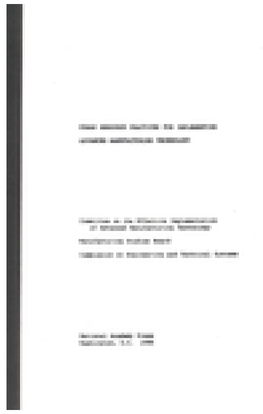

Human Resource Practices for Implementing Advanced Manufacturing Technology

Committee on the Effective Implementation of Advanced Manufacturing Technology, Commission on Engineering and Technical Systems, National Research Council

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Manufacturing Studies Board
Commission on Engineering and Technical Systems

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This report has been reviewed by a group other than the authors according to procedures approved by a Report Review Committee consisting of members of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine.

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The following peer reviewers contributed to the substance of the report through their written comments for the Commission on Engineering and Technical Systems:

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To supplement this peer review process, which is done for all National Research Council reports, the committee sought additional reactions from potential users of the report before it was in final form. Thanks also go to the following participants in a symposium to review the report:

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The willing participation of so many in this study is testimony to the need this report has tried to serve. The committee is grateful for both the financial support and the substantive guidance of the National Commission for Employment Policy and its acting executive director, Carol Romero, and staff members, Stephen Baldwin and Sara Toye.

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Particular mention must be made of the truly remarkable effort on the part of Gerald Susman to staff this committee and report. Professor Susman exercised consensual leadership in the early stages of the report and contributed immeasurably to the drafting of the committee's deliberations. His personal devotion to the agenda of the committee, the thoroughness of his staffing, and his sabbatical devoted to the study are indicative of the commitment he has demonstrated to the committee and are in large measure responsible for the quantity and quality of this committee's efforts. Thanks are also due other staff, including George Kuper, executive director of the Manufacturing Studies Board, and Janice Greene, staff officer, for their expert guidance and valuable substantive contributions, and to Lucy Fusco, administrative secretary, who capably handled the considerable logistical and support work.

All this involvement and assistance notwithstanding, this is the report of a very hard-working volunteer committee, which has been exemplary not only in generously committing time and effort, but also in sharing controversial ideas in a constructive fashion. I am privileged to have been the chairman.

RICHARD E. WALTON

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Contents

Summary

A growing number of U.S. manufacturers are concluding that they must employ advanced manufacturing technology (AMT) to survive and prosper. The experience of those who have started to use AMT suggests that companies can best benefit from these investments if they make complementary changes in organization and management. The critical question is what kind of changes should be made and how.

The manufacturing Studies Board of the National Research Council formed the Committee on the Effective Implementation of Advanced Manufacturing Technology, which was sponsored by the National Commission for Employment Policy, to study that question. The Committee, composed of nine managers, union officials, and academics, visited 16 sites where AMT had recently been implemented. This report contains observations from these visits and conclusions based on both field observations and the prior experience of committee members.

In the context of this report, AMT refers to an array of process technologies, including computer-aided manufacturing, computer-aided design and engineering, manufacturing resource planning, computer-aided process planning, and the integration of these technologies in computer-integrated manufacturing. Severe international competition will prompt manufacturers in most industries in every competitive country to consider the strategic role of this technology. Some will be able to exploit its potential; others will not.

The technology itself will readily cross the boundaries of industries and countries. The human resource practices used for its implementation, however, are not so easily transferred. Manufacturers will need to spend more time and effort to develop the needed organizational and industrial relations capabilities for implementing and operating the technology. Indeed, some U.S. manufacturers may not be able to improve human resource practices at the rate required to remain competitive.

Realizing the full benefits of AMT will require systematic—not piecemeal—change in the management of people and machines. The committee concluded that a critical mass of interrelated changes is required in seven areas of human resource practices: planning; plant culture; plant organization; job design; compensation and appraisal; selection, training, and education; and labor-management relations.

Certain basic characteristics of this new technology are fundamental to identifying human resource practices that are effective in implementing AMT. Compared with the technologies they replaced, the AMT applications the committee observed were characterized by:

- greater interdependence among work activities;
- fewer employees in a unit responsible for each product, part, or process;
- different skill requirements and usually a higher average skill;
- higher capital investment per employee;
- more immediate consequences of the malfunction of part of the production system for the whole system;
- more costly consequences of malfunctions; and
- more sensitivity of output to variations in human skills, knowledge, and attitude, and to mental rather than physical effort.

These characteristics of AMT have prompted many manufacturers involved with the technology to initiate or intensify pursuit of the following interrelated organizational objectives:

- a highly skilled, flexible, problem solving, interacting, and committed work force;
- a flexible, humane, and innovative management organization with fewer levels and job classifications;
- a high retention rate of well-trained workers; and
- a strong partnership between management and labor unions--where unions represent the work force.

These objectives and their related human resource practices are being pursued in diverse workplaces in service and manufacturing industries employing a variety of technologies. They are part of a general transformation of U.S. workplaces, a trend driven by competitive forces unleashed in international markets and deregulated domestic industries and shaped by changing employee expectations.

The committee found that while these objectives are not unique to AMT, they are especially applicable to AMT in a number of respects. For example, increased flexibility and problem solving capabilities are responsive to the greater interdependence among AMT tasks. The higher priority given to employee commitment with AMT is acknowledgment of the more severe consequences of employee antipathy or antipathy. The greater need for retention of employees derives from the greater investment in training and the dependence on people trained to run an individual company's unique system. Changes in management style and labor-management relationships are prerequisites for the other objectives.

The plants visited by the committee had a clearer understanding of the objectives for the work organization than of the precise human resource practices that would achieve those objectives. Plant managers were more articulate about the need for flexibility and closer coordination, for example, than about ways to achieve them. Nevertheless, the committee found many promising trends in the specific human resource practices used to introduce and operate AMT. Frequently observed were the following six practices and corresponding rationales:

- Jobs with broader scope are defined to include more planning and diagnosis, and both operating and maintenance duties, in recognition that traditional distinctions between such tasks are blurring.
- Work teams often are employed to manage the more tightly interdependent work roles usually required by AMT.
- Operating decisions are more often delegated, in recognition of the need for immediate action on AMT problems and the fact that those qualified to operate the equipment also have much of the salient information and expertise.
- Management and unions have developed inventive selection processes for AMT jobs that preserve the concept of seniority, yet place in those jobs the candidates who are more likely to succeed. The new acceptance of this type of selection procedure results from union recognition of the higher level of skills and

knowledge required by AMT and the higher cost associated with mistakes in working with this capital-intensive equipment; it also results from a general improvement in union-management trust.

- Paying employees according to their mastery of a progressively broader range of tasks is often adopted to encourage both the learning and flexibility in work assignments required in the operation of AMT.
- Managers and workers show significantly greater concern for training. The introduction of AMT has forced greater emphasis on the design and implementation of training programs for various segments of the work force.

The committee cannot predict how effective all of these innovations will be over the longer term. Some of them--for example, the judicious use of team structures, the increased delegation of responsibility, and the more systematic assessment of individual potential for success in AMT jobs--seem to be especially promising. Others, such as pay for knowledge mastered and utilized, have a sound underlying rationale, but the committee is concerned about whether they can be implemented over time in a way that is regarded as fair and equitable and is cost effective. Innovation is needed in the area of pay schemes, and the pay-for-knowledge idea is a worthy innovation, but it is too early to endorse the practice generally.

In addition to these specific human resource practices, successful AMT implementations seem to require other characteristics. First, none of these innovative practices can be fully effective unless the planners also give high priority to addressing an overriding concern of the work force and unions--employment security. The effects of AMT on the number of jobs tend to be mixed. On the one hand, AMT can achieve a given level of output with fewer employees than required by order technology. On the other hand, without the increased competitiveness permitted by AMT, the number of jobs may decline even more. Thus, all parties must understand the role of AMT inpreserving or increasing market share and, in turn, jobs. Finally, to build and preserve the human commitment and skills required to operate AMT, the policies that govern employment security and case labor dislocations must be as favorable as the competitive circumstances of the enterprise permit.

Second, a critical prerequisite for effective implementation is a compelling business rationale for AMT--the stronger its economic basis, the better. Moreover, the committee found that the better implementation efforts were accompanied by high performance expectations--major improvements in design for producibility, quality, inventory reduction, cost performance, and so on. Not only are high performance expectations required to justify the major capital investment, but unprecedented increments in performance expectations are also psychologically necessary to drive the processes of organizational invention that will help fully utilize the technology's potential.

Third, AMT will be more profitable when human resource issues are understood and addressed in the planning stage and at every subsequent phase in the design, approval, and implementation of the technology. It is important to give as much thought to the human aspects of the new technology as to the technical and physical aspects.

Fourth, the introduction of AMT will be more effective when management has formulated a guiding philosophy, is dedicated to improvement in plant culture, and is active across the whole range of improvements in plant, equipment, management effectiveness, and personnel development. To introduce AMT effectively, management must also try to build a favorable consensus among company, work force, union, and community.

Fifth, effective implementation processes seem to require an openness to learning from one's experience and that of others. The introduction of new technology is a subject of industry wide and worldwide study and exchange of experience. The committee was struck by the trend in recent years for managers and union officials to take steps to learn from others' experiences.

Finally, other major aspects of an effective implementation processes include:

- unprecedented efforts to communicate thoroughly to employees and their representatives the competitive realities of the business, the conditions requiring AMT, and the plans for implementing it;
- a variety of initiatives to promote a positive culture for employee relations and labor relations;
- employee participation in the implementation activities;
- early assignment to the project;
- broad training that begins before assignment to the project; and
- systematic, periodic evaluation of the effectiveness of AMT.

A noteworthy trend is the frequency with which AMT is used to break with tradition. It becomes the occasion for (1) candidly examining past habits, work rules, prerogatives, and relationships, and (2) assessing their adverse consequences for motivation, cooperation, and other factors affecting productivity. Not infrequently, corporate management considered whether to locate the AMT at a greenfield (i.e., new) site or in an existing unionized plant, and used the leverage inherent in this option to induce unions and local managements to consider new operating modes.

The dominant theme of the policies outlined above is that they were intended to accommodate all parties with a stake in the organization, and thereby to enlist their support. Managers gain decreased cost, increased quality, greater flexibility, decreased cycle time, improved equipment up-time, and greater ability to bring technology on line. Employees gain better information, learning and retraining opportunities, higher skilled jobs, marketable skills, advancement opportunities, more opportunities to feel part of the business and exercise influence, and, on balance, a more secure employment environment because of the increased competitiveness of the enterprise. Where employees are unionized, to the extent that its members gain, the union also gains and participates in a broader agenda of issues affecting the membership.

Fortunately, the policies that are especially appropriate for AMT are also in line with the general changes in work force management strategies that have been driven by increased competitive pressure and rising employee expectations. AMT both benefits from these trends and gives additional meaning to them.

1

Introduction

Advanced manufacturing technology (AMT) promises to reduce product cost, improve product quality, and increase flexibility in responding to changing market conditions. U.S. companies need all of these outcomes to respond to increasing domestic and international competition. Some companies can achieve them without investing in AMT, by organizing and managing their human and physical resources more effectively. A growing number of companies, however, are deciding to make major investments in AMT. Their experience suggests that companies can best benefit from these investments if they make complementary changes in organization and management. The critical question is what kind of changes should be made and how.

The importance and widespread applicability of the question led the National Commission for Employment Policy to ask that the Manufacturing Studies Board (MSB) of the National Research Council appoint a committee to produce a report on the experience of companies that have used effective human resource practices for implementing AMT. As a result, the MSB formed the Committee on the Effective Implementation of Advanced Manufacturing Technology. The nine-member committee was composed of managers, union officials, and academics who have first-hand experience with the multiple dimensions of implementing AMT.

ELEMENTS OF AMT

AMT encompasses several types of technology, as shown in Figure 1. Computer-aided manufacturing (CAM) encompasses flexible manufacturing systems (FMS), robots,

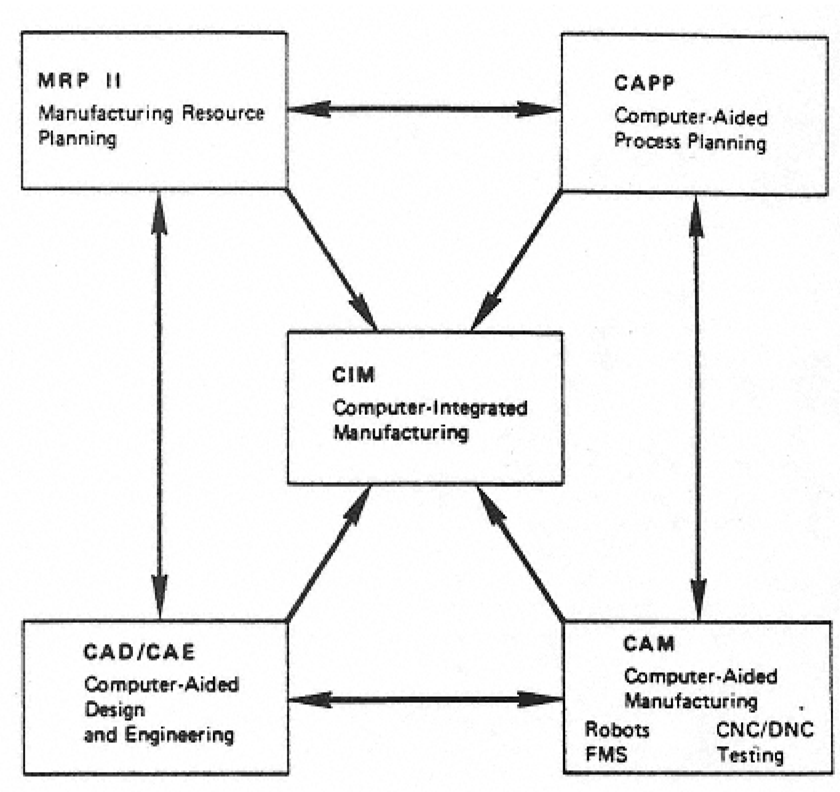

Figure 1
Scheme for the Integration of Four Types of Advanced Manufacturing Technology

material handling devices, and numerically controlled (NC) machines, including computer numerical control (CNC) and direct numerical control (DNC). CAM also can include computer-aided testing. Computer-aided design (CAD) and engineering (CAE) can vary in sophistication from computers that serve as electronic drafting boards to those that test alternative designs on the screen for stress, function, and other characteristics, and then translate the design into a program to produce the product. Manufacturing resource planning (MRP II) is software that translates demand for products into parts needed to produce them and orders the parts from inventory or from suppliers so they will be available when needed. Computer-aided process planning (CAPP) is software that routes parts through the factory to maximize operating time and eliminate bottlenecks.

These four types of AMT can be integrated, as shown by the arrows and central box in Figure 1. Until recently, companies for the most part have adopted each type in isolation from the others, leading to what has been called “islands of automation.” This situation is beginning to change, however. The four technologies increasingly are “speaking” to each other through local-area networks, and formerly isolated applications are being linked as computer-integrated manufacturing (CIM). Companies that are upgrading the technology used for an existing facility and product are more likely to have islands of automation, while companies that are investing in AMT and at the same time are building a new plant or introducing a new product are generally more likely to implement CIM.

The impact of AMT on a plant becomes more pervasive with increasing integration. The closer a plant is to CIM, the less tolerant of error it becomes, the more serious are the consequences of an error, and the more everyone's performance depends on actions taken by nearly everyone else. However, while human resource issues clearly become more important as AMT becomes more integrated, plants have a great deal of discretion in how they deal with such issues.

SITES VISITED

The committee began its work by developing an initial list of effective human resource practices. Not all of

TABLE 1 Sites Visited by the Committee

Plant	Product	Age	Union Status	Location	No. of Employees	When Implementation Started	Type of Technology[a]
A	Electronic components	Existing	Nonunion	Southeast	2,000	1984	R, MH, T Laser Engraving
B	Electronic components	Existing	Nonunion	Southwest	3,300	1985	MRP II (10 modules)
C	Engines	Greenfield	Nonunion	Southeast	400	1981	CNC, R, MH, T
D	Military vehicle components	Greenfield	Nonunion	Southeast	370	1982	CNC, R, AGV
E	Aircraft	Existing	Nonunion	Northeast	18,200	1985	R, S
F	Aircraft	Existing	Union	Midwest	24,000	1985	S
G	Office equipment	Existing	Nonunion	Southeast	6,000	1983	R, MH, AGV, AS/HS
H	Automobile components	Greenfield	Union	Canada	1,460	1981	R, T
I	Automobile assembly	Greenfield	Union	Midwest	6,700	1982	R, MH, AGV
J	Material handling equipment	Existing	Nonunion	Midwest	115	1984	CNC, R, FMS
K	Engines	Existing	Union	Midwest	4,385	1985	FMS
L	Automobile assembly	Greenfield	Union	Midwest	2,400	1982	R, MH
M	Automobile components	Greenfield	Union	Midwest	48[b]	1983	FMS, DNC, MH
N	Electronic components	Existing	Nonunion	Southwest	54	1985	R, T
O	Engines	Existing	Union	Midwest	6,500	1982	FMS
P	Machine tools	Existing	Nonunion	Midwest	1,500	1984	FMS
Additional Sites Known to Individual Committee Members							
Q	Appliances	Existing	Union	Southeast			
R1	Aerospace	Existing	Union	Midwest			
R2	Aerospace	Existing	Union	Midwest			
R3	Aerospace	Existing	Nonunion	Midwest			
S1	Engines	Existing	Nonunion	Southeast			
S2	Engines	Greenfield	Union	Midwest			
S3	Engines	Existing	Union	Northeast			
S4	Engines	Greenfield	Nonunion	Canada			

[a] R = robots; T = computer-aided testing; MH = automated materials handling; AGV = automated guided vehicle; S = specialized fabrication equipment; AS/RS = automated storage and retrieval system; MRP II = manufacturing numerical control
[b] Total number of employees in surrounding facility is 10,000

these practices were new. Some had proved effective when used with more mature technologies; others had proved effective for introducing organizational change whether or not accompanied by new technology. The committee anticipated, however, that it would find recognized practices being used in new ways when linked with the introduction of AMT. The list of practices served as the basis for an interview guide used by committee members during site visits, and as a hypothesis to be tested during site visits.

The committee designed this report primarily to inform managers, union officials, and workers with little experience in implementing AMT about practices being used by early adopters of AMT. So that readers of the report would recognize site findings as potentially applicable to themselves, the committee selected North American plants operated by U.S. companies that, although innovative technologically and organizationally, were not using experimental or exotic technology. The sites were chosen to represent a variety of circumstances, including both union and nonunion plants, new ("greenfield") and existing plants, geographical diversity, and several industries.

The committee decided at the outset to focus primarily on human resource practices that affect production workers. Of the several forms of AMT, computer-aided manufacturing (CAM) has the most direct impact on production workers, so most of the sites selected were implementing applications of CAM, with varying degrees of the integration shown in Figure 1.

The committee, with help from others knowledgeable in this area, developed a list of 22 plants that met its criteria. Of these, 16 plants agreed to site visits. Committee members, usually in pairs, visited the 16 sites over a 2-month period.

The 16 sites and their basic attributes are shown in Table 1. Seven of the 16 sites are union; of those seven, four are existing plants and three are greenfield plants. Of nine nonunion sites, seven are existing plants and two are greenfield plants. The 16 sites are referred to as plants "A" through "P" in the report. Occasionally, committee members offered personal experience with other plants as additional support for observations or conclusions based on the 16 plants visited. These additional plants, also shown in Table 1, are referred to as "Q" through "S" in the report.

TABLE 2 Innovative Human Resource and Manufacturing Practices

Human Resources Practices and Chapter Where Discussed	Manufacturing Practices
Human resources plan developed along with technological plan (ch. 2)	Investment justified for strategic reasons (return on investment important but long-term competitive advantage given equal or greater weight).
Multifaceted employment continuity policy (ch. 2)	
Changes in plant organization and human resource management guided by an articulated philosophy (ch. 3)	Two or more types of AMT introduced simultaneously, guided by a vision of eventually achieving computer-integrated manufacturing
Plant organization (ch. 4) —functions more integrated —fewer organizational levels —self-contained work modules —multifunctional teams plan (ch. 2) and guide (ch. 4) implementation	Introduction of AMT linked to other ambitious objectives, such as "just-in-time" inventory control or "producibility engineering."
Job design (ch. 5) —broad-scoped work and multiskilled workers —fewer job classifications —work teams	Introduction of AMT accompanied by changes in process layout, plant renovation, or new plant construction
Compensation (ch. 6) —pay for knowledge —skill progression programs	Introduction of AMT associated with development of a new product or modification of an existing product.
Selection (ch. 7) —elaborate screening for social and technical skills	
Training and education (ch. 7) —begun well before technology is operational —includes interpersonal and problem solving skills as well as technical skills	
Labor-management relations (ch. 8) —union involved early in implementation —outcomes that benefit all parties sought	

HUMAN RESOURCE PRACTICES

The human resource practices that the committee observed sorted readily into seven areas: planning; plant culture; plant organization; job design; compensation and appraisal; selection, training, and education; and labor-management relations. Each of these seven areas is the subject of a report chapter.

Table 2 shows a comprehensive list of the human resource and manufacturing practices observed at the 16 sites. As might be expected, none of the sites used all of the human resource practices shown. In addition to the innovative human resource practices, the committee also observed innovative manufacturing practices that appeared to augment the benefits of AMT.

Table 3 shows the number of human resource practices (from Table 2) cited in each chapter for each plant visited. The number of citations in a chapter indicates the extent to which plants used the practices discussed in that chapter. The six plants (A, C, D, G, M, and N) that ranked highest in number of human resource practices used--those having 9 or more citations in Table 3--also ranked highest in number of innovative manufacturing practices. Two possible explanations of this finding are (1) that innovative manufacturing practices stimulate innovation in human resource practices, or (2) that willingness to innovate is a general management attribute that can manifest itself in various ways.

Five of the six leaders in human resource practices are nonunion plants, which is consistent with the commonly held belief that it is difficult to introduce new technology in existing, unionized plants. It is noteworthy, however, that the leader in innovative human resource practices (plant M), with 20 citations in Table 3, is a unionized, greenfield plant.

The 16 plants visited had been implementing AMT for varying times, though none had more than 4 years of experience with the AMT that was the focus of inquiry during the visit. Some plants were still installing equipment when committee members visited them and had just begun to use the practices cited in the report. The effectiveness of these practices, therefore, cannot yet be assessed in terms of economic results. Further, because the plants visited by committee members were selected for their differences, not their similarities, conclusions on the relative effectiveness of the practices across sites are necessarily judgmental--as opposed

TABLE 3 Human Resource Practices Cited for Each Plant by Chapter of the Report[a]

Plant	Planning Ch. 2	Plant Culture Ch. 3	Plant Organization Ch. 4	Job Design Ch. 5	Compensation and Appraisal Ch. 6	Selection, Training & Education Ch. 7	Labor-Management Relations Ch. 8	Total[b]
A	2	1		5		2		10
B	1		2					3
C	1	2	5	3	4	2		17
D	2	2	1	3	2	2		12
E	1			1				2
F	1	1		1	1		(2)	4
G	3		4	1	1	2		11
H						3		3
I	2			1	2	2	(2)	7
J			1	1	1	1		4
K	1					2	(1)	3
L	2	1		1		3		7
M	3	2	2	5	3	5	(2)	20
N		4	2	1	2			9
O	4		2	1			(2)	7
P				1	1	2		4
TOTAL	23	13	19	25	17	26	(9)[b]	123

[a] Numbers include citations of practices listed in Table 2, but not citations with caveats.

[b] Chapter 8, Labor-Management Relations, is not included in the total because it applied only to unionized plants.

to statistical--and reflect the views of both the committee and plant personnel.

UNRESOLVED ISSUES

Practices that are effective in one setting may not be effective in others. As a result, the committee noted three questions that it could not answer conclusively: (1) Which human resource practices are effective with which forms of AMT? (2) Did the committee observe practices that were effective at the sites visited but might cause adverse effects under other circumstances? (3) Which practices are effective with AMT while the technology is newly implemented but will be less effective or less likely to be used in the future?

When describing the effectiveness of various practices, the committee has noted, where possible, conditions that might have contributed to that effectiveness. However, because of the judgmental nature of the conclusions, as noted above, the committee can only suggest what those conditions might be.

The apparent lack of adverse effects, such as increased job pressure or increased tension between management and unions, at the sites visited is probably due to the committee's site selection criteria. The sites visited were, in general, effectively implementing AMT and using innovative human resource practices. The committee believes it likely that the human resource practices used in the implementation of AMT at these sites were uniquely appropriate to the technology implemented, representing a carefully planned implementation strategy that draws on both appropriate technology and appropriate human resource practices.

The changing nature of AMT and the growing experience with human resource practices used to implement and operate AMT will require further exploration. Will the AMT applications observed by the committee evolve in a way that makes the recommended human resource practices less necessary in the future? Will the demands for active attention, diagnostic skill, and maintenance know-how decline as further automation simplifies these tasks? Will the second, third, and nth implementations of similar AMT configurations become more routine and require less extensive participation? Will it once again become more feasible to follow a path of “deskilling” and routinizing work and moving decision levels higher in the organization? Even if companies are able to go back to more traditional organizations, will following this path make sense, considering its effect on employee commitment? These issues warrant attention as the technology continues to evolve.

2

Planning

Companies that implement advanced manufacturing technology (AMT) need to consider more human resource dimensions than previously, and they need to consider them simultaneously and earlier in the planning process. Therefore, the need for a comprehensive human resource plan cannot be overestimated. The more sweeping the technological change, the more important is that plan in helping the company to use the new technology to maximum competitive advantage.

EARLY CONSIDERATION OF EMPLOYMENT CONTINUITY

The employment implications of introducing AMT are likely to be the primary concern of workers. Companies, therefore, should articulate their policies about employment continuity before considering specific applications of AMT. If workers feel insecure about their jobs, widespread company support for any application is not likely.

Every plant visited had considered protecting workers from loss of employment caused by introducing the new technology. Some companies, however, dealt with this issue more creatively and thoroughly than others. Employment continuity policies related to the introduction of new technology included:

- promoting and training solely from within the company (plants A and G),
- assigning employees to a 90-day trial at another plant with the opportunity to return to the original plant if no “niche” is found (plant G),

- retaining seniority rights in interplant transfers and providing moving allowances (plants L, M, and O), and
- offering full pay and benefits while employees retrain, if they were laid off because of technological change (plants I, L, M, and O). Committee members cited these additional strategies used by plants that were introducing new technology:
- bringing subcontracted work into the plant,
- understaffing to reduce the likelihood of layoffs during business downturns, and
- slowing plant start-up to reduce the likelihood of layoffs when production reaches steady state.

Some of the plants visited were investing in AMT because they were experiencing or anticipating a business upturn. In such cases, the prospects for retaining all employees are bright, even if AMT significantly increases output per worker. The plants varied in the extent to which their employment continuity policies generalized to maintaining employment during business downturns. The majority of the plants visited, however, did not guarantee continued employment during business downturns.

A CHAMPION FOR ORGANIZATIONAL AND TECHNOLOGICAL INNOVATION

A champion for the AMT project can greatly increase the chances of success. For planning as comprehensive as the committee recommends, the champion needs to support not only technological change, but organizational change as well. It is also the champion's role to clear away obstacles and, if necessary, persuade top management to make the investment.

At several of the greenfield sites visited, the designated managers were the champions before the plant was built and had a clear corporate mandate. Whether the investment is at the plant or the corporate level, a true champion of organizational and technological change may need to be a line manager rather than a technologist. The line manager may be the only one with a perspective broad enough to envision both organizational and technological change. Indeed, the line manager is responsible for describing to others what a comprehensive change might look like and for assuring that planning considers both organizational and technological innovation.

IMPLEMENTATION TEAMS

Plans for implementing AMT can be more effectively developed and carried out with the participation of a cross-section of company personnel. Such participation will ensure that the plans developed include all relevant considerations and have the support of all who will be affected. The committee found the practice used in a number of instances:

- The implementation teams at plants C and D included people with experience in similar efforts to transfer that experience to the new site.
- At plants E and F, shop-floor workers were assigned full-time to work in the development lab with manufacturing engineers. These workers suggested ways to design equipment so that it could be most efficiently operated on the shop-floor.
- At several plants (I, K, M, O, and Q), skilled workers accompanied managers on visits to equipment vendors and made suggestions on modifying the equipment to meet local needs.
- Production workers at plants D and O were part of the team for developing and implementing a flexible manufacturing system.
- At plant B, the implementation of AMT floundered for 2 years until a cross-functional team was formed.

COMMUNICATION OF AMT IMPLEMENTATION PLANS

Even in plants that have a large degree of participation in planning, those people who have the ultimate responsibility to make decisions must communicate them. Early communication of those decisions and an open relationship between decision makers and others who will be affected will make it easier to implement AMT.

Specific design choices cannot always be communicated in detail at an early stage because uncertainties remain. Still, open discussion about the uncertainties involved and the general direction to be taken will go far toward reducing anxieties. Horizontal communication, such as between line and staff at equal levels, is also important.

The plants visited used various methods to communicate with employees about the introduction of new technology; for example:

- An electronics equipment plant (G) showed its employees video tapes that linked automation to making employees more effective and jobs easier. The tapes stressed that, given changing worldwide competition, impending plans to automate were a natural and necessary extension of the plant's nearly 30-year history of automation. Managers described the tapes as effective in allaying fears and linking the future of the plant to automation.
- Another plant (A) of the same company informed employees about new technology and its implications by using video tapes, having superintendents hold “cross-talks” with 10 to 12 people at a time, and arranging career-oriented discussions between individual supervisors and employees.
- The key line manager of plant Q initiated a series of informal meetings with the officers of the local union, followed by more formal meetings with managers and employees, to discuss the strategic rationale for introducing automation and its advantages for the work force.

Meetings do not by themselves mean that communication has occurred. According to employees at one plant (J), managers did not tell them enough at quarterly communication meetings for employees to offer useful feedback on implementation plans.

3

Plant Culture

The culture of a plant is a pattern of beliefs about what is right, important, or acceptable--also called values--shared by the people who work there. It is shaped by the plant's history, technology, and treatment of personnel. A plant's culture significantly influences managers' and employees' behavior. A plant with a culture in which cooperation and trust are important, for example, will have managers that share information with employees. Similarly, a plant's values about product quality will influence employees' views of what is acceptable workmanship.

As described in the previous chapters, the effective introduction of advanced manufacturing technology has a pervasive effect on the organization. People are more interdependent, and human resource considerations are more likely to be an essential aspect of plans for implementing AMT. Existing plant culture can facilitate or impede that implementation.

DECIDING TO CHANGE THE CULTURE

Before considering actions to change a plant's culture, managers may wish to assess the present culture in a formal way--by interview or questionnaire. Asking employees what they think of the company's current values, assumptions, and practices--and what these features should be to achieve the company's objectives-- can help managers judge the time and scope of effort needed to change the culture. Further, by involving the employees, the assessment process may increase their receptiveness to efforts to change the culture.

TABLE 4 Plant Cultural Change

Organizational Aspect	Traditional Practice	Shift to Practice Compatible with AMT
Authority	Base on position	Base on knowledge
Decision making	Locate close to the top	Locate close to required action
Employee contributions	Limit knowledge and skill	Enhance knowledge and skill
Information	Closely control	Share widely and use a number of media
Rewards	Reward individual performance	Reward teamwork and collaboration
Status	Highlight differences in attire, parking, eating facilities, and so on	Mute such differences
Supervision	View supervisor as "watchdog"	View supervisor as resource

Managers at the plants visited varied in the degree to which they tried to change the cultures of their plants, or reinforce existing cultures, while implementing AMT. Companies whose managers consciously communicated their assumptions and values also had the most ambitious plans for introducing AMT.

Table 4 shows the organizational aspects that managers most often tried consciously to change. The traditional practice is paired with the shift that plants undertook when they introduced AMT. Both greenfield sites and existing plants had adopted practices compatible with AMT. Further, some existing plants had cultures that encouraged innovative human resource practices independently of the introduction of new technology.

CHANGE MECHANISMS

Managers can influence the culture of a plant by communicating their assumptions and values to employees not only directly but implicitly, in the design of plant structure, operations, and decision making procedures. Direct communication mechanisms include group meetings, films, video tapes, newspapers, bulletin boards, and personal letters.

Value Statements

Several of the plants visited had written statements about the values that were to guide the introduction of new technology. These value statements were a formal approach to direct communication of values.

- The basic philosophy of management was developed while plant D was being planned. The philosophy was included in the employee handbook.
- The original implementation team at plant C developed a set of principles based on trusting people and allowing them to use their full capabilities at work. The team was also involved in translating these principles into hiring practices and work group procedures.
- Plant L developed a statement of philosophy: “to provide an environment for employee involvement, an atmosphere of trust, of mutual respect and human dignity

so that we may achieve our common goals of high quality, mutual success, job security and effective community relationships." Managers cited many practices in the plant that could be traced to the statement.

- The manager of plant N articulated a "manifesto" of values that was reinforced during training sessions. Support groups were introduced to ensure that these principles could be practiced in the plant.

Conveying Values Through Human Resource Practices

Perhaps more important than the values communicated explicitly are those implicit in management behavior. All of the human resource practices described in this report convey, in some sense, managers' values. Managers can reinforce a new culture by redesigning the organization, jobs, and the compensation and appraisal system. Specific practices associated with redesign will be discussed in Chapters 4 to 6.

Similarly, employee selection, discussed in detail in Chapter 7, not only shapes the desired culture, but can be used to convey it. Some companies screen out many people during hiring interviews by being as explicit as possible about what would be expected of them. Some companies ask prospective employees to fill out questionnaires to help determine how well they will mesh with the plant's culture. These selection procedures also offer employees an opportunity to make an informed choice as to whether they want to work in a particular plant.

- Employees were selected for assignment to plant N on the basis of their agreement with the manifesto of values developed by the plant manager.
- The application form for employment at plant C contained essay questions designed to assess general work attitudes, behaviors, and capabilities. Other examples of communication of values include the following:
- In plants M, N, and Q, the leader responsible for implementing AMT involved managers, workers, and, in unionized plants, union officials in the planning process. By asking the group to visit vendors and make recommendations on equipment, for example, the leader

encouraged openness, rational decision making, participation, and recognition of the dignity of the individual.

- Managers at several plants (A, F, M, and Q) created or expanded employee involvement programs (e.g., quality circles or quality of working life programs).
- At plant Q, the physical working conditions were improved and made more attractive as a prelude to the introduction of new technology.
- Plants D, N, and Q promoted their new sense of plant culture by designing and distributing T-shirts that displayed the company's name.

Managers can reinforce the desired culture by their responses to employee behavior. When managers observe a good example of the attitudes or actions they want to develop, for instance, they can focus attention on that example through some form of reward, such as special recognition or salary increases.

- When an engineer or line production manager at plant Q discussed a problem with the plant manager, the latter would respond, “What do the operators say about this?” or “What do your maintenance craftsmen think?” Engineers and managers soon learned to consult those employees who had something to say about a decision and whose cooperation was needed to implement it.
- In another company, a top manager sent personal notes each week to employees who exemplified aspects of the desired culture. Each note was warm, personal, and filled with praise. This activity required about 1 hour per week, but over time had an important impact on the formation of the desired culture.

BENEFITS AND RISKS OF CHANGING A CULTURE

Plants that consciously change their cultures to complement new technology are more likely to have a committed and multiskilled work force, lower turnover, and higher return on their investment in AMT. Changing a culture, however, can be a slow, difficult process. In particular, the change from a traditional authoritarian culture to a participative one can cause uncertainty and unrealistic expectations.

Communication in a traditional plant culture is usually in one direction--from managers to employees.

Changing to open two-way communications can be inhibited by mistrust between managers and employees. Employees will not accept a manager's explanations of proposed new values and norms until the words are backed by deeds. When the cultural change is extreme, a considerable period of demonstrated consistency between the manager's espoused beliefs and actual behavior will be needed.

Even after explanations of the new values are accepted, managers and employees will need to learn new skills to make the transition from an authoritarian to a participative culture. A participatory work culture requires social skills related to leadership style, goal setting, problem solving, conflict resolution, decision making processes, conduct of meetings, and role clarification. Such skills are not easily acquired, especially by managers and employees with traditional backgrounds. Training in this area is complex, and classroom instruction by itself is inadequate.

People do not change values, norms, and behaviors overnight, so cultural change objectives are reached gradually. Indeed, some may never be realized to everyone's satisfaction. Further, some employees may find that the need to change social as well as technical skills increases job pressure.

Some managers and employees who are successful in the traditional work culture will not be able to adapt to the new culture. Managers and employees who do not fit can be very unhappy and disruptive. Such problems can be avoided more easily in greenfield plants than in existing ones because potential employees can be told clearly what will be expected of them. Those who think they would not like to work in a participative system can opt not to do so.

In existing plants, top managers who clearly communicate their commitment to creating a participative system may convince all employees to try to adapt. Patience and education may eventually convert those who initially reject the change. If not, many organizations can find a useful niche for most managers and workers who are unable to adapt to the new culture. Options for doing so should be considered in the implementation plan.

4

Plant Organization

Advanced manufacturing technology affects all levels of the factory organization simultaneously. As a result, companies are experimenting with new organizational forms and management styles to cope with the demands of the new technology. It should be noted that some companies are pursuing similar organizational changes without the introduction of AMT, in response to increasing competition.

ORGANIZATIONAL DESIGN

The Plant Manager

The manager of a plant that will invest in AMT should be selected well before the new technology is operational and should be assigned full -or part-time to the implementation team. Care must be taken to select managers whose values are in agreement with the plant's desired culture. They must not only know the technology well, but also have a sophisticated conceptual and practical grasp of the technical, human, and business aspects of production. If the operating rationale includes open communication, teamwork, and worker participation in problem solving, managers should be able to function comfortably and competently in this environment.

Senior Plant Management

In most of the plants visited, the level just below the plant manager has remained organized by function. For example, an automobile components plant (M) has

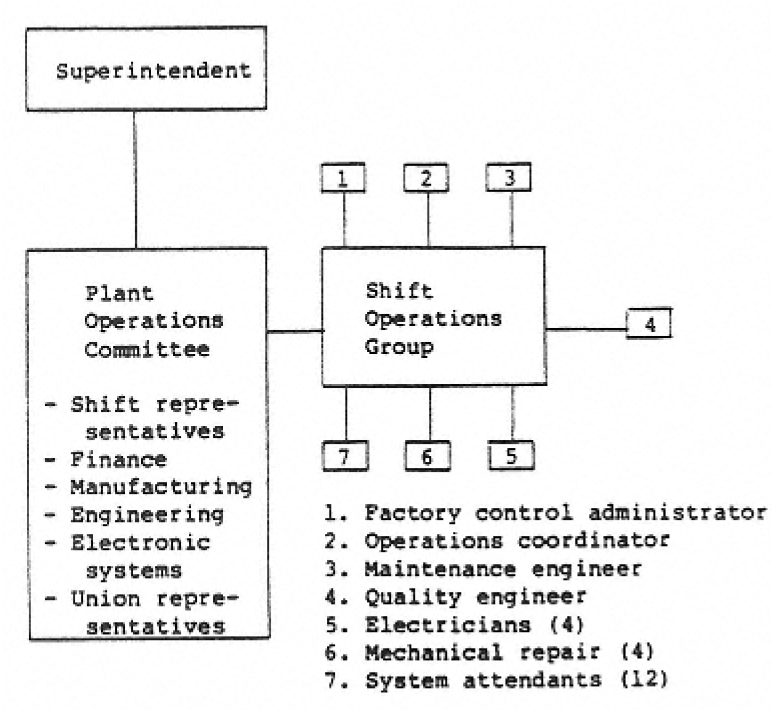

Figure 2
Organizational Structure of Staffed Shifts at an Automobile Components Plant

organized this level into finance, manufacturing, engineering, and information services. An engine plant (C) has organized it into operations, finance, purchasing, human resources, and quality.

Traditional functional labels, however, should not disguise the increased interdependence of the functions. Decisions once made by people in functions that were relatively independent must now be made jointly. Efforts to design the product and process simultaneously, for example, require product engineering and manufacturing engineering to work closely together. The organization may try to facilitate such cooperation by breaking down communication barriers between functions--for example, by locating personnel in the same work area, equalizing status and pay, and improving interpersonal and problem solving skills. Some companies are merging or realigning functions to reflect the higher interdependence among them.

- An electronics equipment plant (G) incorporated quality control/inspection and engineering design into manufacturing.
- A manufacturer of material handling equipment (J) created an "external" reporting line that included sales and engineering and an "internal" reporting line that included production, production control, and data processing, with accounting as a separate unit.

Traditional organization charts may be replaced by diagrams that reflect the consultative forms of decision making that increasingly characterize the factory. Figure 2, from the organizational structure of an automobile components plant (M), provides an example. It illustrates the structure of the two staffed shifts; the afternoon shift is unstaffed. The superintendent of the plant heads the Plant Operations Committee, which is made up of finance, manufacturing, engineering, and electronic systems, as well as representatives from the shifts and from the union. To the right of that committee in Figure 2 is the Shift Operations Group made up of production and support personnel who work on the two staffed shifts. A traditional organization chart, in contrast, would have shown two levels below the superintendent, each reporting to the level above it.

While superior/subordinate relationships still exist in the new factory, diagrams like Figure 2 symbolize the desired change in relationships among factory personnel.

The trend is toward information being shared in committees, committee members making decisions after consulting each other, and consensus being sought whenever possible.

Self-Contained Work Cells

At the sites visited, the factory floor was increasingly being organized into self-contained work cells. Individuals from previously centralized support functions are being assigned to individual work cells. Instead of a separate maintenance department, for example, each cell includes individuals who provide maintenance. The centralized function may or may not continue to exist along with the delegation of the activity to the cells.

The coordination of separate manufacturing processes within work cells does not diminish the importance of coordination between cells; rather, it increases that need. Computer integration of factory data, which helps to make self-contained cells possible, also offers the technology to facilitate coordination between them. Examples of the creation of work cells include the following:

- An electronics equipment plant (G) assigned individuals from information services, quality control, and packaging to report to the first-level manager.
- An engine plant (C) assigned part of support services, such as tooling and material stores, to first-level area managers.
- An engine plant (O) dedicated some support personnel (e.g., a numerical control programmer and a tool engineer) to its flexible manufacturing system.
- An appliance plant (Q) created the role of "unit manager," who could be "his own manufacturing engineer, process engineer, and foreman."

Number of Organizational Levels

As plants assign support functions to self-contained work cells, the number of levels in the factory organization is reduced; for example:

- An electronics equipment plant (G) retained four levels within a new modular structure of minibusinesses. The new organization reduced the responsibilities of the second management level, which will require adjustment. As a result of changes in spans of supervision and budget control, second-level managers lost power and status, and some well-trained and sophisticated first-level managers were running large minibusinesses.

- An engine plant (C) had only four levels: plant manager, directors (for a small number of functional areas), managers, and resources/technicians (exempt and nonexempt positions at the same level).
- The corporate policy of a manufacturer of military vehicle components (plant D) prescribed an upper limit of four management levels in all new plants.

Delegation of supervisory and support functions to lower levels does not necessarily result in fewer levels. In a newly organized electronics plant (N), semiautonomous work teams operate under a four-level functional structure similar to that of an existing facility nearby.

Matrix Management

The link between senior management functions and self-contained work cells is sometimes maintained through a matrix structure in which personnel assigned to functions are deployed temporarily to the cells. This approach maintains some of the advantages of specialization while facilitating coordination within cells.

The arrangement is not easy to run, however. Managers of work cells may compete with their counterparts for the services, such as quality control and maintenance, that functional support personnel provide. Managers of functions may be concerned that temporary assignments of their personnel to cells may become permanent. No consensus on the ideal solution has emerged; although some continuity of staffing may be needed for the success of the project, permanent assignments may impair the ability of the functions to maintain specialized knowledge.

First-Level Supervision

With the introduction of AMT, the supervisor has a greater role in managing interactions between the work team and support personnel. An automobile components plant (O) reported, for example, that the supervisor of an FMS had more lateral relationships to manage.

The supervisor's role changes further as team leadership shifts from a directive toward a facilitative mode. When operators are organized into teams with a greater degree of self-management, supervisors become less concerned with internal team regulation and more involved in monitoring, planning, coordinating, training, and appraising performance. Some plants with self-managing teams, such as plant C, have eliminated the position of first-level supervisor.

With AMT, first-level supervision is responsible for a greater concentration of capital. Many supervisors command large work areas and budgets; at plant G, for example, some first-line supervisors were in charge of $10 million minibusinesses. These supervisors significantly displace the responsibility and authority of the next level of management, which becomes precariously redundant unless augmented with higher responsibilities.

Computer-based information systems tell first-line supervisors the status of all aspects of the manufacturing process in their areas and possibly plantwide. For example, information on machine output and utilization, maintenance status, material flows, quality, and employee attendance may be available.

The case of gathering detailed information can lead to unintended and counterproductive consequences. Supervisors and upper levels of plant management may be tempted to overuse this capability, and workers may regard detailed monitoring of their performance as surveillance and an abuse of the information system.

INFORMATION SYSTEMS

A factory's organization cannot be designed without considering the information system that it will use. The information system must be considered simultaneously with decisions to organize by product or process or to centralize or decentralize decision making.

A company's values about participation and information sharing will affect how information is obtained and used. Companies that have identical capabilities in distributed data processing, but different values, are likely to have different numbers of levels and positions in their factory hierarchies.

Distinguishing between the use of information for process control and for auditing is important. Effective process control requires quick response to unpredictable disturbances in production flow or support activities. Those responsible for such control, ideally those closest to the problem in a decentralized organization, have the greatest need for control-related information. Accordingly, they require quick access to the management information system. Managers at higher levels, in contrast, need information periodically or by exception for auditing and evaluating performance. As a factory approaches computer-integrated manufacturing and the operations-related information increases, the need for data for anticipatory problem solving will increase relative to historical audit information.

The following are examples of the value of data for process control:

- An electronics company (plant B) that implemented a manufacturing resource planning (MRP II) system plantwide reported improved trust and communication between upper and middle managers. The managers had more relevant information at their disposal for tracking and intervention--for example, in the higher visibility of work in process. Manager accountability also increased significantly, with the result that effective managers became more widely recognized.
- The information system at an appliance plant (Q) was capable of alerting all management levels simultaneously to problems that might previously have languished at lower levels. In the tightly coupled production system (with 4 to 5 hours of inventory), problems that once took weeks to surface were found within hours. In the words of the plant's project manager, “In one way, I am more involved in details of the process because they bubble up faster and are more consequential. In another way, there is more delegation, again, because those close to the process have to think and act fast.”

THE TRANSITIONAL ORGANIZATION

The use of radically different management principles to design greenfield plants in the 1970s and early 1980s provides experience that can be used in organizing for AMT. Planners of those earlier system tended to be unduly optimistic about the ease of progressing from start-up to steady state. Frequently they underestimated the need for temporary control and guidance of shop-floor decision making and activity until work teams gained the confidence and competence to become self-managing. Some of the successfully innovative organizations started without transitional management control and technical support, but found it necessary to introduce them ad hoc after experiencing start-up difficulties.

Examples of the use of transitional structures include the following:

- An electronics company (plant N) used an existing plant as a transitional structure in which to train employees destined for a recapitalized plant, in the same metropolitan area, with a state-of-the-art production process using AMT. Employees assigned to the new facility (many of whom had worked there in its former configuration) were selected and trained for the new operations in the mother plant. They also built circuit boards that would be produced in the new plant.
- The start-up structure of an engine plant (C) was designed to be lean, based on difficulties experienced during previous start-ups with innovative work structures.
- An electronics company (plant B) that implemented a manufacturing resource planning system had two transitional structures. Implementation initially was spearheaded by several groups, assisted by two technical groups responsible for reviewing software changes. This structure was changed to one centralized group for the final implementation phase. Eventually, the group was broken up, and individuals returned to their original functions.
- In start-up at an appliance plant (Q), first-line managers were given multiple functional responsibilities, including engineering, manufacturing, process control, and supervision of operators. This plan, although feasible for steady-state production, proved too ambitious for the start-up phase. In addition to the myriad technical problems accompanying start-up, the plant also faced an unexpected surge in product demand, which amplified the pressures. More staff support was required to help the first-line managers cope with the situation.

5

Job Design

The introduction of advanced manufacturing technology offers an opportunity for companies to reexamine job design in their plants. In the 1970s, many companies started this reexamination, whether or not they were introducing new technology, because they recognized that jobs designed in traditional ways failed to motivate employees to do their best. Many of the changes introduced at that time, such as work teams and multiskilled workers, led to increased productivity and employee motivation in plants that introduced little or no new technology.

Managers who did not redesign jobs during the earlier period may now be able to appreciate the potential value of these innovations when used with AMT. When these innovations are used along with the introduction of AMT, especially computer-aided manufacturing, they can be even more effective than when used with traditional technology. Many of the plants visited by the committee used the introduction of new technology as an opportunity to introduce the job design innovations discussed above, as well as to innovate further.

IMPLICATIONS OF AMT FOR JOB DESIGN CRITERIA

Advanced manufacturing technology is taking over many of the discrete and repetitive activities that workers previously performed. Activities of this type that workers continue to perform (e.g., loading and unloading a machine) are required at less frequent intervals. They are being replaced by such activities as adjusting or stopping a machine when it is not doing what it was designed to do, or notifying maintenance or supervisory personnel when a problem exists. The need for such activities is unpredictable, so the worker must be constantly alert to how the machines are performing.

Knowing what action to take requires diagnosis, which calls for information sharing and problem solving among workers and maintenance and supervisory personnel. The more integrated the types of advanced manufacturing technology, the more important it is for each worker to be alert, share information, and act quickly.

With traditional technologies, close supervision can partially compensate for a lack of internal motivation among those who are asked to perform repetitive, short-cycle activities. Close supervision does not work, however, with the new technologies that require alertness and problem solving. The premium on internal motivation increases as the technology increasingly requires intellectual rather than physical effort and fewer workers to produce the same output.

The shortcomings of job design criteria that have been used for 75 years are not as obvious with traditional technologies as with AMT. These criteria lead to designing jobs by drawing boundaries around sets of discrete activities and assigning one job per worker. The boundaries are often drawn so that no worker is idle while another is busy and so that the amount of skill required for each job is limited. With the new technologies, workers need broader skills, their activities do not fall neatly within consistent boundaries, and workers without sufficiently broad skills can cause expensive down-time and repairs.

Companies are still experimenting with approaches to job design that will best complement AMT, but the underlying philosophy is clear. New jobs need to be designed so that they (1) identify the boundaries that distinguish one job from another, even though such boundaries are more open than before, (2) reflect the contributions that workers can make to the production process, and (3) motivate workers to make these contributions.

FEWER JOB CLASSIFICATIONS

The committee found a decrease in the number of job classifications used at nearly every existing site that introduced new technology. For every greenfield site that could be compared to an existing similar plant with conventional technology, the greenfield site had fewer classifications.

The new technology is conducive to fewer job classifications. The activities created by AMT, for example, as well as those that remain after eliminating some of the repetitive, short-cycle activities, are much alike, such as monitoring and maintenance. Less need exists, therefore, to differentiate between jobs made up of similar activities in different parts of the factory.

When more people have the same classification and are capable of performing the same activities, managers have greater flexibility in assigning people where needed in the factory. Also, the administration of the wage system is simpler. Sites where job classifications were reduced with the introduction of new technology include the following:

- A unionized automobile components plant (M), with a $60 million flexible manufacturing system (FMS), planned to have three hourly job classifications, two skilled and one unskilled. In a unionized assembly plant (L) of the same company, job classifications were reduced from 200 to 34.
- An engine plant (C) had only two job classifications, “resources” and “technicians.”
- A manufacturer of military vehicle components (plant D), with an FMS, had one job classification, system operator, which was equivalent to the highest machine operator in other departments.
- A nonunion plant (N) of an electronics company had fewer job classifications after introducing AMT, with one department going from seven job classifications to just one. As further examples of reductions in job classifications, committee members offered the following:
- An aerospace company with 530 employees at a unionized plant (R1) eliminated 39 classifications. Another of its unionized plants (R2) with 95 employees went from 20 to 5 classifications. At its nonunion plant (R3), the work was structured into five versatile and flexible classifications.
- An engine company with a nonunion plant (S1) structured its manufacturing, maintenance, and support work into seven job classifications for 550 hourly employees. Its new unionized plant (S2) had five job

classifications for 450 hourly workers. Another of its unionized plants (S3), which contains a $55 million FMS, planned to have just three versatile job classifications for 100 employees.

BROADENED SCOPE OF WORK AND MULTIPLE SKILLS

Reducing the number of classifications was almost always accompanied by broadening the scope of activities in each classification. Typically, job classifications were associated with increased skills, either by increasing the number of machines or the territory for which workers were responsible, or by systematically rotating workers through a number of different jobs.

Broadening the scope of work can offer two advantages: reducing overhead costs by transferring functions from support personnel to direct labor, and combining jobs to minimize waiting time for services. It is difficult to justify machines sitting idle, for example, while waiting for a maintenance worker to perform simple maintenance.

Workers whose jobs are not redefined when AMT is implemented are likely to have too little to do. Workers with one machine each, for example, may have too much idle time after many of their activities are automated. Providing workers with multiple skills so that assignments can be broadened can help eliminate that problem.

As will be seen in Chapter 8, jobs can be designed so that both managers and workers benefit. Managers gain flexibility and better use of workers. Workers gain more meaningful work, usually at higher pay.

The new job titles reflect the broader range of workers' skills as well as the general nature of their contributions to the production process. Common titles in plants with AMT are system operator, cell manager, system technician, automated factory mechanic, operating technician, owner operator, and system attendant.

Examples of broadening the scope of work include these additional responsibilities taken on by machine operators:

- routine machine maintenance and service: greasing chucks, oiling machines, maintaining coolant conditions, and performing housekeeping tasks;
- simple troubleshooting and debugging (short of machine controller electronics);
- simple NC machine programming;

- increased responsibility for quality: in process inspection and statistical process control, with emphasis on prevention of discrepancies instead of detection after the fact;
- tool grinding and repair; and
- increased decision making on scheduling and machine use.

Underlying these trends are changes not only in technology, but in managers' views of workers' capabilities. The managers interviewed generally thought that many workers, even without additional training, could do more than they have been asked to do. They could, for example, apply skills they use outside of work (such as home repairs or automobile maintenance) to their jobs.

Managers do not yet know the degree of challenge and responsibility that workers are willing and able to accept. To the extent that workers want to undertake training and develop new abilities, management's role is to challenge and motivate them. The managers interviewed recognized that not every worker wants responsibility and challenge. Some lack capabilities; others would find change difficult after years under the current system. The consensus, however, was that most would welcome change and challenge.

One manufacturing executive (plant S3) emphasized the importance of explicit consideration of job design and broadened scope of work. Looking back on the company's 15-year experience as a leader in direct numerical control (DNC), he commented: “And to think that we ignored all human resource angles except basic training. We just superimposed NC and DNC on the traditional setup with little consideration of job enrichment. We even introduced expensive NC and DNC equipment into a plant with piecework incentive pay without any consideration of simultaneous multiple machine operation or other job enrichment. We were either lacking in imagination or too timid to rock the boat and try something new. We achieved some benefits, but not as much for the company or its workers as was possible.”

After deciding to broaden the scope of work and have multiskilled workers, plant S3 and many of the plants visited derived considerably greater benefits from AMT, as shown in the following examples:

- In the previous 2 years, the plant manager of a 2,100 person manufacturing operation (S3) had reduced the number of inspectors by 50—and had achieved better quality at less cost—by increasing operators' responsibilities for quality. Because the change was made during a period of growth, inspectors were reduced only by attrition.

- When workers in a unionized engine plant (S3) said that they could and would like to run several NC machines each, instead of only one, management not only agreed but paid generous suggestion awards and no workers were laid off. That unit was being set up as a team without a foreman.
- A number of semiskilled tasks—parts and tool staging, certain setups, routine maintenance, and shipping and receiving—were grouped into one job classification in plant S3. The purpose was to increase job quality and make the job more interesting. At a higher classification in the same plant, the job of automated factory mechanic included machining skills, coordinate measuring setups, and sophisticated machine diagnosis and repair.
- A nonunion plant (G) of an electronics equipment company created an “owner operator” job title. With AMT, owner operators had a greater range of skills. They were responsible for quality and throughput at one or more machines and contributed to cost reduction. The machine and its immediate environment constituted a small factory; owner operators ran their own work stations and took pride in owning as well as operating them.
- At a unionized components plant (M) of an automobile company, the unskilled and semiskilled work was made multiskilled by including these tasks: monitor and maintain equipment performance; maintain tool setups; receive, distribute, organize, and audit inventories; repackage vendor materials; and perform minor maintenance and housekeeping.
- In an electronics equipment company (plant A), the midskilled machine controller assigned to automated lines combined sophisticated operating skills with an increasing number of maintenance skills.
- A number of companies were cross-training their highly skilled crafts people into a common multiskilled work force. An assembly plant (I) of an automobile company reported a consequent large increase in esprit de corps among its skilled trades. At another company, the maintenance technicians were expected to take on more engineering skills.

WORK TEAMS

A work team is responsible for a clearly identifiable part of a product or a major part of a process. Jobs for teams are usually open-ended, allowing team members to assign and coordinate jobs. With relatively few rules and regulations, team members are given discretion in pursuing the team's goals. The supervisors facilitate the team's work and provide technical assistance.

Many of the sites visited used teams, but their approaches varied. In some organizations, each team had a supervisor; in others, where teams had more self-management, an individual supervisor was responsible for several teams.

The use of work teams gives team members practice in decision making and a greater appreciation of what the management function entails. Members develop and exercise interpersonal skills for solving problems, building consensus, planning, and resolving conflicts. They may find that performing and coordinating the jobs assigned to a team offers greater challenge and involvement than performing any one job alone. Finally, because the team is assigned an identifiable part of the product or process, members more clearly see the relationship between a specific job and a larger goal.

- A new components plant (M) of an automobile company was planning to implement a shift operation group of 20 hourly employees--twelve system attendants, four machine repair workers, and four electricians--backed up by a maintenance engineer and a quality engineer on each shift, plus one factory control administrator. Four zones, each with four or five different machine functions, would each have a team. Efforts were under way to develop team spirit for the entire group.
- A plant (C) of an engine company divided the shop-floor work force into about 20 teams of “technicians,” with 20 to 30 workers per team. The teams had different, evolving styles as all teams approached self-management. Almost all had informal team leaders, some rotating the post among members. Some teams met daily, and some met weekly to discuss problems. The work in each team had been analyzed and divided into 30 to 50 modules per team. Team members were expected to learn and progress in mastering the modules over the years.

- A manufacturer of military vehicle components (plant D) had 5 to 20 workers per team with a team manager who acted as a facilitator. The degree of self-management varied with the skill of the manager/ facilitator.
- An engine plant (S4) had a self-managing multiskilled work force called Team A in each of several shop operation categories. Team A interacted with, but was not supervised by, a smaller multiskilled Team B of personnel from manufacturing and support functions such as quality.

Team members rotate between tasks and, in some companies, between shifts. In a number of companies with FMS, for example, the lower skilled "system attendants," "system technicians," and "stagers" were rotated among tasks to minimize boredom and maintain their skills. Other approaches include the following:

- At a unionized plant (M), workers were required to rotate between jobs at fixed intervals to ensure that they developed and maintained the multiple skills for which they were receiving higher pay.
- At an electronics equipment company (plant A), the five operators on the automated logic unit line rotated responsibilities for different facets of the line, especially one task regarded as tedious. Each team member was a master of particular aspects of the system, a special expertise to be called on to deal with difficult problems.
- A machine tool company (plant P) had a team of workers to run its FMS cells. Each member was responsible for the unit, not just for one machine, as in the past. They were concerned with a complex of machines and described themselves as having the new and exciting role of "machine managers." In addition, the programmers were located behind a glass wall through which they could see the machines they program, in order to increase their familiarity with the machines and machine managers.

WORKER INVOLVEMENT

At most of the sites visited, the new jobs were supplemented by improved communication and a new approach to management. Workers were expected to participate regularly with supervisors in establishing procedures and improving operations, quality, and the work environment. The following examples were observed:

- Employees who would be working in an automobile components plant (M) were asked to review the lighting system and recommend changes in the plant engineer's plan. Their extensive recommendations were adopted. They were also asked to decide which of the three shifts would be unstaffed (nobody on the shop-floor). They chose the second shift.
- An engine company (plant O) held off-site meetings with representatives of all groups (inspectors, skilled trades, operators, union officials, management) to discuss all aspects of an FMS installation, including job design. Comments on specific problems were asked for and considered.
- At an engine plant (C), technicians who were progressing to a higher work module wrote a work plan stating what they needed to learn, how that would be done, and what kind of improvements would be sought in the job. The technicians then worked with the “resources” (support personnel) in developing specific improvements.
- In plants A, E, and F, work teams met 1 hour a week off the plant floor. Communications from management were presented to teams at these meetings, and minutes of the meetings were given to manufacturing engineers.
- At an electronics equipment plant (A), department managers and their staffs regularly participated in “corrective action teams.” At the time of the site visit, the teams were focusing on product quality.
- At a material handling equipment company (plant J), each “cell manager” decided how to organize shifts for operation 24 hours a day, 7 days a week.
- At a military vehicle plant (D), worker representatives defined procedures for bidding on new jobs.

CAREER ADVANCEMENT

A system of many job classifications with highly specialized distinctions and complicated wage categories limits on the job learning, personal development, and career advancement. At most of the sites studied, the newly designed jobs were viewed as opportunities for the work force to overcome these limitations. Many of the sites had developed clear personnel progression plans.

At some sites, manual assemblers had the opportunity to develop into computer operators and applications programmers.

In general, the new technology, particularly the more integrated systems, tends to upgrade the average skill level of workers. At an electronics manufacturing plant (A), for example, lower skilled assembly jobs were eliminated, manual assemblers progressed to the more complicated units, testing jobs became more complicated, and the maintenance jobs became more technically difficult. Workers generally perceived the AMT jobs (and the associated training) as more attractive than the jobs they replaced, and as making workers more marketable in the local labor market.

PRECONDITIONS AND PITFALLS

Workers may not be motivated to learn the skills needed for broadened and multiskilled jobs unless managers develop a culture that values and rewards learning, personal development, and problem solving. Managers' communication and reinforcement of values, therefore, should include (1) providing opportunities for workers to get the training and education they need to qualify for better jobs, and (2) rewarding with higher pay those who accept the challenge. In short, the plant culture practices described in Chapter 3 appear to be a necessary accompaniment to the job design practices in this chapter.

Reducing job classifications and introducing broad-scoped, multiskilled jobs in existing plants, especially union plants, are more easily done when the company can offer workers employment in other parts of the company or can guarantee that any reductions in the work force will be handled by attrition only. Unless both managers and workers benefit from any changes undertaken, they do not have an incentive to try to make any proposed changes succeed.

Two of the sites visited used a new “supergrade” job classification for AMT to protect workers trained for AMT from the consequences of having low seniority. That is, workers with seniority in other job classifications would not be able to “bump” workers in the new classification. In these cases, the number of job classifications increased by one. Such supergrades can be expedients for recruiting and retaining workers in jobs. If used repeatedly, however, they will distort the plant's job classification system and prevent managers and workers from effectively combining AMT and new human resource practices.

In addition, workers who become multiskilled will not necessarily use their skills when and where needed. A supervisor may believe that one worker is more qualified than the others at a particular task and persist in assigning that worker to the task. As a result, the skill level of the other workers may deteriorate from disuse. Similarly, in self-managed teams, team members may fall into a pattern of performing only certain tasks. Not only is the value of multiple skills undermined in such cases, but a company that is paying workers higher wages for their skills and knowledge will not be receiving sufficient benefits in return. Systematic rotation of team members between jobs has been one strategy used to avoid such work habits.

The company will be more vulnerable to the consequences of turnover if it has invested more money and other resources in training workers for the new AMT jobs. This vulnerability will require managers to place special emphasis on developing a culture that encourages commitment and loyalty between the company and its employees. It will challenge managers to design a reward structure that recognizes achievement and allows workers to better themselves by staying with the company.

6

Compensation and Appraisal

THE DEMANDS OF THE NEW JOBS

As the previous chapter indicated, managers are experimenting with ways to design jobs for advanced manufacturing technology. They are grouping new and familiar tasks into fewer job classifications and encouraging workers to broaden the scope of their jobs or to become multiskilled. They are creating teams and considering the team, rather than the individual job, to be the primary unit of work. As members of such teams, workers are asked to coordinate their activities with those of other team members, to make decisions previously made by managers, to solve problems, and in varying degrees, to manage themselves.

In most cases, the job designs are carefully aligned with the characteristics of the new technology; in some cases, the introduction of new technology is taken as an opportunity to try innovative personnel practices that are in keeping with the company's present or emerging culture. No matter what the catalyst, these new job designs and accompanying practices demand more of workers than did their previous jobs. As a result, managers need to reconsider the appraisal and reward of workers' performance.

INTRINSIC REWARDS

Some aspects of the new jobs are intrinsically rewarding to most workers. Broadened and multiskilled jobs offer more variety and are more interesting and challenging. The increased training and education required by such jobs will also be viewed favorably.

The majority of workers are likely to think themselves on the leading edge of work, welcome the opportunity to perform such jobs, report greater job satisfaction, and be optimistic about their future employment prospects. A company that is willing to provide such opportunities is likely to have managers that respect those who work for them and thus is likely to be viewed by workers as a good employer.

The effects of the new technology on working conditions are mixed. The jobs are almost always cleaner and quieter, but often they increase the amount of shift work for operators, supervisors, and the professionals supporting the technology.

COMPENSATION

At the majority of the sites visited, the average pay in the plant increased as a result of introducing AMT. The new technology eliminated many of the lowest paying jobs, thus raising the average pay for the plant as a whole. Some of the workers whose jobs were eliminated were retrained for jobs that paid more than the ones they left.

The trend toward higher compensation is not without exception, however. Some jobs, if they had been assigned exclusively to one worker, would have paid less. Workers were able to keep the same pay or increase it by agreeing to rotate among several jobs and become multiskilled.

Although overtime may be higher during start-up (as it was at plants J and O), it is generally reduced when the technology is debugged and achieves steady state. At that point, the plants are running near full capacity (24 hours, 7 days a week) so that work cannot be expanded, and preventive maintenance is practiced more conscientiously so that maintenance work is limited primarily to the day shift. When a higher level of compensation is combined with lower overtime, the effect on total take-home pay is not clear.

Three of the plants visited (C, M, and N) had no time clocks to record employees' arrival and departure. Plant M continued to pay workers by the hour, plant C paid a salary biweekly, and plant N paid workers a weekly salary.

Three other plants (D, J, and P) also put production workers on weekly salary, which may have contributed to a reduction in overtime. More companies may experiment with this practice as labor increasingly becomes a fixed rather than a variable cost of production. The number of workers required to operate a highly automated plant will be stable, whether or not it is running at full capacity.

Isolated instances of limited reductions in compensation were observed.

- At an automobile company's new components plant (M), workers selected for the new jobs were initially paid less for 6 months while they received full-time training.
- At two other companies (plants F and G), a few jobs were “red-circled” so that those who currently held them received the same pay. Any future occupants of these jobs, however, will be paid less.

LINKING PAY AND CONTRIBUTIONS

Many of the companies visited were experimenting with alternative ways to recognize individuals for their efforts and contributions to the production process. The degree and variety of experimentation suggest that no consensus has emerged on the best ways to evaluate and reward workers for their contributions with AMT.

When every worker in a job classification performed the same set of activities, then it was feasible to place a consistent value on their contributions. As job classifications decrease in number and broaden in scope and skills, however, no two workers holding the same classification are necessarily performing the same activities. As a result, job classifications offer diminishing guidance for valuing a specific worker's contribution to the production process.

The number of work modules a worker can perform appears to be replacing job classifications as an objective basis for pay differentials. At an engine company (plant C), workers decide, with skilled help, what modules they will learn, and they develop a plan for obtaining the training and experience needed to master those modules. Their compensation is based on the number of modules learned.

More judgment is required, however, to determine a workers's mastery of any particular module, vigilance in detecting machine malfunctions, or performance as a problem solver or team member. These are difficult judgments for a supervisor or a worker's fellow team members to make.

Objective measures of performance, such as yield or down-time, are difficult to apply to any one worker because of the interdependence among workers, supervisors, and maintenance and other support personnel in highly integrated technologies. Measurements can more readily be made on a team basis, acknowledging team members' collective responsibility for common machines, products, or territory.

The increasing use of shop-floor scheduling systems that require workers to record when they start and finish jobs (e.g., by passing a wand over bar codes) may permit management to continue keeping track of workers' time and the jobs they perform. Even this technological innovation, however, may not permit such tracking of workers on flexible manufacturing systems (FMS), which may do a large number of jobs at the same time with the workers less likely to be performing hands-on operations on the parts.

PERFORMANCE REVIEW PROCEDURES

Performance reviews in the AMT systems studied were of two types: the traditional one-on-one supervisor and employee review, and the peer or team review of the individual. The choice of review type is determined by how well developed the team is and the extent to which it is encouraged to be self-managing.

Both types of reviews assess individual performance in new ways. The highly integrated nature of the work in AMT systems requires that the review focus on the effort and ideas that workers contribute to their teams or to the overall production process. Supervisors and workers must have good judgment and maturity to make fair assessments. When the team is responsible for the review, it may get comments from support personnel and from managers where relevant.

The reviews may be held according to a strict calendar schedule, such as every 6 or 12 months, or when workers complete work modules and ask to be evaluated on their performance.

ISSUES OF ADVANCEMENT

When there are fewer job classifications, there are also fewer opportunities to promote workers to a higher level in the job hierarchy. Companies with fewer levels were replacing the job hierarchy as a means of advancement with a sequence of work modules to be learned. In some cases, workers will quickly reach a plateau.

- An automobile components plant (M) with only three nonexempt job classifications expected that unskilled workers would reach the top pay level in 2 years, after passing module reviews at 6-months intervals.
- An engine plant (C) with two job classifications had one of them, "technicians," pass through six levels in 5 years. Each team had 30 to 50 work modules to learn in its area. The plant reported that some people chose not to apply for these jobs when they learned of the lack of traditional advancement.
- Managers in a military vehicle components plant (D) expected that team members would reach the highest level after 4 years. The next step for workers would be to learn to operate the software and simulation system in the FMS, thus reducing the work presently done by managers. In non-FMS areas, workers who complete all requirements for one classification could move to another work team or area.

It may be possible to extend the incentive to learn by rewarding workers not only for the number of modules learned, but also for their depth of knowledge and skill in performing any one module. Also, management may not be willing to continue rewarding everyone in the plant for the number of modules they can perform. Beyond some point, it does not pay to have every worker skilled in all activities required in the factory, and management may ask how many multiskilled workers are needed and worth paying for. As managers communicate the plant's values to the work force, they will have to emphasize that learning and development must also be cost effective.

7

Selection, Training, and Education

The introduction of advanced manufacturing technology has significant implications for the selection, training, and education of employees. In general, AMT alters the criteria used to select workers, tends to raise significantly the amount of training needed by the work force, and raises issues concerning the relationship between educational institutions and other sources of industrial training.

SELECTION

In the past, the criteria for selecting workers for industrial jobs were not complicated. Companies rarely assessed workers' attitudes and, in some cases, did not assess skills before hiring and assigning them to a job. Seniority played a major role in determining training opportunities and movement into new jobs.

Workers will need to learn much that was never before part of the job, such as problem solving in teams. As a result, the new technology requires a selection process that values the ability to learn. Furthermore, the training for AMT jobs needs to start earlier, is more intense, and is expensive. Too many resources are wasted if a worker proves not to be capable of the job. It may be risky, therefore, to weigh seniority too heavily in selecting workers for the new jobs.

Several of the plants visited have given a great deal of consideration to developing processes for selecting workers for AMT jobs. After going through an elaborate screening process that clarified the high demands of the new jobs, many workers have removed themselves from consideration for the jobs. Examples of the selection processes include the following:

- At a unionized automobile components plant (M), applicants for skilled jobs had to complete an 8-hour assessment of their technical and interpersonal skills, which was conducted by a local community college. They then took a 4- to 6-hour skill-level inventory. Finally, the applicants attended a family night with spouses to discuss the program. The 45 applicants remaining from an initial 100 were then ranked by seniority. Some of these 45 workers declined the new jobs, and 16 were eventually placed.
- At a unionized automobile assembly plant (L), selection was based on general ability, seniority, and previous employment with another division of the company. Seniority was the deciding factor only in the event of a tie score on the other dimensions.
- At a nonunion engine plant (C), the selection process took 8 to 10 hours over 6 to 8 weeks. In addition to orientation and interviews, applicants were placed in simulated problem solving situations and evaluated on how well they responded.
- An automobile assembly plant (L) would not hire anyone who has not passed a standardized test of ability to read, write, and use simple mathematical formulas.

The experience of two union plants (L and M) suggests that, by careful planning, union and management can devise innovative ways to give weight to selection criteria other than seniority and gain the confidence of the work force in the fairness of the selection process. If a company gives inadequate attention to how it will select workers for AMT jobs, it will use seniority alone by default.

A new high-level job classification was created at several of the sites visited to prevent people trained for the new technology jobs from being “bumped” by employees with higher seniority. Managers have sought such sanctuaries in existing plants to protect their investment in training a few carefully selected workers. The value of such sanctuaries will decrease as more AMT is introduced in these plants. The investment in training will have been made for more and more workers, thus reducing the need to single out any particular worker for protection.

If unionized plants must reduce their work forces because of adverse economic conditions, however, seniority will still be used to determine the order of layoff. Another selection problem for existing plants, whether unionized or not, is that companies that establish a policy of promoting from within will limit the pool of workers potentially qualified for AMT jobs. Managers, however, may find that the benefits of such a policy, such as fostering loyalty among workers and reducing turnover, are worth the price of a smaller selection pool.

The new selection policies of companies with AMT may have the side benefit of enhancing the mobility of minority and women workers. Often these workers have low seniority and so are excluded from advancement within the plant. Selection practices for AMT that are not based solely on seniority would appear to increase their chances for advancement.

INCREASED NEED FOR TRAINING

With traditional manufacturing technology, the training of personnel was seldom considered before plans were completed for plant layout and the deployment of machinery. Issues in training were simple and straight-forward--where to get it at the lowest cost. Production workers usually were trained informally on the job. Most companies did little formal training, relying on the school system and other institutions, such as the military, to provide the background that workers needed to perform their tasks. Only when a specific new process was initiated or a specific new machine deployed did the company pay for training directly. Normally, the vendor of the equipment trained a few of the company's engineering staff, who then informally trained the workers. Companies did little systematic evaluation of training and had little interest in it beyond the teaching of specific skills needed to perform a necessary task.

The introduction of AMT has considerably altered this picture. The knowledge and skills demanded by the deployment of this new equipment have necessitated large-scale formal training programs. This effort has been costly. According to the American Society for Training and Development, U.S. corporations are increasing their spending on technical training of production workers. Further, training is not confined to the production worker, and companies that have successfully implemented AMT have also directed major efforts at training their managerial and engineering staffs.

As AMT changes continuously, constant training is mandatory. Some companies have calculated that the "occupational half-life," the time in which one-half of workers' knowledge and skills becomes obsolete, has declined from 7–14 years to 3–5 years. As a result, companies are rapidly establishing new internal training departments and developing the capacity to train their employees continually.

Because the implementation of AMT involves significant technical and social innovations, the technical knowledge and social skills of workers, professionals, and managers have a degree of obsolescence. Within every employee population, therefore, are individuals whose skills become obsolete and are not ultimately renovated by training. The committee focused on how workers were learning to use the new technology more than on what was done for the employees who did not. Nonetheless, both issues are important in planning for AMT.

The changing content of training for AMT also increases the importance of training. Instead of learning a single skill or how to run one machine, workers must learn to integrate data, troubleshoot problems, and understand the relationships among increasingly integrated pieces of equipment. In brief, they must learn to think about the overall process of production and their role in it. Training requirements remain skills oriented, but the skills are defined more broadly to include the ability to think about the process, as well as interpersonal and team skills. These developments have transformed training programs into more general courses in production strategies and trouble-shooting and have raised concern for management about such issues as the general ability of workers to read, write, and communicate.

The extensive amount of training has also raised serious questions about the choice of training systems. How much of the training should be done by the company--either in-house or through some other system? How much of the training can be done through the educational system, before people enter the work force? The demands for greater training create significant policy issues at the company and plant levels and for educational and governmental authorities at the national, state, and local levels.

In every plant visited by the committee, training of the work force was an important function that plant and corporate management had to plan and implement carefully. The ability to resolve some of the training issues that will be discussed below was a major contributor to the successful implementation of AMT.

CHANGING SCOPE OF TRAINING

Training of Production Workers

Companies that have successfully implemented AMT are far more likely to have major training programs for the production workers who will have direct responsibility for the control, repair, and use of the equipment. Those training programs start earlier, last longer, and include far more than their predecessors with traditional technology. Some examples found by the committee were the following:

- In anticipation of introducing computer-based machinery, the manager of an automobile assembly plant (I) established a training center months before the plant was operational. Skilled workers transferring to the facility from other plants received more than a year of training in the use of the equipment, before the plant was constructed.
- A large automobile components plant (H) established a learning center where at least six workers on each shift were regularly released from their jobs to watch video tapes on technologies used in the plant. The center had a library of tapes with recorders for workers to use on their own time at home. The center also conducted regular classes for employees.
- At another new facility (plant D), all shop employees were required to attend a free 3-month training program at a local technical institution before they could be hired. The program was designed to provide a mastery of machining principles, as well as hands-on experience with some of the technology. Program participants were tested and their progress was monitored by the plant management. Upon graduation (held at the plant facility), they were eligible for jobs as they became available.

- In another plant (M), where the manufacturer was installing an entire “factory of the future,” all workers selected for that part of the plant underwent an extensive skills assessment program and specific technological training, custom designed by a local community college.
- Initial training for semiskilled workers at a greenfield engine plant (C) included almost a month of familiarization with the product, an overview of the company's operations, and basic economics and mathematics.

Broader Scope of Training

Companies are training employees not only for work in specific areas of the plant, but also in far more general concepts, such as how a specific machine process fits into the entire plant perspective. Indeed, a good many of the plants visited showed far more concern with basic skills, the ability to read, write, think, and, perhaps most significantly, knowing how to learn. Companies appear to want workers who not only have specific skills, but also will continue to learn as AMT continues to change.

- At an automobile assembly plant (I), the manager determined that training of production workers in basic communications skills was mandatory if they were to contribute significantly to the weekly quality circle meetings.
- An electronics equipment plant (A) extensively assessed the basic skills of its employees to determine what sort of additional training they would require.
- At an automobile components plant (M), training in basic and interpersonal skills preceded training in specific technical skills.

Many of the companies visited by the committee had discovered a need to consider training as a continual process. Most of the managers said that they had underestimated the funds and organizational resources needed for the training process.

Joint Training of Production and Salaried Employees

Perhaps the most striking innovation in the training associated with the new technology is the increasing overlap of training for managers, engineers, and the work force. Indeed, implementation of the technology imposes new demands on the entire plant, often resulting in more interaction between segments of the work force.

Companies in the past have generally permitted production personnel to be trained by the local managers, and professional and managerial staff to be trained at the centralized corporate level. Plants are increasingly using a single training system for production and salaried workers, especially skilled workers and engineering personnel. Some of the companies visited were setting compatible training goals for production and salaried workers and training them together. In a few of the plants, engineers were taking courses from the skilled workers.

- At an automobile components plant (H), engineers and skilled workers were sent together to a vendor's school to be trained in maintaining programmable controllers. The management said, “A few years ago, we would have never spent money to send production people to courses.”
- To stimulate interest in computer literacy, one smaller company (plant J) gave all managers and production workers the same discount to purchase their own personal computers.
- An executive of a machine tool company (plant P), at the time of the site visit, believed that 15 percent of the engineering work force would be permanently in training as a result of the adoption of “simultaneous engineering” (wherein the client works with the company to develop a concept into a machine, as opposed to the traditional way of building products from preset specifications).
- A major machine tool builder (plant P) upgraded skilled workers into programmers, transferring them into management ranks when it introduced a flexible manufacturing system (FMS) that began to displace workers' machining skills. As their skills became obsolete, the workers were given an opportunity to learn new skills.
- At an electronics equipment plant (G), managers and owner operators were trained together for 12 weeks to ensure that the machines and the general process of production are understood by the entire plant.
- To decide what specific type of FMS to purchase, a company (plant K) formed an “implementation team” that included workers, engineers, and managers. They spent

2 years learning about flexible manufacturing systems, visiting vendors and installations, and, finally, jointly recommending a system for the company to purchase.

- At an automobile components plant (M), team-building skills were taught to production and salaried personnel together. This cooperative training was part of the building of a new spirit at this older facility.

Retaining the Training Investment

One result of greater training is the loss of a correspondingly greater investment if workers leave the plant or are laid off. Especially in some of the newer technologies, such as programmable controllers or computer-aided design (CAD), the training invested in workers often gives them greater job mobility. The issue for the company is how to continue to provide the required training without facing the continual threat of work force turnover and consequent further training costs. Means of meeting this challenge include competitive pay and working conditions, challenging work, advancement opportunities, a favorable work culture, and, in cases of a unionized work force, a constructive union-management relationship.

INDIVIDUAL INVESTMENTS IN TRAINING

Workers are also investing their own time and money to train for AMT jobs.

- Voluntary enrollments at universities and community colleges near an electronics plant (G) increased 64 percent after the plant announced its future automation plans.
- At another plant (A) of the same company, test technician trainees were given 400 hours of training over 20 weeks. Many of the trainees subsequently took courses on their own time from local educational institutions.
- Workers who wanted to work at a military vehicle components plant (D) attended a local technical institute tuition-free for a 3-month training program required by the plant. These workers, however, invested their time; they were not paid for their 3 nights a week in the program, and there was no guarantee that jobs would be available when they completed the program.

Many companies reimburse workers for tuition if they receive passing grades in classes at local educational institutions. Time, however, may limit training opportunities more than money does, especially for workers with child-rearing responsibilities outside of work. A significant amount of training for AMT jobs involves evening classes and homework.

EDUCATION AND TRAINING SYSTEMS

The consensus on the need for more training in basic skills does not extend to the type of training system used. Indeed, the growing concern with training has produced a blizzard of options. Some companies depend on equipment vendors to provide training, while others use community college programs, develop in-house training centers, or work within governmental programs. Most of the larger companies use a variety of basic training systems. The choice of a training system appears to depend on the responsiveness of individual training systems and the amount of pressure to keep costs low in the local plant. Within this mixture of approaches, however, are the following themes:

- Training programs should be customized. Good programs are designed for specific company needs, including plans for the technology.
- The effectiveness of training programs should be continually assessed. Some of the companies visited reported that training programs were successful only on a hit- or-miss basis; managers were unsure how to ensure consistent success. Many of these companies now evaluate their training programs, through surveys of the training given or efforts to detect productivity increases. In plants H and K, these evaluations have resulted in modifications of the company's training system.
- Most training for AMT includes cross-training or training in the variety of skills needed to run computer-integrated systems. The number of skills in which workers should be trained, however, is an open question. Some plants rotate workers in jobs; others keep them within a particular work area.
- Good technical training is essential, and companies are willing to pay for it. The successful companies have found no shortcuts to a trained work force and, for specific key technologies, will spend large amounts of

money to train relatively few workers. As one executive put it, “To spend $5,000 on an inferior training program that creates down-time on a $7 million machine without improving productivity is incorrect thinking.”

The need for training raises the issue of the proper mesh between public educational institutions and companies' demands for training. Many public institutions have helped to develop customized training programs for companies. The committee's visits indicate that community colleges have successfully trained workers in the new technologies for local industries. One unresolved issue is how well this format could be used to develop retraining programs for engineers and other professional workers in the new technologies.

While the immediate emphasis of many companies has been on retraining their workers, a more general concern exists about the U.S. work force and the skills required for AMT. How much hands-on training should people have had by the time they apply for entry level jobs? Whose responsibility (the public school, the corporation, the individual) is it to pay for and develop this hands-on training? Although the answers to these questions are not clear, the committee's site visits indicate that employers are less concerned with initial hands-on training than with the ability of their workers to read, write, and think. An appropriate balance might be for public institutions to continue to provide training in basic skills--reading, writing, computation, and communication skills--while companies train their workers in specific technologies.

Attaining the appropriate mesh of basic and specific skills provides a real challenge to vocational school authorities. Instead of developing many specific technical programs for younger students, under the assumption that such training will get them better jobs, vocational schools might be better off promoting the concept that possessing basic skills will place an individual in a company, ready for further, specific training. Too narrow a vocational training could be disadvantageous to many young people seeking AMT job opportunities. In contrast, public institutions that focus on teaching specific technical skills to adult workers already on the job are also meeting a real need.

8

Labor-Management Relations

A theme underlying the various ways in which companies have responded to the issues raised in earlier chapters of this report is that an individual's activities and compensation are not determined by technology alone. They result from managerial choices about how people should be employed and, in unionized settings, from the relationship between union and management.

In traditional adversarial conditions, union and management can benefit from a large number of narrow job classifications. Management pays the average worker less for performing relatively low-skilled jobs, while the union has more workers employed as well as an elaborate job security mechanism to protect workers with high seniority in specific job classifications. If neither side trusts the other, such a system will be self-perpetuating. In the long run, however, this system may hurt both union and management if their foreign and domestic competitors employ their workers more effectively and produce higher quality products at lower cost.

The committee's site visits produced a good deal of evidence that both union and management can benefit from a broader definition of jobs. Management can benefits from workers who are better trained and who can exercise the judgment needed to operate and maintain expensive equipment. The union benefits by its members' having more secure employment, more interesting and challenging jobs, and higher pay.

Noted in the report are a number of instances in which cooperation and joint problem solving between unions and management about AMT were part of a general change in the balance between cooperative and adversarial processes. Today's forms of union-management cooperation, often born of adversity and championed by particular leaders, may pose complex dilemmas for both union and management as they move in this direction. These problems may be complicated by jurisdictional issues between unions.

For example, the site visits suggest that advanced manufacturing technology requires more skill and knowledge in operation and maintenance than does traditional technology. How that skill and knowledge will be distributed between nonunion, white-collar professionals and workers in the bargaining unit can be a source of controversy. Committee evidence suggests that some managers are reversing a pattern of recent decades and assigning multiskilled tasks to workers in the bargaining unit. Direct consideration and discussion of these issues is a necessary part of implementation planning for AMT in unionized workplaces. The committee has not explored how far it is reasonable to go toward joint planning of technology and other matters of mutual concern.

QUALITY OF LABOR-MANAGEMENT RELATIONS

Implementation of AMT in a way that benefits managers and workers (and their unions) requires strong labor-management relations. In addition, both groups need an understanding of how to deal with a number of issues that arise from the introduction of new technology.

Today's competitive environment provides adequate reason for union and management to improve their relationship. Self-serving tactics divert the time and energy of both workers and managers from producing higher quality products more efficiently and thereby securing jobs. A better labor-management relationship can lead to improved performance regardless of whether the plant invests in new technology. But a plant that invests in new technology is even more likely to reach its full productive potential if it has a good labor-management relationship.

Managers would be well advised to begin working to improve the relationship before introducing new technology. One way to begin is to introduce quality-circle or quality of working life programs in the plant. Several of the unionized sites visited had such programs before new technology was introduced. Management and union officials at these sites reported that the programs gave them experience in working cooperatively on subjects of mutual interest. These programs helped them recognize that it was possible to solve problems and bargain with the same people, depending on the issue and circumstances. These programs are particularly important if managers use the quality of the relationship as a criterion for deciding whether to invest in a particular plant.

National contracts affecting most of the unionized sites visited require management to notify the union of plans to introduce new technology. One indicator of the quality of the labor-management relationship is the willingness of management to notify the union as early as possible and the extent to which management involves the union in implementing the new technology. The union could be involved as early as the selection or design of the technology. Union officers or members at five unionized sites (I, K, M, O, and Q) accompanied engineers on trips to vendors and made recommendations on what equipment to buy. Knowledgeable union officers or rank-and-file employees can also offer ideas on how to make the equipment operate more effectively on the shop-floor, how jobs might be designed, planning for displacement, training, and so on.

If consulted early, the union may be an advocate for the new technology, arguing that it is the only way in the long run to retain members' jobs. In fact, union officials at two of the sites visited (plants F and O) specifically said they frequently make this point to their membership. Such advocacy is much less likely to occur if the union is not informed about the technology until all key decisions have been made. The union may oppose what it views as decisions made without considering union members' interests.

Union officials who participate in decisions about the introduction of new technology are taking some political risk in the interest of maintaining the health of the industries and plants where their members are employed. They might be seen by their members as “being in management's pocket,” as one manager put it. Union officials willing to take this risk seem to recognize that greater risk may lie in doing nothing or opposing everything that management initiates. The consequence of such a position may be a plant becoming noncompetitive and subsequent loss of jobs for union members.

To deal intelligently with issues that arise from the introduction of new technology, managers and union officials at the industry and plant levels need to keep up-to-date on developments in AMT and their implications for labor relations. Corporate managers and national union officers are in a natural leadership position to educate their plant-level counterparts about AMT and to develop policies to deal with it.

MODIFYING CONDITIONS OF EMPLOYMENT

Most of the sites visited were experimenting with combining existing job classifications into broad-scoped or multiskilled job classifications. The total number of job classifications was thereby reduced.

Managers at three unionized plants (F, O, and Q) agreed to create a new, higher paying classification for AMT jobs, primarily to prevent the occupants from being bumped during layoffs. All three sites are existing plants in which the majority of workers held traditional jobs; seniority is plantwide, so workers with high seniority in such jobs can bump down to lower-rated jobs to avoid being laid off. With the new job classification, management gains some flexibility in assignments and assures continuity for workers it trains for AMT jobs. These workers receive higher pay and greater job security, but the number of job classifications increased by one. Management at a fourth unionized site (K) proposed such an arrangement, but the union rejected it because it did not want to tamper with basic seniority provisions while a high percentage of its membership was laid off.

New job classifications need not be created to gain flexibility in assignment. At two of the unionized plants (I and M), workers in skilled trades informally agreed to perform work normally performed by other skilled trades. All received the same pay and retained their skilled trades identification under the contract. Thus, flexibility can be greater in practice than it may appear to be on paper. Workers have important reasons for retaining their skilled trades identification. State laws may specify criteria for apprentice and journeyman status in a particular trade, and workers may need their identity as electrician, pipe fitter, millwright, and so on, if they leave their present employer and seek a job on the open market. Lines of demarcation between trades within a particular plant are established by custom and past practice. In some cases, the plant culture and the degree of trust between the local union and plant management can offer as much flexibility as a formal change of rules.

INTEGRITY OF THE BARGAINING UNIT

Management and union need to agree on criteria for what work will remain in the bargaining unit. This task is complicated by the blurring of distinctions between professional and shop-floor work with AMT. As a result, both parties may view the introduction of AMT as an opportunity to try to change the bargaining unit in their own favor. The outcome most likely to avoid controversy, at least initially, is the status quo; jobs that replace work done by members of the bargaining unit can remain in the bargaining unit. This appears to be the solution most likely to avoid controversies that would interfere with the implementation of AMT technology. But it is important to recognize that this approach may or may not lead to an optimal use of the new technology, and therefore must be carefully considered.

Union and management at several of the plants visited raised issues related to the diminishing boundaries between management and work force functions with AMT, but no trend was apparent in how they were dealing with it. Computer programming by production workers, for example, was an issue in some places but not others. The committee talked to shop-floor workers in nonunion settings who could write, or at least proofread and edit, software programs. In some unionized settings, programming by shop-floor workers was an issue because of the impact it might have on the bargaining unit. At one unionized site (plant O), the issue was not the worker's ability to write or modify programs, but that the program in question involved scheduling, which is traditionally a management function.

EMPLOYMENT SECURITY

Employment security is often a prerequisite for union acceptance of changes described in this report. The job classification system, for example, currently serves in part as a mechanism for handling layoff and shift assignments. It will be difficult for union and management to agree on reducing job classifications when bumping rights and shift preferences are based on seniority in classifications. A system of radically fewer job classifications is more likely to be accepted in a new, highly automated plant than is a gradual shift to fewer classifications in an existing plant. Fewer job classifications in any plant means that straight seniority will eventually play a greater role in determining bumping and shift preferences; a plant with a single job classification would have a pure seniority system. A gradual shift to fewer job classifications, however, will still provide safe niches for some employees, and they will not readily give them up.

Most of the sites visited had policies for providing employment for workers displaced by technological change. Such workers were offered other jobs with the company and retraining where necessary. The majority of the sites, however, did not guarantee job security in a business downturn. Many of the plants expected to employ fewer workers in the next few years, but thought they could handle the reduction by attrition and plant transfers. The management at one site (plant F) anticipated that it would employ the same number of workers in 10 years, even though it expected to invest heavily in new technology, because it foresaw a substantial increase in business.

Employment security may be greater, in general, for workers in highly automated plants as labor costs shift from variable to fixed. A stable but smaller number of workers will be required to operate the plant regardless of the volume of output. Protection can be provided to workers who might otherwise be displaced by technological change, however. A company can guarantee employment, for example, as long as an employee is willing to be trained for a new job. The 1984 agreement between General Motors Corporation and the United Auto Workers established the Job Opportunity Bank-Security (JOBS), to which employees displaced by new technology can be assigned at full pay and benefits. While in the “bank,” employees can be assigned to training programs or to fill in for other workers who are themselves in training programs. A similar program is the Protected Employee Program (PEP) at Ford Motor Company.

None of the companies visited reported any involuntary loss of employment directly attributable to technological change. Workers whose jobs were displaced by new technology were being retrained for new jobs or given the opportunity to transfer to another plant within the company. The plant managers believed that attrition would be sufficient to accommodate any work force reductions that resulted from new technology. Some of the plants had workers on layoff because of a decline in business. Workers or union officials interviewed at the plants, however, did not view the layoffs as the result of new technology.

Most sites had stable employment because of increased demand for a superior product or because they were bringing previously subcontracted work back into the plant. The reason for the latter is that the new technology is so expensive that plants try to run two and three shifts a day to shorten the payback period on the investment. While plants that do previously subcontracted work may not suffer loss of employment, the companies that lost the work probably will.

One aspect of employment stability directly under management's control is how well it plans for plant start-up with new technology. If a company plans for too rapid a start-up to full capacity, it will need a much larger number of support and maintenance personnel early, but may have to reduce that number as the plant approaches steady-state conditions. Planning for a gradual buildup to full capacity may permit a more predictable increase in the personnel needed to operate the plant and avoid the need to lay off people later.

Personnel planning requires care in both unionized and nonunionized settings. Management has less flexibility in unionized settings, however, because of its limited ability to hire nonunion people, such as “job-shoppers,” to cope with temporary surges in personnel needs. Unions rarely accept the employment of people who would normally do the work of members they represent.

9

Epilogue

Chapters 1–8 have reported the committee's findings on AMT implementation obtained primarily at plant sites visited by one or more committee members. Some of the findings have been additionally supported by examples known personally to committee members (usually because these cases are internal to their own companies or unions).

The committee has carefully reported findings about implementation practices, often without drawing conclusions about the general applicability of any particular practice to AMT. It certainly cannot be certified in any particular instance that the particular practice (e.g., selection strategy) will work out as intended or expected by the planners.

What the committee does endorse as appropriate to the types of AMT applications studied is the overall thrust of the practices involved:

- defining jobs more broadly to include more interrelated tasks,
- creating more flexibility in work assignments,
- delegating more discretion to lower levels of the organization where the information and expertise exist,
- communicating more about plans and business conditions,
- involving more employees and their representatives in more activities that affect them and require their support and cooperation, and
- changing the culture in ways that reflect and encourage these changes in practices.

Throughout the report, the committee has emphasized how these practices were tailored to fit the technology, and the committee believes the practices were particularly instrumental in implementing the technologies represented by its AMT examples. Beyond that, however, the committee views these and related practices as suitable responses to the increasing competitive pressures on managers to improve their motivation and use of employees, and to the changing expectations of these employees about their participation and treatment in the workplace.