

**THE U.S. MANUFACTURING RENAISSANCE:  
MORE FOLKS ARE TALKING ABOUT HEAVEN  
THAN GOING THERE**

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## Introduction

Fundamental changes in product, process and organization have rocked the manufacturing industry of this country during the last decade. In an effort to document the nature and extent of these changes, we conducted a survey of senior manufacturing executives. We wanted to determine exactly how U.S. manufacturing companies were changing and why. Our specific goals were (1) to document the nature and extent of technological change that has occurred since 1980, (2) to determine the likely direction of change through 1990, and (3) to compile opinions both on the strategic issues facing the industry and on the keys to success in dealing with these issues.

The study was undertaken in two phases (see Insert A for details). First, personal interviews with some 50 senior manufacturing executives were conducted to surface the variety of facts, beliefs, and concerns held by this sample of managers. A questionnaire based upon interview findings was then developed and distributed to 1500 CEOs in an effort to document how widely the opinions of our sample were held.

The interviews uncovered dramatic examples of productivity improvement:

- o Line workers had been reduced from 360 to 10 with a 100 percent increase in production through application of robotics.
- o Raw material inventories had been reduced from more than 10 weeks to less than 3 days.
- o A machine set-up time had been reduced from 2 hours to 12 minutes.
- o Work-in-process had been effectively eliminated as a production cycle was reduced from more than 2 days to less than 30 minutes.
- o Product cost of an assembled product had been reduced from more than \$600 to less than \$150 through use of a multi-discipline design

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INSERT A  
THE FACT GATHERING PROCESS

The Executive Interviews

Fifteen manufacturing organizations, with annual sales ranging from \$100 million to \$50 billion participated in the Phase 1 study. The companies represented a broad cross section of products (capital, industrial, and consumer goods), industries (automotive, steel, electronics, rubber, plastics), and production processes (one of a kind through continuous process). A structured interview process was used to discuss the nature of the company's strategic management process, impediments to change in a manufacturing firm, and tactics or advice for success in accomplishing strategic change.

Typically interviewed were:

- o the CEO, as the the primary architect and mover for strategic change,
- o the chief planning officer, where one was used to facilitate the planning process,
- o the chief financial officer, who provided the structure used to analyze strategy alternatives and the information used to monitor strategy implementation, and
- o one or more operating executives, who had been responsible for the implementation of corporate strategy.

Each interview required approximately 90 minutes and confidentiality was assured. The executives came from a wide range of industry experience and educational backgrounds. Each had been provided in advance with a description of our purpose and of the areas in which our questions would delve. All interviews in a business unit were completed in one or two days and were complemented with a tour of the firm's manufacturing facilities.

The CEO Questionnaire Study

The CEO questionnaire was designed to more precisely document opinion on fundamental strategic issues facing manufacturing companies and to calibrate the nature, direction and extent of strategic change. The survey consisted of 30 multi-part questions divided into 5 sections:

- Section 1: Competitive pressures upon the firm.
- Section 2: Past attempts and future plans to improve competitiveness.
- Section 3: Description and critique of the strategic planning process.
- Section 4: Attitudes toward strategic planning and change.
- Section 5: Factual information about the firm.

Survey questions were pretested on industry representatives and refined with the help of survey specialists at the University of Michigan's Institute for Social Research. Questionnaires were then mailed to the CEOs of the 1500 largest U.S. based manufacturing firms. One hundred and eighty usable questionnaires were returned. The average annual sales for the business units analyzed was \$1.6 billion and the return on sales was 10.5 percent. Respondent titles were as follows: Chairman (10%), CEO (14.4%), President (11.7%), Group VP (15.5%), GM/Director (10%), VP (25.6%), Other (12.8%).

team composed of representatives from marketing, manufacturing, engineering and accounting.

- o A total work force reduction of 60 percent had been achieved with no drop in production.
- o Quality control inspectors were totally eliminated because the finished product simply had no defects.

Recurring themes for profit improvement emerged from the interviews: innovate process, enhance quality, eliminate inventory, reduce direct-labor and slash overhead. However, no agreement was found on the extent of real change that had taken place within U.S. manufacturing as a whole, nor on what future actions were most needed to assure a firm's survival in the 1990s. The large sample questionnaire described in Insert A was designed to explore these issues.

The questionnaire asked CEOs to identify areas in which substantial company effort for profit improvement had been invested over the past three years. They were asked also to identify those efforts that had been most successful or disappointing, as well as those that held the greatest hope for improvement in the future. The one hundred and eighty responses summarized by Table 1 paint a clear picture of a manufacturing strategy widely adopted by U.S. manufacturing firms in the 1980's:

The dominant manufacturing strategy of the 1980's has been one of dramatic quality improvement coupled with significant cost reduction achieved through the elimination of inventories and the slashing of direct-labor content. The dominant market strategy has been to increase market share while offering new products into the market. Strategy implementation has been characterized by substantial

**Table 1**  
**Past Efforts To Improve**  
**Company Competitiveness**

Substantial Effort (Number of Respondents)			Percent of Those Who Tried	
			Rewarding Results	Disappointing Results
<b>Quality Improvement</b>				
a.	123	–Quality Circles/Worker Involvement.....	72	23
b.	108	–Statistical Quality Control.....	81	11
c.	95	–Vendor Quality Control.....	75	9
<b>Inventory Reduction</b>				
d.	125	–Raw Material.....	82	11
e.	116	–Work in Process.....	75	18
f.	115	–Finished Goods.....	71	24
<b>New Investments</b>				
g.	127	–Plant and Equipment.....	85	10
h.	111	–Research and Development.....	69	24
i.	78	–Education/Retraining.....	74	21
<b>Manufacturing Reorganization</b>				
j.	98	–New Management Team.....	80	10
k.	33	–New Incentive System.....	70	21
l.	69	–New Labor/Management Relationship.....	78	16
m.	106	–Work Force Reduction.....	90	8
n.	48	–Labor Cost Concessions.....	71	27
o.	68	–Plant Closings.....	85	9
p.	25	–Plant Relocation.....	80	12
q.	69	–Job Automation and Robotics.....	73	16
<b>New Information Systems</b>				
r.	55	–Integration with Customers.....	69	22
s.	35	–Integration with Suppliers.....	74	23
t.	66	–Integration Across Business Functions.....	65	26
u.	87	–Computer-Aided Design (CAD).....	79	9
v.	59	–Computer-Aided Manufacturing (CAM).....	71	19
w.	116	–Production/Inventory Control.....	74	21
x.	73	–Warehousing/Distribution Control.....	80	14
y.	77	–Product Cost Accounting.....	65	27
<b>New Market Strategy</b>				
aa.	118	–Increase Share of Current Market.....	60	32
bb.	71	–New Markets for Current Products.....	63	27
cc.	119	–New Products for Current Markets.....	82	11
dd.	68	–New Products for New Markets.....	72	27
ee.	21	–Backward Integration Toward Suppliers.....	62	29
ff.	33	–Forward Integration Toward Customers.....	64	24
gg.	24	–Lateral Integration with Other Business Units...	71	25
hh.	47	–Narrowing Product/Market Focus.....	81	13

investments in plant, equipment, R&D, and manufacturing control systems, and has been punctuated by replacement of the management team. Greatest disappointment was experienced in attempts to increase market share, to reduce finished goods inventory, to involve workers in quality improvement programs, and to achieve anticipated payback from research and development expenditures.

The levels of investments projected for the future match closely those reported for the past (see Table 2). Efforts at quality improvement will continue; additional emphasis will be placed upon control of quality in vendor products; and worker cooperation in quality assurance programs is seen as essential for their success. The emphasis on reducing work in process and finished goods inventory will continue. Significant, but reduced, efforts will be directed at: the control of raw material inventories, investment in new plant and equipment, and reductions in work force. Deemphasis of the latter areas is consistent with the success reported on past efforts. Significantly fewer plant closings and less turnover of management teams are anticipated. A noticeable increase in investment is projected for: job automation and robotics, continuing employee education, computer aided manufacturing, and integrative information system to improve communication with customers and suppliers. Continued efforts to capture market share and to provide new products to current customers is considered important. New markets will be addressed with new and existing products.

Table 3 summarizes the net effects of past changes and investments. On average the respondents had had increases in capital investment, production capacity, capacity utilization, offshore production, labor/management cooperation, and reductions in the sizes of middle management and the total



**Table 2**  
**Future Plans To Improve**  
**Company Competitiveness**

	Will be Emphasized (Number of Respondents)		Most Important  (Percent of Those Who Will)
<b>Quality Improvement</b>			
a.	114	–Quality Circles/Worker Involvement.....	80
b.	102	–Statistical Quality Control.....	58
c.	108	–Vendor Quality Control.....	57
<b>Inventory Reduction</b>			
d.	105	–Raw Material.....	49
e.	118	–Work in Process.....	61
f.	112	–Finished Goods.....	59
<b>New Investments</b>			
g.	103	–Plant and Equipment.....	65
h.	109	–Research and Development.....	73
i.	94	–Education/Retraining.....	67
<b>Manufacturing Reorganization</b>			
j.	35	–New Management Team.....	63
k.	32	–New Incentive System.....	59
l.	52	–New Labor/Management Relationship.....	85
m.	74	–Work Force Reduction.....	57
n.	30	–Labor Cost Concessions.....	57
o.	18	–Plant Closings.....	50
p.	20	–Plant Relocation.....	50
q.	87	–Job Automation and Robotics.....	71
<b>New Information Systems</b>			
r.	76	–Integration with Customers.....	58
s.	53	–Integration with Suppliers.....	60
t.	68	–Integration Across Business Functions.....	62
u.	77	–Computer-Aided Design (CAD).....	48
v.	71	–Computer-Aided Manufacturing (CAM).....	66
w.	103	–Production/Inventory Control.....	60
x.	56	–Warehousing/Distribution Control.....	46
y.	80	–Product Cost Accounting.....	50
<b>New Market Strategy</b>			
aa.	114	–Increase Share of Current Market.....	78
bb.	77	–New Markets for Current Products.....	65
cc.	122	–New Products for Current Markets.....	79
dd.	83	–New Products for New Markets.....	70
ee.	16	–Backward Integration Toward Suppliers.....	63
ff.	36	–Forward Integration Toward Customers.....	69
gg.	28	–Lateral Integration with Other Business Units...	61
hh.	27	–Narrowing Product/Market Focus.....	63

**Table 3**  
**What has Happened To This Business**  
**In The Last Three Years?**

	Average Rating	Percent by Rating				
		Substantially Decreased	About the Same		Substantially Increased	
			1	2		3
a. Sales Volume in Units.....	3.76	3.4	7.3	31.1	26.0	32.2
b. Profitability.....	3.62	11.4	10.2	17.0	27.8	33.5
c. Capacity Utilization.....	3.45	6.8	10.8	32.4	30.1	19.9
d. Production Capacity.....	3.60	2.3	8.0	37.4	32.2	20.1
e. Offshore Production.....	3.52	4.7	3.1	43.4	33.3	15.5
f. Size of Labor Force.....	2.69	10.8	40.3	25.6	15.3	8.0
g. Size of Middle Management...	2.75	9.7	30.1	40.3	15.3	4.5
h. Labor/Mgmt. Cooperation....	3.57	1.1	1.1	46.3	42.9	8.6
i. Capital Investment.....	3.71	2.3	9.6	28.8	33.9	25.4
j. Share of Market.....	3.47	0.6	4.6	57.6	32.0	10.3
k. Number of Competitors.....	3.15	1.7	15.4	56.6	18.9	7.4
l. Total Industry Capacity.....	3.32	3.4	13.6	42.6	28.4	11.9

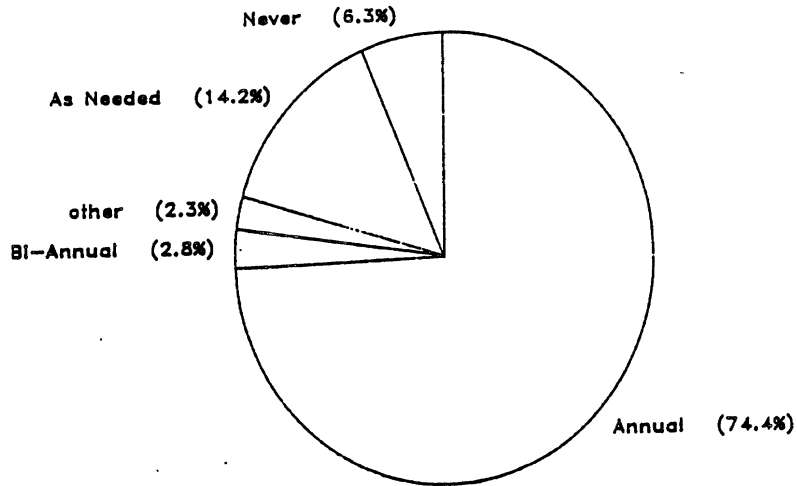
labor force. Since sales, market share, and profit had each increased on average it could be argued that these actions are a prescription for performance improvement. However, a closer analysis of the respondent data reveals that the cure to U.S. manufacturing problems may not be quite so simple.

### **More Folks Are Talking About Heaven Than Going There**

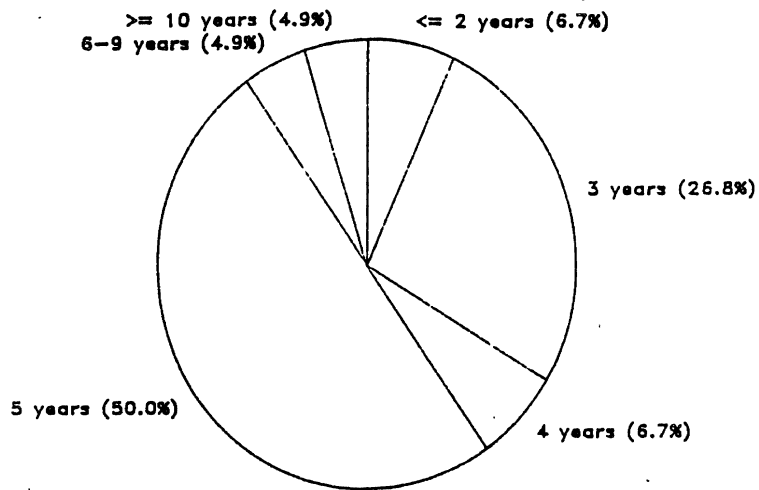
Over the years, we have observed a number of companies who "on average" were doing the "right things," and yet losing ground to their competitors. They planned seriously, invested heavily and worked hard, yet they appeared no better off for their efforts. To test the hypothesis that successful companies had in fact pursued strategies distinct from other firms, we divided the questionnaire respondents into "profitable" and "unprofitable" firms. We wanted to know if the profitable companies had concerns that were unique. Did they plan differently or more frequently? Were their strategic efforts different or considered more successful? Had they invested more (or less) in new facilities, equipment or systems? To what did they attribute past success? What was their view of the future? Did they have novel plans for new investments? Some answers were surprising.

We isolated profitable firms based upon total profit as well as the ratio of profit to sales. We found no significant differences in the nature of their strategic planning process. Figure 1 shows the typical company produced a 5-year strategic plan of 10 to 50 pages on an annual basis. As summarized in Table 4, our respondents graded the process as somewhat formal but reasonably fast and participative. The cost to the company was considered modest while the resulting plan was believed to be of good quality with a reasonably tight linkage to the subsequent operating plan. The respondents

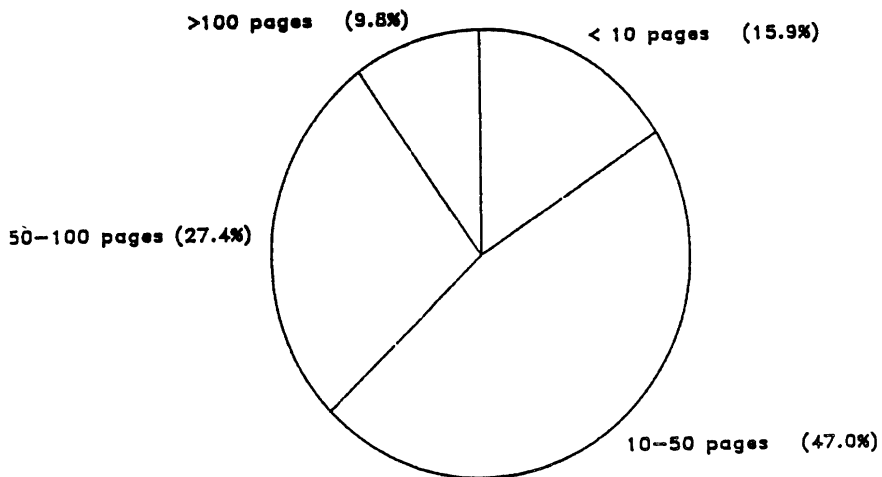
# Figure 1 Planning Process Statistics



Frequency of Strategic Planning



Strategic Planning Horizon



Length of the Planning Document

**Table 4**  
**Ratings Of The Company's**  
**Strategic Planning Process**

	Average Rating	Percent by Rating				
		Little 1	2	3	4	Great 5
a. Amount of Planning.....	3.64	2.8	9.7	28.4	39.2	19.9
b. Formality of Process.....	3.48	Informal 7.9	13.5	21.3	37.1	Formal 20.2
c. Speed of Process.....	3.07	Slow 4.5	20.9	44.1	24.3	Fast 6.2
d. Leadership Style.....	3.69	Directive 3.4	13.0	20.3	37.3	Participative 26.0
e. Linkage to Operating Plans.....	3.97	Little 1.7	5.1	22.0	37.3	Great 33.9
f. Cost to Company.....	2.38	Low 18.6	41.2	25.4	12.4	High 2.3
g. Value of Process This Year.....	3.56	Low 4.0	11.3	27.7	39.0	High 18.1
h. Value of Repeating Next Year.....	3.84	Low 6.3	4.5	22.7	31.8	High 34.7
i. Adequacy of Process.....	3.58	Need less 0.0	6.2	43.8	35.4	Need more 14.6
j. Quality of Company Data Used.....	3.67	Inaccurate 2.3	8.5	26.7	44.9	Accurate 17.6
k. Quality of External Data Used.....	3.14	Inaccurate 0.6	20.7	45.4	30.5	Accurate 2.9
l. Quality of the Resulting Plan.....	3.52	Low 1.7	5.7	38.6	46.6	High 7.4
m. Your Enjoyment of the Process.....	3.85	Dislike 2.3	6.8	22.0	41.2	Enjoy 27.7

believed that substantial planning was performed within their companies already but that even more was needed. The planning process was rated as enjoyable and of significant value; repetition of the process was expected to be of even more value in the coming year.

We did find a statistically significant positive correlation between business unit profit and spending on new equipment, facilities and research and development. In addition, profit growth had a strong positive correlation with growth in: market share, capital investment, sales volume, production capacity, capacity utilization, labor/management cooperation, size of labor force and the size of middle management. No relationship surfaced between growth in profit and offshore production, number of competitors or total industry capacity.

Notice in particular that there was a positive relationship between profit growth and growth in both labor and middle management. While this is reasonable since both sales and production were up for these companies, it runs counter to the full sample statistics that showed profits to be up, while the size of both labor and management were down. The refined data analysis revealed also that companies with substantial profit growth were little concerned with competitor price pressure and overhead costs. Rather they were most concerned with product innovation and the possibility of management obsolescence.

To contrast companies with recent differences in performance, two additional groups were extracted from the sample: those who reported a substantial increase in profits in the last three years and those with a substantial decrease. We compared the areas in which these groups had attempted to improve their competitiveness.

The less successful companies reported applying effort in as many areas as the successful ones. The focus and intensity of effort differed however. Profitable companies placed more emphasis on inventory reduction, plant and equipment investments, labor/management relations improvement, robotics, and non-accounting oriented information systems. On average they applied more effort to increasing their market share, to opening new markets and to introducing new products. They were also more satisfied with their efforts in finished inventory reduction, plant and equipment investments, employee education, labor/management relations, and new investments in integrated information systems.

The profitable companies' relationships with their employees were different in a number of dimensions as well. They reported greater satisfaction with worker involvement in quality improvement programs and higher investments in employee education. They were less likely to have focused substantial effort on workforce reduction or wage concessions, and yet more satisfied with the results of such efforts when they did. Finally, profitable companies were much more likely to have established new labor/management relationships and much more satisfied with the results.

Given such a variety of facts, are there common threads that link the findings together? What implications for management action can be drawn? The following section summarizes our beliefs.

#### Advice for Senior Management

Statistical correlation does not imply a cause-and-effect relationship, and therefore one needs to be cautious in drawing conclusions from any survey data. Our results do not "prove," for example, that investments in information systems and employee education have led to the increased earnings

of the profitable companies. A cynic might argue alternatively that the profitable companies simply had more earnings to squander on computers and education. While our beliefs on the nature of strategic change and the keys to its successful management are thus not provable in an academic sense, still they are strongly held. Our original textbook understanding evolved considerably during the fifty personal interviews held before the design of our questionnaire. Moreover, our interpretations of the resulting data were tested and refined through frank discussion of preliminary conclusions with groups of senior managers in dozens of meetings held subsequently. Our beliefs therefore are a summarization of the reflection and advice provided by the executives who participated in our study.

A section of both our interviews and the questionnaire dealt with the dynamics of change management. Specifically, we had asked each executive to describe the advice they would offer to a young manufacturing CEO attempting to lead strategic change. At the heart of their answers lay a simple but powerful prescription: Three key ingredients are required to accomplish strategic change in a manufacturing company today; they are organizational flexibility, a clear management vision, and an integrated implementation plan. Flexibility is needed for the organization to adapt to current market realities and to react later as market forces change over time. The vision is required to focus the organization's energies on a common set of strategic goals and the most critical of competing operational objectives. An integrated plan is essential for effective deployment of the technologies which are driving the cost reductions and product improvement efforts required to remain competitive.

The logic which led to this advice ran as follows. Global competition is forcing U.S. manufacturers to deliver significant productivity, quality, and



service improvements while simultaneously shortening the product life cycle over which required investments can be amortized. Insidiously, the group of technologies collectively referred to as Computer Integrated Manufacturing (CIM) which enable such improvements have been introduced and refined slowly over the past twenty years. Somewhat like a frog placed in a pan of cool water over a low flame, many companies have failed to notice their slowly changing environment or have reacted with only marginal adjustment of traditional posture. The immediate cost of change and the uncertainty of survival outside the known world constrain the frog to inadequate action and an inevitable fate.

Survival now lies beyond modest changes to current practice. The order-of-magnitude improvements required to remain competitive can be captured only with fundamental redefinition of traditional roles, responsibilities, and processes within the manufacturing functions of design, engineering, procurement, production, distribution, marketing and service. The greatest opportunities for cost saving, time compression and product improvement exist at the boundaries between these functions, and in their interface with customers and suppliers. Communication, coordination and cooperation among traditional rivals is needed to capture these opportunities. And the new relationships are difficult for the combatants to imagine.

Thus, to lead strategic change executive management must do more than allocate money to the "right things." They must cultivate organizational flexibility, establish a strategic vision, and orchestrate development of an integrated plan of implementation.

Organizational flexibility is required in a number of dimensions. Strategic change may imply radical departure from established concepts, policies and procedures. Flexibility is required not only in manufacturing

equipment and facilities but also in the firm's organizational structures, procedures, systems, and most especially in its people. Everything must be viewed as a candidate for change: organizational structure, production process, plant locations, distribution channels, product offerings, pricing structure, functional missions, staffing levels, job descriptions, and compensation plans.

The creativity required to generate radical ideas and the courage needed to champion them needs to be nurtured. Mechanisms to stimulate creativity reported in our interviews included: inter-divisional transfers, hiring from outside the company, cross-functional planning teams, industry case discussion, offsite planning meetings, planning meeting facilitators, formalized brainstorming sessions, acknowledgment of risk and the possibility of failure, and awards to recognize successful innovation. Management's openness in discussing planned changes and a willingness to invest in employee retraining and development were considered key to successful strategy implementation.

The second important task of the CEO in fostering strategic change is to establish a shared vision of the new world. The most effective implementations of CIM technologies have occurred in new organizations with no existing employees or power structures to protect. In an existing plant however success depends heavily upon the support and cooperation of the current management, staff, and workers. And often these people fear that the system's success will lead to a loss of personal job security. The CEO must generate a widespread understanding, acceptance and commitment to the new direction. Top managers must convince middle management that the new systems are essential to corporate strategy and survival. They, in turn, must persuade supervisors and shop floor workers that use of new technologies and

operating methods will provide a better quality job and greater security at the factory level. Some companies have gone so far as to guarantee retraining and employment to all employees whose jobs were changed or eliminated.

Without total employee commitment implementation of the vision is jeopardized.

To sell the vision, our interviews suggest that at one level it must be as uncomplicated as possible so that it can be easily described, easily understood, easily referred to, and easily repeated to others. At this level, symbolism such as slogans, pictures, cartoons, anecdotes, and ceremony play a visible and important role in broadly communicating a new direction. To guide actions however the vision must also be translated into an integrated implementation plan with specific operational goals.

Without clear operational goals and a plan that integrates activities across functions, it is possible to spend money on the "right things" and yet fail to derive full benefit. In product engineering, for example, we have found that traditional product designs often go unchanged after the introduction of automation onto the shop floor. When people were used for production, products were designed to be easily made and assembled with human skills and simple machines. People and robots each do different things well, however, and product designs must change to take maximum advantage of investments made in robotics and flexible manufacturing equipment. As a second example, a large corporation that we studied had made a major investment in computer aided design equipment with the hope that its product development cycle would be dramatically reduced. After two years, management discovered that in fact no reduction at all had been achieved. An investigation revealed that while the product design, product engineering, and process engineering functions each made heavy use of CAD equipment, they independently had selected different hardware with incompatible data

structures. As a result, the transfer and sharing of designs between functions was cumbersome, time-consuming and done only when absolutely necessary. The potential for cooperative design and parallel development activities went untapped. In addition, the goal of development cycle reduction had somehow been lost. No operation within any function considered themselves to be on the critical development path, and the new equipment was simply being used to perform more design iterations in the same amount of time. There had been no elimination, resequencing or redesign of traditional processes.

Both examples illustrate the human tendency to anchor on the current mode of operation as the starting point in the search for improvement. There was a failure to step back and ask, "What is it that we really want to do, and how can it be best accomplished with available technology given no constraints?" Table 5 sketches three sets of questions suggested by executives in our study to involve operating managers in strategy development and to draw out specific goal statements and details of an implementation plan. In our experience those companies which have been most successful in applying the new manufacturing technologies have been guided by three interacting principles: Simplify, Automate, and Integrate.

Simplification attempts to streamline organizational structure, product design and production processes by eliminating unnecessary complexity. It starts with an "80/20 assumption," that 80 percent of the real value of most activities derives from 20 percent of what is actually done. It then asks the fundamental questions, "What are our real goals; what factors are most critical to achieving them; and, how does what we do contribute to our success?" All current operations are examined closely to distinguish elements which are essential from those that can be pared back or eliminated.

## Table 5

# Ten Key Questions In Detailing An Implementation Plan

### **DIAGNOSIS**

1. Who buys our product and what is it that they value or might value from us?
2. What are the key factors of competition in our market and what is our strategy for superior performance?
3. What are the "things that we do" in our company and what does each cost?
4. Are the things that we do compatible with our strategy; how does each contribute?

### **PRESCRIPTION**

5. Where can we cut costs significantly with little or no impact on buyer value?
6. Where can we increase buyer value significantly with little or no impact on costs?
7. What key actions would improve the competitive position of our company?

### **IMPLEMENTATION**

8. What do we need to do to implement the key competitive actions? What constrains us from doing these things?
9. What specific actions should be taken? Who must do what when, and with whom? What resources will be required; when and how will they be available?
10. How will we know our plan is succeeding? How will interdependent activities be coordinated and how will performance be measured and rewarded?

Organizational boundaries are realigned to improve communication within the company, products are redesigned to make them suitable for automated production, and existing operations are adjusted to reduce cost, speed process or improve product. Typical improvements include better use of factory and warehouse space, and significant reductions in inventory investments, machine setup, product development and manufacturing lead times, and direct and indirect labor costs.

Automation attempts to identify new uses of technology which can improve either manufacturing processes or the business functions that support them. Automation and simplification efforts reinforce each other in that simplified processes are easier to automate, while automated processes are simpler to manage. Automation improves design productivity, reduces labor costs, enhances product quality, eliminates tedious and hazardous tasks, and reduces lead time for product development and manufacturing. It also yields timely and accurate information to support the third effort of integration.

Integration attempts to link physical manufacturing and management control processes using computers and communication networks. The goal is to drive out sources of uncertainty and delay in the manufacturing system by exchanging information needed to coordinate interdependent activities. Integration with customers and suppliers enables the scheduling of efficient production, reduces the need for expediting, and slashes safety stocks in raw material and finished goods. In addition, administrative costs associated with order entry, invoicing, billing and payments systems can be dramatically reduced. Integration between functions within the firm reduces product component redundancy and work-in-process inventory. It also enhances product quality while compressing product development and manufacturing lead times.

The CEO questionnaire data revealed that some subtle but equally important benefits are also sought by executive management from the planning process. Clearly the resulting plan has value in that it details the broad vision and becomes a formalized contract for action against which performance of cooperating functions can be measured and rewarded. As important, however, the planning process itself forges commitment to shared goals while providing a forum in which the CEO can give direction to subordinates. In addition, the activities of planning require managers to look up from the detail of their daily work, and force them to take a broad organizational and market perspective in their thinking. Finally, the process strengthens the vision and proselytizes the missionaries who must carry it with zeal to the rest of the organization.

In short, our interviews suggest that the specific details of an implementation plan and tenacious commitment to its goals are best developed by assuring active participation of affected functions and their management in a strategic planning process. A critical analysis of a manufacturing company's current organization, policies and procedures with an eye toward simplification, automation and integration will enhance the firm's capacity for innovation while increasing productivity, responsiveness and control.

### Summary

Global competition is forcing U.S. manufacturers to improve efficiency, productivity and quality, while simultaneously shortening their product life cycles. Computer integrated manufacturing technologies exist to support the coordinated planning, execution and control of business activities from product concept and design through engineering and manufacturing to marketing, delivery and service. They have enabled some companies to face the challenge

of today's increasingly competitive marketplace by providing product and production advantages.

Effective applications of these technologies within any company can be simply identified through the basic principles of simplify, automate, and integrate. And yet the introduction of the technologies into an organization is problematic. It may require companies to restructure their organizations, reallocate people and change long-standing manufacturing practices and philosophies. There is a natural inertia which resists such change. To lead an organization on a journey to the promised land, executive management must do more than allocate resources to the right things. They must nurture organizational flexibility, provide a strategic vision, and assure development of an integrated plan of implementation. While the challenge is indeed formidable, the investment is needed for survival; and we are convinced that its rewards will allow U.S. manufacturing companies to prosper in the global economy.