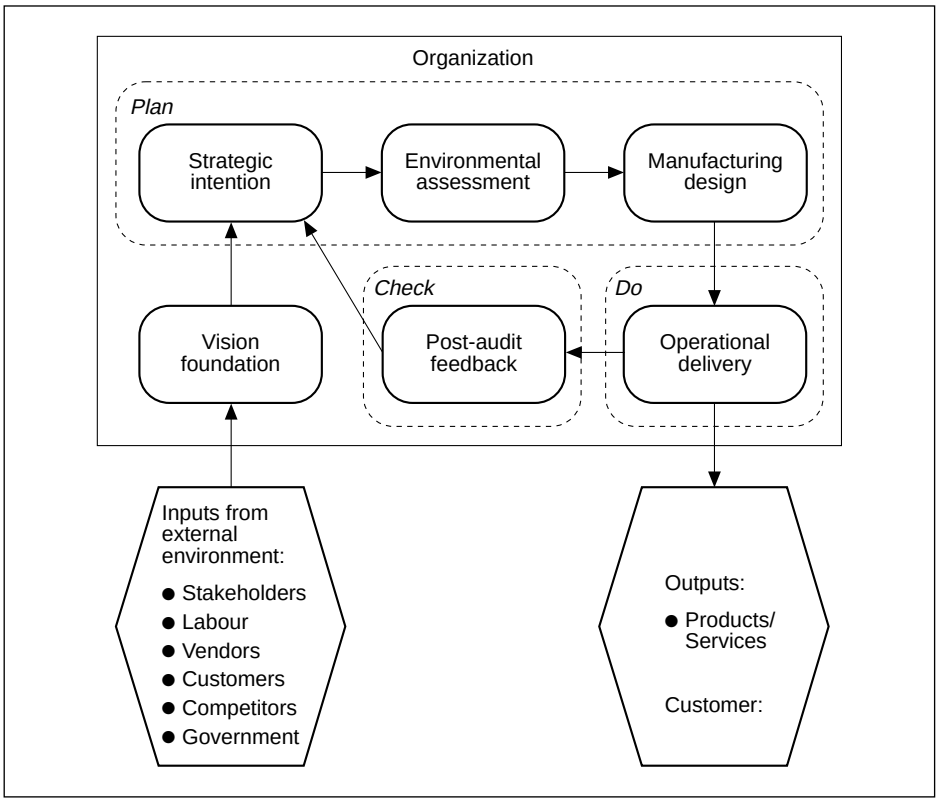

Figure 4.
Strategic Formulation Process

Modelling the six-phase strategy formulation procedure as a PDCA cycle clearly communicates the importance of continuous improvement. An alternative point of view partitions the six phases into two sets: phases primarily concerned with constancy of purpose, and phases maintaining consistency of purpose. Vision foundation and strategic intention primarily create constancy of purpose while the remaining phases maintain consistency. Considered next is the issue of creating constancy of purpose from a strategic perspective.

Vision Foundation and Strategic Intention

A vision creates constancy of purpose. Notwithstanding the many policy issues and details involved in the creation of a strategy, a creative vision that is clear, challenging, coherent, consistent and realistic must guide the strategy formulation process. A vision does more than describe current operations. Rather, it is a crisp, inspirational statement that galvanizes employees. A great vision is so fundamental that it lasts for decades. A vision is similar to both a compass and beacon; it provides direction and a destination in the wild and stormy global competitive markets. Competitive advantages resulting from analysis and reacting to rivals are transparent and, ultimately, short lived. Only creative visions, and derived creative strategies, hold the key to future business success. Essentially, organizations must create a vision rather than merely react[39]. Consequently, a creative vision is imperative for achieving competitive advantages of AMT.

A vision is a single overarching manifesto encompassing three major components: vision foundation, strategic intention and strategic statement. Each component corresponds to a unique phase. Vision foundation embodies both mission and philosophy; strategic intention incorporates goals and policies; the strategic statement encompasses objectives and methodology. An alternative decomposition partitions a vision into leadership and management concepts. Leadership concentrates on doing the right things whereas management attends to doing things right. Mission, goals and objectives espouse leadership while philosophy, policies and methodologies support management. A true corporate leader uses all vision components to guide and empower a company.

A mission defines why an organization exists – what distinguishes an organization from other similar enterprises. The philosophy explains how the organization should act. The vision foundation combines the two into a statement of what the organization wants to be. Mission and philosophy are timeless. The primary mission statement components are: purpose; principal business aims; and corporate identity. There are four fundamental approaches to setting a mission:

(1) targeting;
(2) common enemy;
(3) role model; and
(4) internal transformation[40].

Introducing AMT into an organization often requires an internal transformation involving a dramatic organizational restructuring.

Strategic intention follows vision foundation and consists of creating goals and policies. Both policies and goals provide constancy of purpose by respectively communicating how business activities are to function, and expected long-term accomplishments. Although setting a course today to be in business tomorrow is important, maintaining consistency of purpose is equally important. Consistency of purpose strives to reduce the spread around the course. Managing the variance is often much more difficult than managing the centre. Furthermore, short-term measures have long-term impacts; consistency of purpose ensures that the strategic course is efficiently traversed. Environmental assessment, discussed next, is the first of four phases designed to maintain consistency of purpose.

Environmental Assessment

Environmental assessment essentially is strategic reconnaissance; it provides the vital information of the strategic terrain required to construct the strategic statement. The strategic statement addresses two basic questions:

(1) What should the business accomplish in the scheduled time period?

(2) How should the business achieve these objectives?

In short, the strategic statement designates who does what by when. Strengths and weaknesses of an organization's managerial, technical, financial and human resource capabilities largely determine potential short-term environmental opportunities.

From a TQM point of view, objectives and methodology are products of the environmental assessment. As with all transformation processes, high-quality raw materials are prerequisites. The vision statement, strategic intention and external environmental information are the raw materials of environmental assessment. Forecasts of technology and markets, based on these raw materials, constitute the foundation for product and process proposals.

Ideally, a cross-functional strategy steering committee, headed by the CEO, develops strategic guidelines and budgetary constraints designed to guide functional areas such as manufacturing and marketing. The ultimate product of environmental assessment, the strategic statement, incorporates these guidelines and constraints (see Figure 5). A cross-functional team facilitates AMT implementation by removing impediments. For example, a cross-functional steering committee breaks down traditional barriers and orients attitudes towards a positive win-win direction. In turn, this encourages vital internal feedback from all functions concerning strategic progress. Teaching strategic planners structured problem-solving skills minimizes pride in hunches and intuition, creating a fact-based strategic plan.

Environmental assessment consists of scanning and analysis. The strategy steering committee defines broad objectives based on process inputs (i.e. vision foundation, strategic intention and external environmental information).

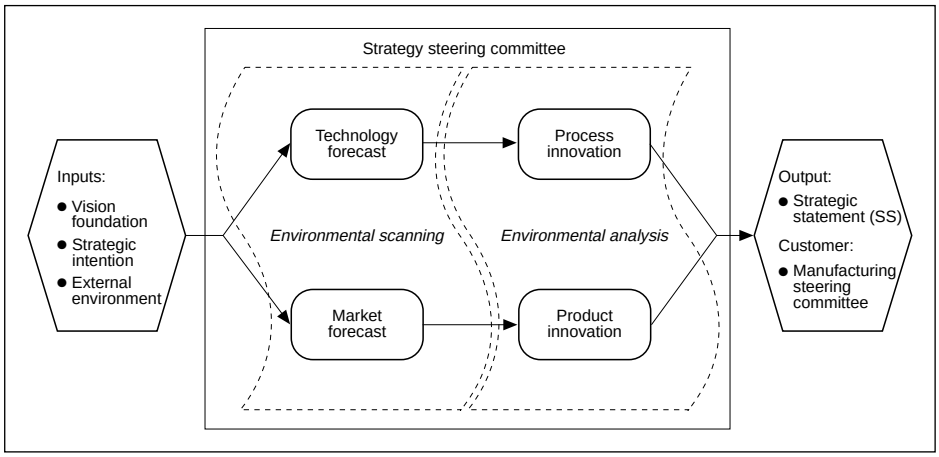

Figure 5. Environmental Assessment

Subsequently, environmental scanning synthesizes information gathered pertaining to external threats and opportunities to the firm's core competences. Market forecasting predicts the growth potential of existing and proposed products. Sales personnel, customers, suppliers and new hires are all invaluable sources of product, market, and technological information.

Successful development of effective manufacturing technology strategies, particularly with respect to AMT, requires a considerable amount of external information concerning both current and future process technologies. Technology is so complex, dispersed and expensive that no organization can be world-class in all technologies. Sharply focusing technology forecasts on key core technologies that offer the greatest competitive advantage greatly enhances chances of organizational success. Forecasting formally defines potential future technology states. A necessary but not sufficient condition for technological innovation is the perceived existence of potential demand. Firms within the same industry face a common set of technological opportunities. However, clearly technological differences do exist and are attributable to a firm's competences, capabilities, and strategies[41]. Prototyping potential core technologies facilitate organizational learning.

The market and technology forecasts obtained during environmental scanning provide the impetus for the product and process innovation proposals created during analysis. Proposals concentrate on elements critical to the firm's future competitiveness. In order to produce products designed for manufacturability, product innovation proposals consider both current and future manufacturing processes. In addition, manufacturing process proposals should take into account future product mixes. Therefore, conducting a thorough qualitative and quantitative analysis of current and proposed operations ensures development of products congruent with manufacturing processes. Consequently, product and process innovation proposals should

match existing and future competitive advantages with the opportunities identified during market and technology forecasting.

The strategic statement combines the results of both scanning and analysis. Obviously, the strategic statement evolves over time as technology, consumer expectations, and resources change. Objectives provided by the strategic statement provide guidelines for evaluating product and process innovation proposals based on their compatibility with the corporate vision, available scarce resources and perceived competitive advantages. Historical statistics, market opportunities, and organizational competences and resources, as documented by analysis of internal capabilities, provide valuable input for evaluating proposals. Upon completion of the environmental assessment, the manufacturing steering committee receives the strategic statement as well as the innovation proposals.

Obviously, translating strategies into action requires coupling strategies with functional plans. As discussed next, manufacturing design produces a functional-level plan referred to as the manufacturing strategic statement (MSS). The manufacturing strategic statement specifies allocation of available resources so as to achieve strategic objectives. The MSS concentrates on current operations and has a shorter planning horizon than does the strategic statement.

Manufacturing Design

Strategically managing an organization extends the responsibilities of strategic managers beyond planning to design. Design matches external environmental opportunities with internal organizational capabilities. Figure 6 highlights the manufacturing design phase. During environmental assessment, planners focus largely on "what" questions whereas during design the emphasis is on "how". Analysis during design should be substantive and act as glue, creating an organizational plan by binding together individual decisions[42]. Consequently, the goal of the manufacturing strategic statement (MSS) is to move an organization in the direction charted by the strategic statement and corporate vision.

As indicated earlier, proposals are passed to the manufacturing steering committee. This functional team formulates and solves macro AMT planning

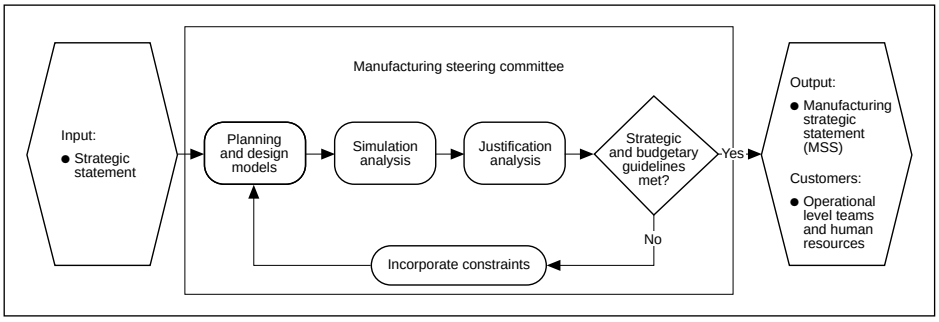

Figure 6.
Manufacturing Design

and design models. Subsequently, simulation analysis determines overall feasibility and operational impact of AMT proposals. Modelling reveals invaluable information about operating characteristics before substantial outlays occur. Simulation analysis evaluates and documents such issues as downtime, reliability, throughput, bottlenecks, and product mix. Both modelling and simulation are concerned with technical completeness and rigour.

Justification analysis begins by soliciting reputable AMT vendors. This request for information includes all potential acquisition costs, both direct and indirect. After estimating relevant costs, a cash flow analysis is performed. The two general types of investment appraisal techniques are financial and strategic. If both financial and strategic evaluations indicate the same course of action, then no conflict reconciliation procedure is required. However, conflicts are quite common, in which case issues other than the obvious budget constraints become important. Such issues include, but are not limited to:

(1) process reliability and product quality standards;

(2) compatibility with existing and planned operations; and

(3) flexibility to accommodate expected product mix and product design changes.

If an AMT proposal fails to meet the strategic and budgetary guidelines, new constraints are incorporated and the modelling process cycles.

During manufacturing design, the steering committee examines its strengths, weaknesses, opportunities, and threats. Subsequently, product and process innovation proposals are prioritized in terms of risk and resources required. Examining existing project mix and resource capacity, the manufacturing steering committee escapes the crisis management of a poorly selected collection of *ad hoc* projects. Instead, the committee manages a robust set of projects congruent with the strategic statement and corporate vision.

In the process of creating the MSS, the steering committee should consider particularly undesirable alternatives and why they are so undesirable, as well as undesirable consequences of the proposed project mix. This self-reflection helps identify issues that would otherwise be omitted. However, leaders do the right things; managers do things right. The committee must resist the temptation of over-justification, tampering and micro-analysis. When evaluating and prioritizing proposals, the steering committee must continually remember that they are in a position of leadership, not management.

Operational Delivery

Historically, management considered the choice or adoption of new technology to be paramount, shamefully neglecting implementation. Porter pointed out that a firm's performance is just as dependent on the implementation of a business' strategy as it is on the selected strategy itself[43]. Factors affecting operational delivery include education, training, personnel selection, motivation systems, and job and organization structure. In fact, many of the requirements

for achieving AMT competitive advantages discussed earlier affect operational delivery. Since this article is concerned primarily with achieving AMT competitive advantages, this work will focus strictly on the role of education and training.

Ongoing education and training is an effective means of overcoming cultural barriers of AMT. However, management often grossly underestimates the cost and time involved in educating and training workers. Education re-orients employees towards required organizational restructuring by motivating employees to be committed to change. Education accomplishes its objectives by openly and honestly addressing the issues of job security, job redesign and job position[44]. Training provides cognitive, cross-functional, evolutionary learning of procedural and functional knowledge of AMT[44]. Properly educating and training employees, in itself, creates a competitive advantage. Measuring the success of operational delivery is the task of the next phase – post-audit feedback.

Post-audit Feedback

Post-audit feedback concerns two types of control: strategic and operating. Strategic control feedback monitors, measures, and evaluates, often qualitatively, how well ongoing operations satisfy external customers, whereas operating control feedback focuses on internal customers. Both controls are required in order actively to anticipate and close strategic and operational gaps.

Upon completion of the post-audit feedback phase, the planning process repeats itself. Table II summarizes the products of each phase of the strategy formulation process. Strategic planning provides an organization with the ability to anticipate and cope with change. In an AMT environment, this is extremely important to achieving competitive advantages.

Concluding Remarks

Companies seeking to compete against the world's most imaginative and competent competitors, in sophisticated and demanding markets, create sustainable global competitive advantages[45]. World-class manufacturers realize that the only constant is the need to satisfy customers. WCM systems are flexible, timely, and responsive. Installing AMT, in itself, is not enough to create a WCM system; technology is neutral. In order to achieve a unique and sustainable source of competitive advantage, organizations must leverage their human capital.

How successful AMT is at achieving competitive advantages depends primarily on correctly selecting and properly managing AMT projects that enhance an organization's core competences. Management practices are key to successful AMT implementation; and even though AMT places great emphasis on the use of technological innovation, management's fundamental role is to build trust and co-operation, change negative attitudes, educate and train, and enhance team building. It is imperative that the decisions to invest in AMT and the subsequent roles of management are strategically directed.

Purpose	Phase	Product	Description
Constancy	Vision foundation	Mission	Mission describes the business' primary purpose of existence
		Philosophy	Philosophy is concerned with the business' shared values and beliefs. Issues of concern include equal opportunity, honesty, and integrity
	Strategic intention	Goals	Goals state what is to be achieved through long-term sustained effort. Issues of concern include market share, profitability, productivity, and growth. Goals should be clear, acceptable, flexible, achievable, and action-oriented
		Policies	Policies communicate how business activities are to function by providing general guidelines that establish decision-making limits or boundaries designed to channel management thinking
Consistency	Environmental assessment creates strategic statement (SS)	Objectives	Objectives consider what is to be achieved in the scheduled time period and should be definitive, specific descriptions of accomplishments or results, not activities. Objectives should be measurable and are concerned with such issues as productivity, profitability, efficiency, and growth
		Methodology	How objectives are to be achieved is referred to as methodology
	Manufacturing design creates manufacturing strategic statement (MSS)	Process choice	Process choice specifies which processes are to be pursued given such issues as capacity, technology trade-offs and make versus buy
		Infra-structure changes	Infrastructure specifies what work and organi-zational changes will be made. Issues of concern include compensation, quality assurance and control, and functional support
	Operational delivery	Education programme	Education reorients employees towards organi-zational restructuring by fostering motivation and commitment for change. Education addresses job security, job redesign, and job position
		Training programme	Training provides cognitive, cross-functional, evolutionary learning of procedural and functional knowledge of AMT
	Post-audit feedback	Strategic control feedback	Strategic control feedback monitors, measures, and evaluates, often qualitatively, how well ongoing operations satisfy external customers
		Operating control feedback	Operating control feedback monitors, measures, and evaluates how well ongoing operations satisfy internal customers

Table II. Product Descriptions of Six-phase Strategy Formulation Process

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