WORKING PAPER
ALFRED P. SLOAN SCHOOL OF MANAGEMENT

Technological Choice: Obstacles and Opportunities for Union-Mangement Consultation on New Technology

Robert J. Thomas

February 1988 WP# 1987-88

MASSACHUSETTS
INSTITUTE OF TECHNOLOGY
50 MEMORIAL DRIVE
CAMBRIDGE, MASSACHUSETTS 02139

Technological Choice:
Obstacles and Opportunities for
Union-Mangement Consultation on New Technology

Robert J. Thomas

February 1988 WP# 1987-88

Technological Choice:

Obstacles and Opportunities for Union-Management Consultation on New Technology

Robert J. Thomas
Associate Professor of Organization Studies
Sloan School of Management
M.I.T.

This research was conducted with the assistance of the Industrial Relations Section of the Sloan School of Management at MIT. Research support was provided by the sponsoring company and the joint union-management committee on new technology. The author wishes to thank Tom Kochan, John Van Maanen, Paul Osterman, Michael Scott Morton, and Rosanna Hertz for their valuable comments on earlier drafts.

Contents

Introduction

Over the past decade, efforts to reverse the decline in manufacturing productivity have stimulated rapid increases in the sophistication of production technologies. Though often conceded as necessary in light of increased global economic competition, technological change nonetheless creates serious tensions in an already troubled system of labor-management relations. Tensions are building in several directions. Many union members see new technology as a threat to job security and skills and are pressing their leaders to include technology as part of the package of issues over which union leaders should negotiate (Parker 1985; Slaughter 1983; Shaiken 1985). Many union leaders are now haunted by concessions (particularly in the area of job structures and work rules) that were granted to employers during the recent recession and are attempting to reconsolidate their influence in the workplace (Kuttner 1986; Hershizer 1987; Solomon 1987; Cornfield 1987; Kochan and Piore 1985). Employers may be attracted by the lure of substantial reductions in labor cost and by the negotiating leverage to be gained from new equipment and processes, but they cannot ignore the human resource and industrial relations impacts of indiscriminate adoption of new technology (Beer, et al 1985). As some companies have discovered, headlong rushes into untried technologies, or trying too much at once, can lead to painful results (cf., Liker, Roitman and Roskies 1987); many more have come to realize that the benefits of new technology cannot be fully realized without the right combination of equipment, skills and people (Davis and Taylor 1976; Walton 1981, 1987).

Yet, as these tensions mount, corporate executives and union leaders operate far removed from intimate knowledge of how new equipment and processes work, how they evolve, and whether new technology is, in fact, responsible for job loss and deskilling. Corporate investment decisions may be tempered by projected impacts on employees and labor-management relations, but determining what is technologically possible is not something corporate leaders generally do (cf., Donaldson and Lorsch 1983). They rely, instead, on the recommendations of technical staffs for whom industrial relations and human resource management questions are a secondary concern, at best. Labor unions, when they develop a stance with respect to new technology, do so on the basis of indirect and usually imprecise sources of information (e.g., industry or trade journals) and the rare glimpses they might be given of a particular company's future plans. By the time the latter information is made available, it is likely that major decisions about investment have already been made; more importantly, the information provided has already undergone a screening by technical staffs and thus appears not as a description of "possibilities" but as a depiction of "realities." Thus, leaders on both sides of the fence delegate considerable influence to technical staffs who are not routinely expected to deal with the choices (or the range of impacts) implied by new technology.

The tension between and within unions and management has given rise, in recent years, to a number of agreements which commit contract partners to monitor and, in some limited instances, to jointly consult over issues associated with new technology.[1] Yet, despite the growing number of contractual and less formal agreements between companies and unions to address technological change, the short- and long-term implications of those efforts are unclear. Critical questions remain to be answered at two levels. The first level concerns the immediate organizational and procedural aspects of technological change. What changes will be required in the way new technologies are developed or acquired? What role, if any, will the industrial relations or human resource development functions of an organization play in regard to the selection of technologies? How will unions be represented in the decision-making process?

And, will unions be willing and able to make meaningful contributions?

The second level of questions concerns the longer-term prospects for joint union-management approaches to new technology. Will the efforts initiated in recent years erode once the current wave of technological change has crested and unions and companies have accomodated it, perhaps through the establishment of a process of negotiation over the effects of new technology? Or, will a process of joint consultation and/or joint decision-making emerge in which unions become actively involved in the design of new technology and job structures? The first path sustains the traditional concept of "management rights" to organize production and insulate the process of new technology development and acquisition from external intervention. The second path, however, broaches the possibility of a "social choice" approach (Shaiken 1985) to technological change: featuring earlier communication and more extensive consultation between companies and unions around the types of problems to be solved and the alternative technological *or* social solutions available to deal with those problems.

Debate over which of these or other paths are likely to be pursued has been limited largely to speculation and earnest but limited efforts to draw insights for the American scene from European and Japanese experiences (cf., Shaiken 1985; Parker 1985; Martin 1987; Howard and Schneider 1987; Sirianni 1987; Cole 1979, 1987; Shimada 1985; Shimada and MacDuffie 1986; and Kuttner 1986). Descriptive research on developments in the U.S. is growing in volume; yet, to date, few systematic attempts have been made to assess the implications of joint consultation for the conduct of industrial relations at the level of the firm.[2] The relative newness of the agreements accounts, in part, for the paucity of research and analysis. More important, however, the field has lacked a firm understanding about the practices which underlie the first level of questions, in particular: *how new technologies are chosen, developed* *and implemented at the level of the enterprise.* If the agreements are to become part of what Kochan, Katz and McKersie (1986) envision as the strategic contribution of industrial relations, then a clearer sense of the decision-making process and the implications of change are essential first steps.

This paper represents an opening effort to address both levels of questions through an analysis of the process of organizational decision-making about new technology. More specifically, three different case studies of technological change in a large unionized manufacturing firm are presented. These case studies chronicle the introduction of the innovations from their earliest stages up to and through their implementation and provide a window on three critical aspects of technological change: (1) *how technological change possibilities are surfaced*, e.g., how problems demanding solutions (and, as we will point out, how solutions in search of problems) are identified; (2) *how technological solutions are selected and, once selected, modified in practice*; and (3) *how and when the human resource and industrial relations dimensions of technological change are considered.*[3]

Following a brief discussion of the research site and the methods employed in data collection, we provide a summary of each of the case studies. In presenting the case studies, we focus particular attention on the three critical aspects of technological change. In the discussion, we will summarize the relevant findings from the research and what they imply for the organizational and procedural questions and for the longer term prospects of joint consultation on new technology.

Investigating the Technology Development Process

To more thoroughly examine organizational decision-making around new production technology, we undertook research in a Fortune 100 aerospace and electronics manufacturing enterprise in the summer of 1987. The company employs nearly 100,000 people in the United States and Canada has contracts with three major North American unions. The union with which we dealt most directly represents nearly two-thirds of the company's hourly employees in the U.S.

The study was jointly sponsored by a management and union "New Technology" committee. The New Technology committee was created in the early 1980s to foster pilot projects in work redesign, to coordinate retraining for employees displaced by new technology, and to serve as a vehicle for the company to brief the union annually on its short-term plans for technological change. The committee, its charter, and its policies are specified in the collective bargaining agreement. This specific research was part of an effort to assess the implications of a broader-based approach to information-sharing and joint consultation on new technology issues. It was, however, also stimulated by concerns expressed among union representatives that the rapid pace and uncertain impacts of technological change in the firm were undermining union members' confidence in the New Technology agreement.

Three recent technological changes were selected for the research.[4] The three cases were chosen to represent new but substantially different technologies being applied in the company's major manufacturing facilities; but, they were also chosen for their "generic" qualities, i.e., their similarity to technologies being developed or applied in a wide range of manufacturing enterprises. Two of the three -- a flexible machining system or cell (referred to as an "FMS") and a robotized assembly cell -- fell under the broad definition of new technology contained in the language of the parties' collective bargaining agreement. The third project involved the introduction of a new generation of machine tools used in the parts fabrication process. This last project was not explicitly referred to in the contract but was deemed by both sides to represent a new direction in machine control systems and one which was likely to become more common in the company.

The projects became the unit of analysis for the research. Although the project unit focuses attention on the specific technology divorced from a stream of efforts of which it might be only one example, this approach allowed us to investigate a case from beginning to end (i.e., from concept to and through implementation). Beginning and ending points were chosen arbitrarily: the beginning was designated as the first formal (written) reference to a particular problem (or solution) which could be linked to one of the projects; and the endpoint was chosen as the date in which the new equipment was brought formally into production.

Data collection consisted of three main activities:

(1) In-depth semi-structured interviews were conducted with participants in the decision-making and development processes. Initial interviews were conducted with division-level research and development (R&D) managers to determine who was involved in the various phases of each project. Subsequent interviews included additional people who were mentioned by those interviewed on recommendation of R&D management. Thus, it was possible to expand beyond the central engineering personnel to include representatives of allied functions (e.g., facilities maintenance, materiel and purchasing, industrial engineering, training, and industrial relations). Later interviews were conducted with line managers, supervisors, and workers in the facilities into which the projects were placed. The interviews focused on the history of each project and on the direct or indirect contributions each respondent made in that process. The interviews were tape-recorded and transcribed for later analysis. Each of the respondents was assured of anonymity in the reporting process and every effort has been made to insure the confidentiality of the interview transcripts and the comments/ideas/criticisms they

contain. The factual content, as well as further exploration of key items, has been aided enormously by the opportunity to reinterview selected respondents. In all, a total of 54 people were interviewed in the research; this included representatives from each of the three sites, as well as corporate and union staff. An additional ten individuals were consulted informally or for short periods around specific issues.

(2) All available documentation associated with these projects was collected. This material included project proposals and comments, memoranda and letters circulated internally, purchase specifications, bids from equipment vendors, and capital equipment requests. In order to avoid the distortions commonly present in retrospective interviews, every effort was made to corroborate dates, events, and (where appropriate) disputes by means of existing documentation. On occasion this took the form of reviews of engineer's journals and notes, i.e., logbooks which many engineers kept to document their progress, the hours they devoted to given projects, and their comments on meetings and conversations. These latter materials were especially useful in annotating and occasionally clarifying official reports and schedules.

(3) Field notes were kept on the time spent in each site observing the equipment at work and questioning the operators, supervisors and technicians in attendance about the technology, particularly in terms of how it departed from past practices and how it affected adjacent processes. Records were also kept on the tours, hallway conversations and phone calls. Taken together, these notes provided a measure of continuity to the analysis-in-progress and were especially useful in generating new questions and lines of investigation. In addition, briefings have been held (and will continue to be held) for the sponsors of the project. These briefings and the feedback received in them has proven an important opportunity for learning on the part of the sponsors and the author.

Flexible Machining System (FMS)

By 1988 standards, the FMS in the company's aerospace and military contracts division is a modest example of flexible machining technology. Indeed, there is some question as to whether it deserves the name "FMS", especially when compared to the enormous and extraordinarily complex cells that now exist elsewhere in the company and the industry. Yet, at the time of its inception as an idea -- roughly the end of 1980 -- the FMS project had virtually no precedent in the company; the concept had been implemented in other firms, principally in non-aerospace industries. The manufacturing R&D project team which guided the project through its various phases was plowing new ground technically and, as we will suggest, organizationally, as well. What emerged as a linked set of three machining centers driven by a stand-alone computer represents, in many respects, a classic example of the slow tandem evolution of technology and organization.

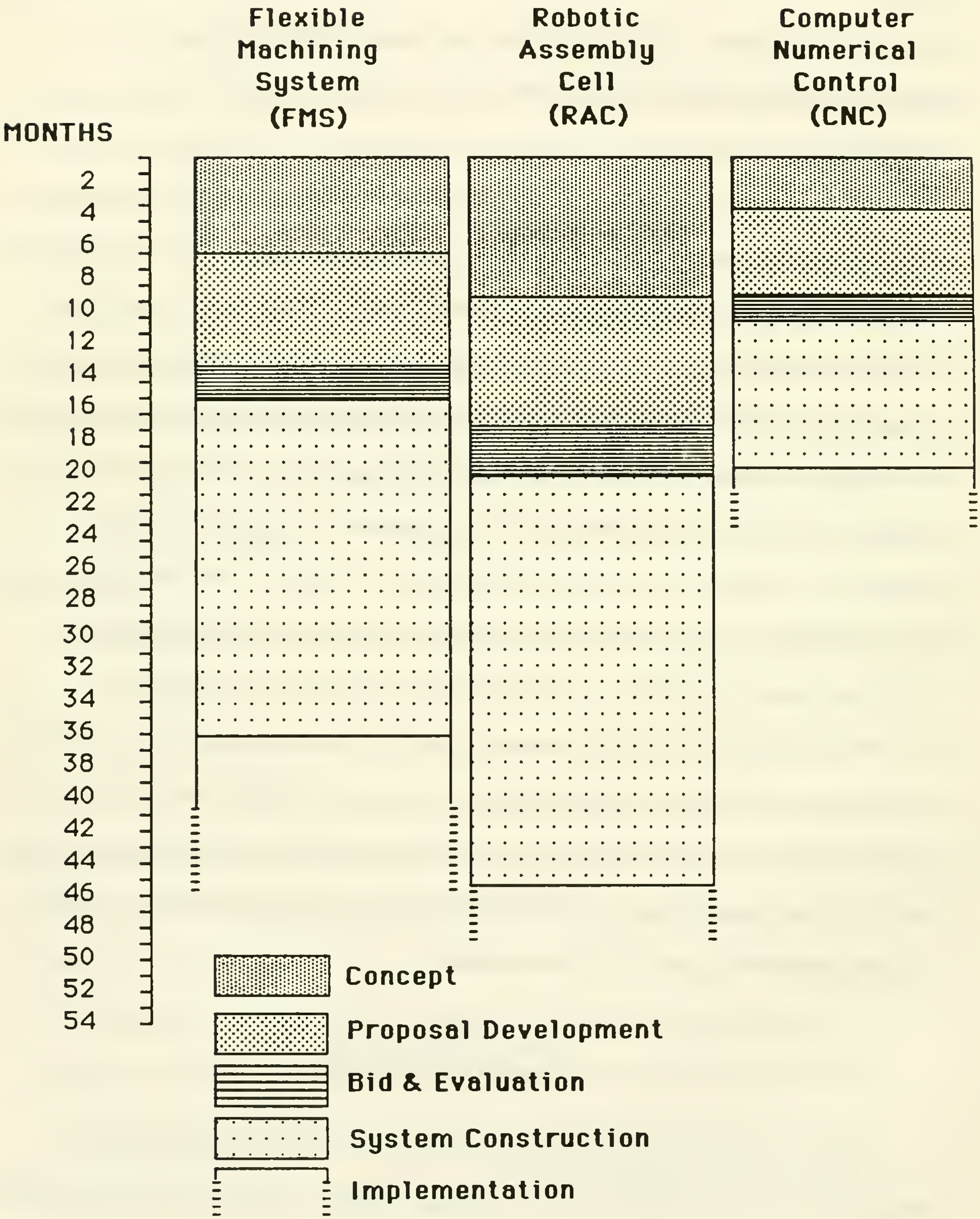
The development process was driven by a set of problems and opportunities. The problems were clear and persistent: the machining areas were cluttered with stock and work in progress; inventory control was a drama unto itself, with parts and orders slowly moving between operations when they were not lost in transit; machine cutting time was seen as deplorable with some estimates suggesting that machines were idle 95% of the time; and the areas were felt to be overly labor intensive. Alongside the problems, however, were opportunities. New developments in technology were making it possible to more accurately control the machines and to monitor tool wear and the placement of fixtures. Sophisticated software promised to revolutionize time-consuming tasks like production scheduling, parts routing and inventory control. Automated guided vehicles could silently and predictably move parts and fixtures between machining stations. It appeared that under the right conditions -- with the right combination of hardware and software -- a system could be devised to solve the problems of material handling, inventory control, and lagging productivity. Helping matters was the unveiling of a fully-integrated FMS by a major vendor at the 1980 machine tool show in Chicago.

The long time span between the "concept" and the actual implementation of the cell (as depicted in Figure 1 below) indicates very clearly that new systems like the FMS are not rushed into the production flow of the company. The manufacturing R&D team spent the better part of the first year engaged in an iterative process: developing proposals and presenting them to management to secure "seed" funding; searching for information about design alternatives from technical journals, other FMS users and equipment vendors; working up cost projections for another round of project funding; and waiting for management's response to the revised proposals. After management approved a revised proposal -- but before any hardware purchases were made -- the team spent several months in a second iteration: responding to financial and material constraints imposed with funding approval; working with product engineering to redesign the parts to fit the emerging process; revising proposals; integrating the parts of the proposed process; writing and documenting software; making revised "pitches" to management; and, finally, proceeding to a set of purchase specifications. What began as a clean sheet of paper and an ambitious set of plans emerged ultimately as a scaled-down but highly inventive blueprint for the first FMS in the company.

INSERT FIGURE 1 HERE
(Comparative Chronology)

Arriving at a successful proposal and a clear set of purchase specifications did not, however, end the development process. For, although a single vendor was selected to provide the

Figure 1: Chronology of Development Activities for Each Case



bulk of the hardware and a part of the software for the system, the actual construction and modification of the cell took another year and a half. Software demands were far greater than anticipated. The constraints imposed on the project itself made for unique problems: money was saved by using machines already in place and linking them by means of a power roller conveyor, but the machines were not identical, the conveyor would have to operate at a partial incline, the adaptation of sensing devices proved intractable, and chip removal was hampered by problems in coolant circulation.

The iterative process or evolution which characterized the development of the FMS in this division was not at all unusual for the company, at least according to our interviews, nor was it unique by comparison to other companies (cf., Utterback 1971; Sahal 1981). That process reflected both the technical complexity of the development activity and the reality of attempting to gain sponsorship, funds, and acceptance of an innovation in production technique. But, precisely because the innovation lacked precedent technically and organizationally, the evolution proceeded somewhat blindly toward its final phases. The project team, which ultimately included representatives from the major technical contributors to the effort as well as a representative of shop management, had to search outside the organization for lessons in both the technological and the human resource dimensions of the undertaking. In searching outside and in attempting to carve space for the FMS inside, the team encountered a number of gray areas, the most important of which (for the purposes of this analysis) had to do with arriving at an acceptable and workable plan for staffing the cell.

The Staffing Questions

How the FMS would be staffed and by whom were questions that arose early on in the undertaking. These questions were important for four basic reasons. First, the level of staffing predicted for the new cell would clearly affect its chances as a competitor for funding within the company. Given that there was considerable competition for capital to purchase equipment within the division and the company overall, arriving at an attractive return on investment (ROI) was a critical step in the development process. If the FMS "won" approval, it would give the project engineers a challenging and unprecedented assignment and it would be a feather in the division's cap to be on the leading edge of technology in the company. Thus, there was a clear temptation to search for formulations -- or at least potential configurations -- which indicated the maximum reduction in labor possible in order to make the ROI and payback figures compelling to those who would sit in judgement on the proposed investment. For example, various configurations were considered as the project unfolded. At one point, it was expected that one lead worker/operator and two load/unload workers would be in charge of the cell; later it was argued that the cell would formally be operated by a supervisor and two load/unload workers (i.e., leading to the anomaly, under existing accounting procedures, in which no direct labor rate could be charged against the parts being produced). Relatively independent of how the FMS would be staffed, however, most proposals argued that the cell would, at minimum , replace 6 machine operators (1 for each of the three machines, working over two shifts).

Second, there were no comparable systems available within the company (and only to a limited extent in the industry) to make possible a clear sense of how many people would realistically be needed or what skills they should have in order to competently operate the FMS. Site visits to other companies employing similar technologies helped define the range of possible staffing solutions for the project team. Even these were complicated by the variations in context between the firms being surveyed and the company: for example, in some instances there was no union in the shop and therefore comparison between jobs was confused by differences in job classifications and work rules; in other instances, differences in the product or the volume of parts being produced rendered comparisons meaningless. Several of the project team members told us that the staffing solutions they had seen elsewhere "would not fly" in their company. One pointed to the "tenderness" that existed in union-management relations at the time -- particularly around the issue of one man/multiple machine operation. The suggestion was that not only should an hourly employee not operate the cell because of complexities in its operation, but that the company should not challenge the union so close to the next (1983) round of contract negotiations. Another team member recalled being advised by managers in one of the firms they visited to install a system of job rotation which would allow several employees to gain experience as cell operators; when asked what became of this suggestion, the team member remembered passing it along to "someone in industrial relations" but was not sure if it had ever been seriously considered.

Third, the FMS not only lacked precedent, but there was concern as the project proceeded that staffing plans should not set precedent, either. A highly-placed divisional manager confirmed this when he said that his major concern in staffing the FMS was to avoid a precedent that might create problems "for anyone else who wants to set up a similar system." In particular, he argued, he did not want to have hourly employees engaged in programming the system or operating the computer which drove it. His concerns were reflected in the payback calculations developed in support of the proposal. Yet, as he indicated in the same interview, the staffing plan that went to corporate for funding review was "sketchy and it was designed to not raise any eyebrows. We'd figure out what to do once we got the thing running."

Fourth, other issues arose which had an indirect bearing on the staffing questions but which could not be answered by the project team. The most important issue had to do with the volume of work to be scheduled for the FMS once it was fully operational. One of the parameters for development of the cell -- in addition to what machines could be employed -- was that it be capable of machining parts for a particular military contract. However, under conditions in which it was unclear how productive the cell would be and how feasible it would be to attempt to mix work orders (especially from different contracts) in order to utilize the cell's anticipated capacity, staffing solutions were all the more difficult to devise. Put slightly different, staffing would remain an issue because it was not immediately clear how the system would fit into the existing organizational approach to scheduling, accounting and production control. Thus, the project team was led to speculate on answers to the staffing questions up to and through the system construction phase of the process.

The Staffing Solution

Once it became clear that the majority of the technical problems were surmountable, the staffing question was finally addressed. The project team, including the shop general supervisor who had by this time been named head of the team, strongly encouraged an extensive program of training for hourly maintenance employees and the one hourly machinist who had been helping bring the machinery up to capacity. Three hourly employees were sent off-site to the vendor for training.

But, most significantly, it was not until six months before the cell was to come on-line that the industrial relations function -- specifically job evaluation -- was called in for consultation. By that time, however, the bulk of the technical design elements had crystallized, the hardware was largely in place, and opportunities for engaging in any significant effort at job redesign were dwindling. Rather than press the issue, the job evaluator from industrial relations undertook a standard comparative evaluation of the jobs "created" by the FMS. He circulated a report within the compensation group to determine whether there existed similar jobs elsewhere in the corporation which might serve as a precedent for this instance. When it was decided that a new classification was not warranted by the new technology, a standard NC machinist classification and wage grade were attached to the job.

Although the decision from job evaluation was not seriously disputed by any of the parties (including the union, which will be discussed in a moment), two areas of confusion and possible contention remained. First, it was not particularly obvious that the NC classification was appropriate to the job. In this instance, the machinist was not operating a single machine but instead was controlling three. Beyond an increased number of machines to tend, the system of monitoring controls and machining activities appeared to some observers as a sufficiently different activity from the standard NC classification so as to warrant a new job description. Second, there was concern voiced that greater skills were required of the single operator and, while the wage level might be appropriate for the expected skill level, the potential for disruption to workflow due to turnover or surplusing might be great enough to warrant a "fence drawn around the trained operators in place," i.e., create a new job classification specific to the FMS.

As it stood in 1987, the staffing questions have been mitigated somewhat by the shortfall of work for the FMS. While it had been anticipated that the cell would work three shifts; it worked (at the time of the study) all of one shift and part of another. Part of the explanation resided in the productivity of the cell, as mentioned earlier; the remainder, however, derived from the shutdown of the contract which served to justify the project in the first place and the lack of subsequent orders to exploit the FMS's potential.

The Union's Role

The union learned of the FMS, its purpose and its potential long the machinery was bolted into the ground and on its way to operation -- some three and a half years after the project was intitiated. Arriving as they did late in the game, union representatives viewed the FMS as another example of what one steward described as the company's policy of "keeping the union in the dark." Calls were received from union members concerned about the implications of the new technology for pay and job security issues and a formal letter of inquiry was filed with the company. Union representatives challenged the wage level associated with the job and questioned the appropriateness of the job classification. In many respects, these points of contention were themselves quite familiar: a new job with new tasks, particularly one associated with automation and computer controls, deserved higher wages. Ultimately, the question of a new job description was dropped as was the contention about the wage level; with regard to the latter, it was agreed that the wage which had been received by the initial operator was acceptable to the job.

Robotics Assembly Cell

Robotics technology has made tremendous strides in recent years, particularly in the movement from relatively simple "pick and place" transfer devices to flexible systems for such complicated tasks as assembly. However, two major stumbling blocks deter the accelerated implementation of robotics work systems: (1) finding tasks which make economic sense to robotize and (2) developing manageable systems to control them, i.e., systems which do not themselves require massive support in order to function. To date, the broadest application of robotics in manufacturing has tended to take place under the same circumstances as the application of FMS technology: high volume, low variety tasks, such as body welding and paint spraying in the automobile industry. Many assembly jobs have not yielded themselves to robotics technology due to their complexity -- the robots need a greater degree of dexterity, sensitivity to shapes, positions and the nature of materials with which they are working. Developments in artificial intelligence and computer vision will undoubtedly resolve some of these problems and allow further application of robotics technology. Yet, in the meantime, firms which seek to apply the technology in their core production processes often must scale back their expectations, willingly take on the role of system integrator (especially since the robotics hardware and software industry is itself proving less stable than was originally expected), or both.

The Robotics Assembly Cell (RAC) in the aircraft assembly division shared a number of important similarities with the FMS in the aerospace and military contracts division. Both represented "cutting edge" developments in the company at the time of their inception and, therefore, protracted periods of time were devoted to researching the feasibility of the technology. Both were centered in division-level manufacturing R&D groups but, of necessity, both required the expertise of allied functions during the conceptualization and development phases. Both found justification for their efforts in the high level of labor intensivity which characterized the processes they sought to transform. And, finally, both lacked precedent on the human resource side of the technology equation: how the systems were to be staffed, by whom, and within what framework.

When considered retrospectively, however, the robotics cell for assembling ceiling and sidewall panels appears as more of a venture into the unknown than the FMS. Even though the manufacturing R&D group had successfully adapted a single-armed pedestal robot to the one highly repetitive segment of the assembly process some time earlier, the integrated cell concept multiplied the number and complexity of operations to be performed (e.g., pick-and-place, clamping and unclamping from fixtures, heat-bonding, glueing, and precision placement of the hardware attachments). Moreover, the simultaneous performance and monitoring of individual and sequential operations introduced a feedback dimension of much greater sophistication (and, therefore, of greater potential difficulty) than the FMS in the aerospace and military contracts division.

Two other dimensions of difference between the systems help explain the relatively greater amount of time devoted to the pre-implementation stages of the RAC project. First, constraints imposed on the scope of the FMS limited its potential complexity and, in the process, rendered the manufacturing R&D activity less dependent on the expertise (and responsiveness) of equipment vendors. In the case of the RAC, however, the development process seemed more driven by the promise of robotics technology -- making it appear more as a solution in search of a problem than the other way around. As a result, financial, technical and organizational problems in the company which won the bid for system construction substantially hindered the progress of the project. The company and its divisional manufacturing R&D project team shepherded the assembly cell but were ultimately put in the position where they had to act as system integrator, accepting the equipment before the system was finalized and having to slog through the swamp of software problems in order to render the RAC operational.

Second, the evolution of the RAC design required a far greater collaborative effort between the manufacturing R&D engineers and their counterparts in production engineering.[5] That is, as the assembly cell idea evolved, it became clear that some of the components of the panels would have to be re-engineered to facilitate the robotic system. This process of reverse engineering -- a concept which has become integral to the "design-build" philosophy emerging in the company -- was further stimulated by difficulties and limitations encountered in the robotics technology itself.

Robotics and Human Resources

With the numerous delays and technical problems encountered in the development of the RAC, it is not surprising that human resource questions (e.g., staffing and job design) were (and, to some extent, remain) up in the air. The projected cost savings in direct labor and rework which initially served to justify the undertaking had to be revised several times as the limits on the technology and restrictions in the cell's "flexibility" emerged (e.g., the robot arms proved unable to perform some of the more intricate tasks). Whereas it was anticipated that the cell would enable a crew of six to eight assemblers to be replaced with a "system operator" and one or two load/unload workers in addition to providing an unspecified reduction of labor devoted to rework, questions remained as to what would ultimately be the employment impacts.

More important than the difficulties encountered in predicting how many people might be replaced by the assembly cell, the development process put the principal human resource issues at the tail end of the effort. Like the FMS case, the project team lacked a comparable internal precedent to turn to in the process of designing the job structure of the cell. Unlike the FMS case, the search for staffing examples and solutions did not proceed extensively beyond the boundaries of the company. In part, this can be explained by the uniqueness of the assembly cell effort and by the technical difficulties that seemed to arise at every turn. However, it cannot be argued that innovative approaches to staffing were considered in the process of technology development, despite the inclusion of industrial relations representatives in the early stages of the project. Instead, as the project proceeded, the technical process of the cell came to mirror, robotically, the actions of the human labor it sought to replace. To borrow from another context, it appears that the cell was designed to robotize the worker, not the task. This occurred, it should be noted, in spite of some truly innovative efforts at reverse engineering which took place during the development of the cell. In other words, the potential existed to create a revolutionary restructuring of the work process -- incorporating technical and human resource dimensions -- which might have pushed the "design-build" philosophy beyond its emphasis on only technical issues.

While provision was made early in the implementation stage for maintenance and manufacturing R&D personnel to receive training in the operations of the cell, the absence of a human resource dimension during the evolution of the technology led to considerable confusion among those we interviewed about how the cell would be staffed. One interviewee suggested that as many as five people would be required, with responsibility for operating the control station turned over to a supervisory employee. Another speculated that an NC machine operator would be imported to run the cell and a single load/unload worker would feed parts to the robot arms and keep track of supplies. Employees in the area (who had seen the equipment being installed and tested) claimed to be unaware of how the cell would be staffed. Assemblers were assured that even if their jobs were to be eliminated, they should not worry because there was plenty of other work to be done; this may have helped to assuage fears about job security, but it did little to explain why that technology was being implemented or whether assemblers would have an opportunity to operate it.

The Union's Role

At no point during the development and later installation of the RAC was the union contacted. Industrial relations representatives were aware of the assembly cell (having been alterted at the outset of the project) and had been notified that maintenance workers had been released for training in how to repair various parts of the cell. Union representatives became aware of the undertaking when they began receiving phone calls from members inquiring about their job security and the opportunities for receiving training to operate the cell. Since all but the last details about the technology had been determined by that time, the union was left with little else to do but file a formal inquiry with industrial relations relating to the classifications and wage levels assigned to the cell. Again, the union representatives expressed resentment about the company's failure to give advance them warning and underscored this as another instance in which a lack of trust was demonstrated.

Shop Programmable (CNC) Machine Tools

The advent of programmable machine tools predates this study by at least 15 years. Yet, in the time since the initial experiments were made with "driving" the cutting, grinding, and shaping of a piece of metal by an external controller, the array of alternative approaches has expanded enormously. Shop programmable machine tools stand out as departures from the now-familiar NC and direct numerical control (DNC) machines in that each is equipped with its own small computer which can be programmed on-the-spot, on the shopfloor, by a trained operator. Since this new generation of machine tool is far less expensive than its NC or DNC counterparts and is available off-the-shelf from vendors, it is often referred to as the "throw away" machine. Graphics capabilities and a color monitor allow the operator to input data on the type of work to be done, the type of material to be machined, and the tolerances required in cutting. The computer, in turn, suggests appropriate feed rates for the cutting process and speeds for the various cutting tools. The resulting cutting angles, feeds and speeds are stored as a separate program in the computer's memory (as well as on a floppy disk which can be removed from the machine). Once completed, the program drives the machine.

The process through which the CNC machine tools arrived in mid-1986 and the human resource aspects of the new technology offer three important contrasts with the preceding two cases. First, the CNC equipment took a very different route to the shopfloor. It was introduced as part of the normal equipment replacement process. This helps explain why the time-span associated with the new technology is so much shorter in this instance (see Figure 1 earlier). The equipment replacement process routinely takes place outside the purview of manufacturing R&D and, in this division at least, it is part of an activity orchestrated by the Facilities and Equipment (F&E) organization. Thus, the acquisition of the CNC machine tools did not initially provoke the attention of groups outside of the shop from which they were requested.

Second, the CNC machine tools were requested within a different organizational context and with different purposes in mind than the FMS and the RAC. Although they were justified in terms of their expected contributions to shop productivity (i.e., allowing six machines and operators to be replaced by four), the CNC machine tools were attractive for what they could contribute to the mission of the shop. The work done in this shop was divided into jobs devoted to NC machines and conventional machines. The "conventional side of the house", where the CNC equipment was located, was given responsibility to attend to what is referred to as "emergent" work, i.e., high priority ("blue streak") parts or parts needed by customers with airplanes on the ground. Acquisition of the CNC machines promised to give shop management some control over the scheduling and performance of emergent work by reducing its reliance on a separate NC programming group located in an upstairs office to retrieve, revise, and/or write tapes for the NC equipment on the other side of the house.

Third, as updated replacements, the CNC equipment represented an incremental change in the technology of machine tools. In the reasoning of one line manager close to the process, the point of bringing shop programmable equipment into the conventional machining area was to "preserve and extend the skills of the machinists already in the shop." That is, from a shop-level perspective, the goal was to enhance skills rather than drastically revise or reduce them. That perspective, our interviews revealed, had a substantial pay-off in this instance: machine operators in the area enthusiastically took to the machines and often spent lunch and break times discussing the ways in which to maximize the capabilities of the machinery. In practice, however, the machines do not presuppose a lengthy apprenticeship in the range of machining skills in order to be run adequately. Indeed, a brief comparison with other shops in the industry where they are employed indicated that some companies assign relatively unskilled operators to run similar equipment. What is distinctive about this case, however, is the opportunity for skilled operators to employ their extensive experience in machining to exploit the potential benefits of the new technology.

The Human Resource and Organizational Dimensions

The relatively limited scope to the change in technology helps explain why the introduction of the CNC machines represented a less problematic effort to incorporate the human resource dimension. There was no revolution in concept and the low price tag of the equipment enabled the new technology to be incorporated with relatively little fanfare. The closeness of shop management to the acquisition process made it possible for a philosophy of "preserving and extending skills" to guide the selection. While it might have been possible (and desireable, according to some people we interviewed) to substantially reduce the job classifications and wage levels associated with the equipment, the net effect would likely have been the creation of animosity and resistance in the shop instead of enthusiasm and inventiveness.

Not anticipated, however, were reactions to the CNC machines from outside the shop. Most relevant for this study were the concerns expressed by allied functions such as NC programming and Resource Planning. What the shop foresaw as advantages -- especially the ability to gain some measure of control over scheduling and configuration of parts production -- were seen outside the shop as cutting other functions out of the "loop" of configuration control. To be more specific, concerns were expressed that growth in the number of CNC machines or similar machines would drive a wedge between the "upstairs" offices which document and store parts specifications and programs and the shopfloor where the work is to be done.

The Union's Role

The union, which had not been informed of the impending arrival of the CNC equipment, filed an inquiry nearly as soon as the machines were bolted down. An extensive discussion with several stewards revealed that, on the surface, the bones of contention with the company were the wage grade and the job classifications assigned to the machines. For these stewards, the added responsibility of inputting data required an increase in pay. The classification -- numerical control machine operator -- was, they felt, inappropriate for the job since other workers with similar classifications were not trained to run the machines. But, beneath the surface there was a knottier problem: the machines had the capability of being staffed by one worker for two or possibly three machines. Since this had been a sore issue in the shop, the stewards wondered openly if the company did not intend to attempt multiple machine operation in the near future. Union representatives did not, however, resist the idea that the CNC machines (or similar types of machines) increased the productivity of the shop or of machinist's labor. Instead, their major concerns, in addition to appropriate classifications and wage levels, involved guaranteeing access to training for interested employees.

Findings from the Case Studies

The case studies highlight four key points about the process through which new technologies enter organizations. The points are directly relevant for assessing the chances for development of a joint union-mnagement approach to new technology.

1. New technologies call into question, if only briefly, human resource management and organizational policies. The FMS and the RAC introduced new techniques, new staffing questions, and new opportunities for job design. In a much more visible way than the CNC equipment in the parts fabrication division, they challenged existing assumptions about how work should be organized and, perhaps more importantly, about how system control responsibilities should be delegated. The FMS called into question the existing system of staffing and work distribution, particularly when it proved more productive than originally anticipated. The RAC required substantially greater coordination across functions than expected but also underlined the potential advantages of a design-build approach to the production process. The CNC equipment helped make it possible for one shop to meet its organizational responsibilities but, in the process, it challenged the status quo for other, allied functions.

2. New technologies enter the company by different paths. At least two entry paths were identified in the case studies. In the case of the CNC machine tools, the standard equipment replacement process -- centering on the specific needs of the shops -- provided the entry path for this updated replacement technology. This path proved relatively invisible to other technological "gatekeeping" departments and, as a result, led to some concern about the appropriateness of shop involvement in technology acquisition. Both the FMS and the RAC entered by way of extensive research in two different manufacturing R&D groups. As is the case in many new system acquisitions, these gatekeepers worked with outside vendors to tailor the equipment to specific needs. However, in retrospect, the manner of entry for the FMS and the RAC differed in one important respect: the FMS was more clearly an instance of a problem stimulating a search for a solution; in the case of the RAC, there is some reason to believe that the solution stimulated a search for a problem to be solved.

3. New technology development and/or acquisition is neither an instantaneous nor a linear process. The brief case study descriptions can only partially depict the long time and circuitous route taken by the individual projects from concept to shopfloor. As described earlier, the FMS began as an ambitious solution to a broadly-based problem; much of the time before implementation involved information searches, problem-solving and various rounds of funding approval. Even the CNC equipment had to wait in line through two funding cycles before capital funding was approved. The iterative and frequently non-linear nature of the development process was probably best exemplified in the RAC case. The robotics assembly cell began smoothly enough but as technical problems arose, the project ricocheted like a pinball from the company to the vendor and within subgroups of the company as each sought to solve problems and salvage the investment.

4. The absence of advance consultation with the union contributes to an emphasis on bargaining and bureaucratic rule-making at lower levels. Even though union representatives expressed dissatisfaction with the manner in which new technologies are introduced, the upset encountered in the individual cases was not nearly as great as was expected from our early discussions with the union. A good measure of the difference can probably be accounted for by the finite character of the individual cases by comparison to the broader image and reality of technological change in the company. That is, three instances are a very small fraction of the total number of cases encountered in one year or five years. On the other hand, it could be that technological change does not represent a major point of controversy when the people displaced by new equipment are not laid off. In either case, in the absence of advance warning, and in the presence of an attitude that suggested that non-engineering employees do not have a stake in the process, technological change does create anxiety and confusion for workers and for the union. The absence of advance information and explanation, in particular, led both the company and the union to adopt a "bargaining" approach to technological change. The object of bargaining became classifications and wage grades -- essential elements of the web of rules which govern the relationship between company and union, but also elements which direct attention away from innovation in job design or the deployment of labor. When hourly employees were engaged only in the final moments of the technology development process, minor dissatisfactions may evolve into generalized distrust.

While these points about the process of technological change indicate very clearly that technical, human and organizational issues are tightly coupled, the use of projects as the unit of analysis tends to draw attention away from the structural and procedural constraints on change in industrial relations practice. In particular, we wish to draw attention to the present constraints on two functional groups -- R&D and Industrial Relations -- and on one institutionalized process -- collective bargaining -- which make them obstacles to any effort in the direction of joint union-management consultation on new technology.

The R&D Connection

As has been argued elsewhere (cf., Chen, et al 1984), the bulk of technological change appears incrementally. A small fraction is introduced as revolutionary new developments. Yet, new systems like the FMS and RAC are increasing in number and interdependence as microelectronic technology makes possible integrated (e.g., CAD-CAM) solutions to production problems. Great imagination is not necessary to recognize that manufacturing R&D groups and cross-functional task forces will play an ever more important role in creating and coordinating future generations of factories. It would seem reasonable to assume, therefore, that manufacturing R&D groups and similar departments will be influential organizations in the practice of human resource management. However, is it reasonable to conclude that a manufacturing R&D group can effectively respond to the industrial relations and human resource management issues?

As manufacturing R&D in this company and others like it is presently configured, the answer would have to be no. Despite what we found to be a genuine regard for people's skills and knowledge, manufacturing R&D is tethered by external influences and performance criteria. Functionally, manufacturing R&D groups tend to be expected to respond to problems identified by manufacturing management and to suggest directions which may fulfill objectives defined from the outside. Recognizing that budgets for challenging engineering work are restricted, manufacturing R&D personnel are encouraged to pay close attention to "themes" which are generated by higher level management (cf., Thomas 1987). Repeatedly we were told in interviews that those themes centered around three objectives: reduced costs, increased quality, and fewer heads (less labor). In order to fly, a proposal had to address those objectives and meet certain explicit payback figures. The efficacy of manufacturing R&D efforts, we were told, were measured precisely in those terms. Under those conditions, it is difficult to imagine generating a proposal which cannot make a direct claim to dramatically reducing "X%" heads in 18 months. When it is perceived that neither individuals nor the manufacturing R&D function will be rewarded for attention to industrial relations or human resource questions, it is much easier to ignore them, to delegate them to the functions given formal responsibility for policing the "people issues", or to subcontract them to a vendor.

Beyond the constraints already experienced by manufacturing R&D, problems of coordination diminish the capacity of this single group to cover the spectrum issues. Despite the decentralized organization of manufacturing research and development at the company, considerable distance separated R&D and the shops. This distance leads to problems of perception on both sides. Conscious efforts had been made by manufacturing R&D to familiarize itself with the shops and to avoid the traditional "laboratory" approach to the development and implementation of new technology. That is, instead of perfecting innovations in a laboratory and then "tossing them over the transom" to the shop, communication and coordination with shop management had become more common, as demonstrated in the FMS project team and, to a lesser extent, in the case of the RAC. Yet, the fact of functionally different responsibilities and physical distance from the shopfloor perpetuated friction between manufacturing R&D and shop management. This quote from one of the interviews summarizes the friction: "We often feel like those guys in the shop have to be dragged kicking and screaming into the 20th century." Such sentiments may be the product of momentary frustrations, but they generate suspicion in the shop which is, in turn, communicated to workers.

On the other hand, shop management was paid to focus its attention on day-to-day responsibilities and, despite the recognition by many of the necessity of manufacturing R&D activities, engineers are quite often seen as interlopers in shop affairs. This perception of manufacturing R&D is also a reflection of the nature of the shop as a social system. The shop (broadly conceived) is a form of social organization governed as much by custom and informal agreement as it is by contract (cf., Thomas, forthcoming; Van Maanen and Barley 1984; Katz

1965; and Whyte 1961). Informal understandings about issues as varied as job security, promotional opportunities, the distribution of overtime and even who gets the next new machine are not visible to the outside; but the fact that they are not visible does not make them any less critical to the functioning of the shop. Thus, when manufacturing R&D appears with an innovation not expressly requested or anticipated by the shop, the innovation appears to threaten the web of informal understandings. This, in turn, reinforces the perception by some "outsiders" (a category that is not limited to engineers) that the shop management is conservative, parochial, and "more oriented to the employees than to the company," as one respondent argued.

In sum, the constraints on manufacturing R&D may not be insurmountable but neither are they simple and straightforward. While we would once again stress the limited nature of our case studies, we would also emphasize that laying the burden on the shoulders of manufacturing R&D may not be an adequate solution.

The Industrial Relations connection.

Industrial relations appeared to be a logical place to locate the responsibility for monitoring the human resource issues associated with technological change. Yet, with few exceptions, the industrial relations function appeared not to play a central role in fashioning either the technical or the human solutions to the problems which stimulated these cases. Here, as in the case of manufacturing R&D, it is useful to consider the present configuration of IR activities before contemplating the implications of change. At the divisional level -- where the bulk of our attention was focused -- IR played a game of catch-up with new equipment in terms of job classifications, evaluations, and wage rates. In the case studies, this was evidenced in the late and often hurried involvement of IR in the implementation process. Three ostensible reasons account for this situation.

First, IR's multiple responsibilities and limited resources made it difficult to stay ahead of the flood of new equipment. Significant chunks of staff members' time were eaten up in routine bureaucratic affairs. Absent the resources to release staff to "patrol" the technological frontier, IR generally reacted to changes outside of its domain. A reactive mode was also produced by the relative lack of engineering expertise in the industrial relations group. Few IR professionals had an extensive engineering background and those who did had been in the IR career track long enough to have suffered some obsolescence in their skills.

Second, advance involvement in new technology decisions or in the development process runs counter to the existing division of labor in industrial relations. While that division of labor need not be described in detail, some basic distinctions should be noted. Labor relations in this company (as in many others) focuses on the world of contractual language and precedent and, given that the topic of technological change has not historically been part of that world, many labor relations personnel felt ill-prepared and out of place discussing the implications of technological change. Compensation personnel -- especially those in job evaluation -- focused on the tangled underbrush of job descriptions, job classifications, and wage grades. Of necessity, that brought them more directly into contact with new technology. However, the compensation function has not traditionally been rewarded for "keeping the peace" around new technology issues; rather, they are rewarded for holding the line on wage levels. This led to an interpretation of most technological changes as "making the job easier" and, therefore, less expensive in wage terms. In line with this interpretation, the principle of comparative evaluation which underlies the most common approach to job evaluation limits the range of innovation possible with new technologies. When confronted with a new system or an updated replacement which must be staffed, classified and given a wage grade, compensation personnel are encouraged to "find something like it that we already have." That conservative orientation inhibits innovative approaches to job design and staffing. Conservatism is also encouraged by the complexity of most organizations: industrial relations staff noted in several of the interviews that they were warned that innovation in one locale may be satisfying, but it may very well create problems in another shop or division which uses the same technology but wishes to staff it or pay it in an entirely different way. Under those circumstances, innovative precedents are something to be avoided.

Third, when it comes to new technology, industrial relations personnel get caught up in "playing poker" with their union counterparts, especially at the level of the shop or the division. Given that the union generally does not receive advance information about new technology (or, at least not information in a form that enables it to prepare for the arrival of specific pieces of equipment), business representatives and stewards find out after-the-fact and usually only when the individual workers affected raise questions about what's going on. This prompts the business representatives, in particular, to fire off letters to industrial relations demanding information and/or a re-evaluation of a classification and an improvement in the wage grade. Industrial relations personnel -- who were probably informed of the technological change only shortly before the union representatives -- often respond with the product of their own comparative evaluation and the poker game begins. The idea of giving advance information to the union regarding new technology is thus viewed as the equivalent of showing one's cards to the player on the other side of the table.

In sum, industrial relations staff may be attuned to the "destabilizing" effects of new technology, but they are also likely to focus their attention on dealing with change in terms of the existing rules and language of negotiated agreements. Given the complexity of job classifications, wage grades and the like, it is common for the routine problem to drive out the strategic issue, e.g., the creation of a new "class" of employee, the system operator, gets redefined as a problem of finding an existing job classification into which these people can be squeezed. The limits to perception are only strengthened by the late involvement of industrial relations personnel in the process of technological development and change.

The Collective Bargaining Connection

If, as the preceeding analysis suggests, neither R&D nor industrial relations can independently shoulder the task of monitoring the process and the potential of technological change, then we are left to consider the mechanism already established to coordinate labor-management relations, i.e., collective bargaining. Collective bargaining might appear to be particularly well-suited to serve as the forum for discussing the strategic implications of technological change. It is, after all, the locale in which the rules governing the behavior of local-level and day-to-day industrial relations are forged; if any alteration in rules is to be made, it most likely will need to be codified in contract language.

There are, however, two important reasons why collective bargaining is ill-suited to the task. First, the points made earlier about variations in scope, origins and velocity of technological change apply to any effort to make joint consultation an activity limited to biennial or triennial affairs. In large organizations such as the one described here, the volume of equipment purchased and developed is just too great to allow periodic discussion to cature the full implications and potential for change.

Second, even if meaningful discussions could be carried out in a periodic, bargaining environment, a much higher level of technical expertise would be required to make any real headway. Union representatives interviewed in this study readily admitted far greater familiarity and comfort in discussing long-range financial and economic matters than they did in talking about technology. They did not prefer delegating long-range technology strategy to the company's engineering/technical staffs; at the same time, however, they did admit to being unprepared to put forth their own proposals about general issues of work organization or job design. In this regard, they displayed a remarkable parallel in substance as well as approach to their counterparts in industrial relations.

Discussion

In this section, we turn our attention first to the immediate and then to the longer-term implications of the research. We begin with the first level questions about organizational procedure and the practice of industrial relations at the level of the firm.

At the outset of the article, we suggested that in the absence of a more detailed understanding of how new technologies are chosen, developed and implemented, little could be said about the implications of joint consultation. The case studies reported here have highlighted the fact that technological possibilities come in too many shapes and sizes, from too many directions, and such different velocities to allow any single entity or procedure to serve as a focus for joint consultation. Rather, it should be clear from the forgoing that any effort to move beyond non-binding agreements or, to use Solomon's (1987) term, "protective clauses which deal with outcomes (not process or content) will have important implications not only for the practice of technological change but for broader organizational policies, as well.[6]

We limit our discussion here to four major aspects of organizational practice which bear directly on new technology: technology management, industrial relations, union-management relations, and union practice.[7]

Implications for the Management of Technology

The case studies provide evidence that the process of technology development and/or acquisition cannot be simply characterized as focused (i.e., targetted at solutions to specific problems) or open-ended (i.e., allowing for consideration of the widest possible array of alternative problems and solutions). The bounded rationality of organizational decision-making is exacerbated, we suggested, by the inherently political nature of the process. Yet, unlike other categories of organizational decision which might engage or challenge the interests of established (functional) stakeholders, decisions about technology are unique in that they add the politics of labor-management relations to complicate the picture. That is, questions regarding the expenditure of capital and the structuring of outcomes in other categories of decision can be handled explicitly (if not always easily) through the exercise of organizationally-conferred authority. For example, top executives can decide to launch a new product line or shut another down on the basis of the authority vested in the offices they occupy. Under present conditions, decisions about technology -- and the process of technology development -- are managed very carefully so as to minimize the leakage of information to unions and to force unions into a reactive mode. Moreover, as the case studies showed, top managers' insistence on technologies which can be justified according to traditional criteria leads the engineering group (in this case, manufacturing R&D) to limit the size of their solution set ot any given problem. Indeed, as has been argued elsewhere (cf., Thomas 1987), such criteria are extremely influential even when there is good reason to believe that no evidence is available to satisfy them.

Opening up the decision-making process to union involvement -- even without granting any formal vote or veto -- would shift the terrain of discussion from the "impacts" of technology (on both economic performance and employment levels) to the "possibilities" of technology. That is, criteria for selecting problems and evaluating proposals would, of necessity, require a shift in the direction of integrative rather than distributive solutions (Walton and McKersie 1965). More specifically, managers who approve or reject capital expenditures for new technolgy would have to work with union representatives to establish jointly acceptable "themes" or strategic directions for technology. An emphasis on possibilities -- or a solution set broadly enough drawn to encompass both human resource development and economic performance goals -- would further require *technical competence on the part of managers* in order for them to comprehend what is, in fact, possible. As the case studies show, it would not be enough to expect engineers engaged in technology development to be "socially" aware. Rather, it would be as important -- if not more important -- that managers be technically aware so that they might balance the social and the technical sides of the organizational equation.

Implications for Industrial Relations

Staff in Industrial Relations/Human Resources could have an important role to play in shifting the terrain of discussion from impacts to possibilities and from traditional performance criteria to an integrated solution. To accomplish that, however, it would be essential that some portion of industrial relations staff be given the responsibility for assessing the strategic dimensions of human resources and technological change. More specifically:

(1) Industrial relations representatives would have to be early and active participants in the technology development and acquisition process. Rather than being invited in toward the end to make sure that changes determined elsewhere are "squared with the contract," industrial relations/human resources staff would maintain a continuous presence in R&D and at the level of the divisions to ensure that the human resource issues are raised and considered before

budgetary decisions are made.

(2) In order to provide meaningful assistance, it would be essential that the IR staff involved in these activities have the technical competence to credibly engage in discussions with both line managers and engineers. Without a legitimate two-way flow of information between industrial relations, on the one side, and technical and managerial personnel, on the other, such a consultative role will be perceived as a hindrance, rather than an aid. However, technical competence may not be expected under the existing system; thus, it may precipitate changes in the existing career tracks for IR professionals.

(3) Industrial relations personnel would have to work with representatives from management and from R&D to devise a protocol for assessing the industrial relations and human resource issues associated with proposed development projects and acquisitions. Such a protocol may initially take the form of a "checklist" of issues to be examined or responded to in a capital or pre-capital funding request. However, care should be taken to avoid this turning into another form to be filled out mechanically.

Implications for Union-Management Relations

Advance briefings on new technology between companies and unions may be a first step toward joint consultation but they can become obstacles unless information is pushed down the hierarchy. During the course of this research and in the initial round of meetings which followed its conclusion, it became very evident that both sides saw benefit to be gained from open channels of communication between the company and the union on issues surrounding new technology. Resistance to change can be reduced, it was argued, and a willingness to accomodate new developments can be increased through the simple mechanism of information sharing. However, it has also become clear that annual briefings on new technology were not enough to fully cover the range of issues raised in connection with new technology. The reasons for this are varied, but the most important deserve mention here: (1)The information tends to be "dense," i.e., provided in so condensed a form as to be overwhelming. (2) The information does not filter down to the levels at which it would do the most to promote two-way communication and a climate conducive to change. (3) The information does not take into account the processes through which technological alternatives are generated.

Taking these factors into account, two implications are important. First, information about new technology developments would have to be "pushed" down to the level in which it is most relevant. In other words, information-sharing would be multi-leveled, with the broadest overview provided at the level of a joint committee and more specific renderings made at the divisional and/or the facility level. Equally important, lower (division-level) pre-purchase briefings would have to be conducted in order to provide union officials and business representatives with adequate advance information about new developments. This would have the advantage of reducing anxiety on the shopfloor and precluding the bargaining that presently occurs when new equipment arrives unannounced.

Second, the agendas of joint union-management committees, such as described in this case, should be broadened to include the context of technological change. Discussions at the level of a joint committee are likely to reveal the connection between technological change and the broader business strategy of the company. In order for that connection to be made meaningful, however, greater efforts would have to be made to fill in the context of technological change, especially how new technologies are expected to contribute to the competitive strength of the company.

Implications for Union Practice

To make its own independent contribution to the process, a union would have to devote resources to achieving technical competence. The case studies showed that the union was a participant in the process of technological change only in the final stages of implementation. When new equipment arrived on the shopfloor, union representatives were generally engaged as "fire-fighters" attempting to deal with the flames of confusion and concern. However, in order for joint consultation on new technology to do anything more than make union representatives better fire-fighters, the union would have to prepare itself to contribute to the change process. In particular, this would mean investments in the personnel necessary to engage in technical discussions with company about new directions and alternatives in new technology.

Achieving technical competence would require mobilization of both internal and external resources. For example, interviews conducted in conjunction with this research uncovered a substantial number of union members who were avid followers of developments in new technology who could form the core of a group of "technology stewards" to collect and distribute information. External resources, especially in the form of expertise culled from unions in allied industries, could be called upon to aid in the process of building technical competence and for purposes of generating alternative approaches to the design and implementation of new technology. If feasible, efforts should be made to create centers for education in new technology, for example at the level of the international union.

Unions would also have an important role to play in distributing information about new technology and in communicating members' ideas to the company. Classically, unions have played an important role as information-providers to their members, in addition to representing members' interests. Efforts at joint consultation around new technology would underscore the role of a union as information-provider. Whether this took the form of jointly-sponsored presentations to plant or departmental groups or meetings independently arranged by the union, the union would channel information down its own hierarchy. At the same time, the union could enhance its effect as a mechanism for communicating the concerns and the proposals of its membership directly to the company. Pursing the latter course, however, would require unions to recognize their obligation to the process of joint consultation: in other words, representing the interests and the ideas of the membership cannot be reduced to the single forum of collective bargaining.

Longer-Term Prospects for Joint Consultation

Though the longer-term prospects for joint consultation on new technology remain cloudy, some light can be shed as a result of these case studies.[8] We point to the broader pressures on both managers and union leaders.

Pressures Against Joint Consultation

The pressures against joint consultation are substantial. As suggested by the case studies, the present process of technology development and implementation insulates managerial decision-making from external scrutiny and intervention and, while it often leaves technical staff in the position of blindly designing human resource systems, it also prevents the erosion of traditional management "rights." Even in the setting in which these studies were conducted -- where contract language had been in place for over four years -- line management clung tenaciously to the claim that only management fully understood and was willing to take responsibility for the organization of work. While these managers recognized that the firm's future competitiveness would depend heavily on its ability to achieve production flexibility through the use of new technology and new approaches to work organization, contemplation of advance consultation with the union provoked decidedly negative sentiments.

There are two alternative explanations to this apparent conflict in views -- neither of which is especially supportive of the joint consultation approach. This first explanation can be stated simply: managers want to establish flexible work arrangements but do not see unions, at least as presently structured, as willing to allow them. One need not go so far as to suggest that a structural contradiction or antagonism underlies management opposition (e.g., as Edwards 1979, or Braverman, 1974, might). Rather, managers see unions as brokers on behalf of their members who use job control tactics and seniority mechanisms as a means to obstruct managerial discretion in work organization and job design -- or, at minimum, make it expensive and cumbersome to rearrange the work process. Under these conditions, managers perceive unions as loathe to relinquish their influence in the bureaucracy of job classifications and work rules which give them negotatiating leverage.

Such a perspective need not be equated with anti-unionism. It is, however, quite consistent with a strategy of introducing industrial relations "innovations" such as quality of work life or quality circle programs as a means to carve out areas of management-labor relations which promote new approaches to traditional problems (e.g., product quality, but also the workplace environment) but do so in the cracks between contract provisions and under conditions which, if not defined as experimental by company and union, are almost entirely designed (and paid for) by management. In terms of this explanation, therefore, it is not information-sharing which managers oppose, but information-sharing with an agent capable of using what it learns to increase its bargaining leverage (i.e., its poker hand).

The other explanation is more plainly skeptical of both managerial intent and managers' capacity to engage in what we described earlier as discussion of technological "possibilities." Whether viewed from a systemic perspective -- i.e., managers remain accountable for the economic performance of the firm and, therefore, are hard-pressed to justify work systems which cannot promise them -- or from a more explicitly power (e.g., Dahrendorf 1959) or control perspective (e.g., Edwards 1979), joint consultation in the form we have described fundamentally contradicts the role of management in the capitalist enterprise. In other words, there is no happy middle ground for even the most "enlightened" manager. What would appear to be that utopian solution -- where managers and union leaders sit together peaceably to chart the future -- would, in fact, turn out to be a chimera: what Burawoy (1985) refers to as the "hegemonic despotism" of the Japanese factory or what Parker (1985) and others see as a coopted union speaking the language and doing the bidding of management.

Pressures within unions against joint consultation are equally as strong on both procedural and ideological grounds. The prospect of investing resources in acquiring technical competence is likely to appear daunting to many union organizations. In this study, objections were raised at both the local and the national levels of the union about the prohibitive costs of achieving the technical competence necessary to engage in advance discussions on new technology. The words of one highly-placed official summarized the issue: "We can't compete with any company's engineers." Resource issues are undeniably important, particularly in light of the secular decline in dues-paying union membership; even the AFL-CIO's recent plans to redouble organizing efforts and to create new classes of membership are not likely to provide enough money to any individual union to adquately compete with the vast complex of private and public (e.g., university and industry-university based) research at the disposal of the private sector.[9] While decrying the resource issues, union representatives also acknowledged greater political and ideological obstacles to joint consultation.

Yet, resource costs and personnel are largely surface constraints when compared to the political and ideological obstacles in the path of union involvement in joint consultation.[10] Most importantly, joint consultation raises the fear of being perceived by members (and other unions) of the union's cooptation by management. Maintaining distance from the decision-making and design processes allows union organizations to choose when to take credit for cooperation and when to deny they were ever involved.

Distance connotes independence in two significant ways. First, it prohibits prior knowledge and agreement from undercutting a union's ability to negotiate for gains in accord with the short-term performance of the firm. If, for example, a union knows that profits are to be reinvested in expansion and/or modernization of a company's facilities and has, through a process of joint consultation, struck an accord with management over the appropriateness of that move, it will be hard-pressed to justify asking its membership to hold the line on wage demands. Absent a serious effort to mobilize the members' consent to such a strategy, union leadership will undoubtedly suffer.

Second, distance from the inner workings of the enterprise maintains at least the image, if not the reality, of union solidarity. This is more than just a rhetorical point: in order for any company/union pair to engage in meaningful consultation on new technology, a substantial measure of proprietary information would have to be shared. But, if it is shared between company and union, it will be extremely difficult to share it between unions or between company-based departments within a union. While corporatist solutions of this sort are not unknown internationally, they have been discussed only gingerly in the U.S. trade union movement.

Pressure for Joint Consultation

Firms which see new production technologies as critical to their competitive positions face the greatest pressure to make effective use of innovations. Effective use of innovations is directly related to the timeliness of their development and implementation. Under conditions in which these firms exclude employees and union representatives from advance information about both the impact and the purpose of changes in technology, they maximize the probability that change will be resisted, alterations will be costly (both in inefficient integration into existing work flows and in wage terms) and the match between existing human resources and new production systems will be sub-optimal. If, as Walton (1987), Hirschhorn (1984), and Piore and Sabel (1984) have argued, new generations of manufacturing technology will require greater measures of employee commitment in order to achieve their optimal use, then advance consideration of impacts and alternatives cannot proceed without employee and union involvement.

Unions which operate in an environment of rapid technological change face great pressure to respond to the potential for job loss, reduced membership and a loss of influence over the content of the jobs which remain. However, giving voice to the concerns of members through traditional means appears increasingly difficult and ineffective: contract language regarding employment security (e.g., "no displacement" clauses) may offer some relief, but specific technological changes can only rarely be directly tied to displacement. Moreover, job displacement is often disguised through the process of subcontracting, e.g., when changes in product technology or sourcing strategies make it possible for work to be done outside the bargaining unit. Equally important, as the case studies show, responding to technological change "after-the-fact" engages union representatives in protracted and energy-consuming bureaucratic fire-fighting which does nothing to save jobs. Limiting information-sharing to the time-constrained and periodic forum of collective bargaining practically guarantees that technological change will be consigned to the back burner while more immediate issues are debated.

• • • •

Though it would be premature to conclude that progress will not be made, this paper has provided much clearer indications than previously available as to the obstacles to joint consultation on new technology. By means of case study research, we have been able to identify the major aspects of the technology development/acquisition process and what they imply for changes in organizational procedure. Unlike studies which take as their point of departure the last stage of technological change -- implementation -- we have argued for an analysis of the entire process from concept to and through implementation. This approach has made it possible to combine insights from organizational behavior and industrial relations. Needless to say, we now need to move beyond a single industry to a comparative analysis of the process of technological change.

FOOTNOTES

1 AT&T and the Communication Workers were among the early participants in the process (Department of Labor 1985). In 1982, Ford Motor Company and General Motors established memoranda of understanding with the United Auto Workers to consult on the introduction of new technology (Katz 1985; Simmons and Mares 1982). Shortly thereafter several firms and unions in the aerospace and electronics industries followed suit (cf., Kochan, Katz and McKersie 1986; Cutcher-Gershenfeld 1987). GM's "Saturn" project began, at least, with the intention of involving teams of hourly and salaried employees consulting over the design of a new production facility. For a more complete listing of companies and unions which have negotiated similar agreements, see Solomon (1987).

2 There has been considerable documentation of efforts on the part of various companies and unions to cooperate in experiments in work and job redesign (cf., Walton 1987; Guest 1982; Kochan, Katz and Mower 1984; Macy 1980; Witte 1980; Liker and Thomas forthcoming; Joyce 1985; among others). However, those studies have largely been about isolated undertakings, occasionally in non-union enterprises, and have tended to focus on non-traditional approaches to the implementation of new technology, not in the crucial steps which precede the purchase and subsequent configuration of equipment and processes. The differences in scale, timing, and degree of union-management interaction implied by a joint consultation approach are sufficient to distinguish them from past efforts in the United States, even efforts which proceeded under the banner of the "socio-technical" approach proposed by Trist (1981), Emery and Thorsrud (1976) and Davis and Taylor (1976). Chen, Eisley, Liker, Rothman and Thomas (1984) do provide some insights on the planning process for a new production facility in one American automobile company; however, their effort was not designed to analyze the decision-making process in terms of union-management joint consultation. Shaiken (1985), who represents

one of the most ardent supporters of the "social choice" approach and who helped author the International Association of Machinist's unprecedented "Technology Bill of Rights," was not especially clear about just what that approach would mean in practice.

3 These aspects and their centrality to a broader theory of organizational decision-making are developed in greater detail in Thomas (1987). For our purposes here, they are intended to represent three major assumptions. First, that new technologies rarely "drop from the sky" but are instead subjected to screening by various organizational stakeholders, including top executives, line managers, engineers and purchasing departments, i.e., choosing a problem or a solution is part of an inherently political process (cf., Pettigrew 1973). Second, that even though it is increasingly common to ascribe to technology an independent capacity to stimulate particular organizational and human resource arrangements (e.g., as argued from the so-called "post-industrial" perspective by Hirschhorn 1984 and Adler 1986), there is considerable evidence to suggest that traditional managerial concerns about control over work and workers continue to influence the selection and application of technological alternatives (cf., Barley 1986; Francis 1986; Shaiken 1985; Kelley 1986; Kelly 1982; Wells 1983; Noble 1984; and Thomas 1988). Third, that even though industrial relations and/or human resource professionals may not be formally part of the decision-making process, they are commonly quite involved in the implementation of new technology, as the case studies will show.

4 Since case-study based research invariably raises questions about the generalizability of the findings, we build the analysis with two explicit reservations in mind. First, the aerospace industry varies from other manufacturing industries in its emphasis on batch or low-volume, high value production. This biases the organization's manufacturing research and development activities in the direction of technologies which enable it to produce high quality precision

components, rather than repetitive, high volume activities. It will become apparent in the case studies, however, that the diversity of manufacturing processes in this company (e.g., parts fabrication and machining, as well as assembly) enabled us to include a case of technological change targetted at high volume production. Second, because the company engages in a considerable amount of in-house product and process development, it maintains an extensive R&D apparatus. The process or manufacturing R&D function is largely decentralized to the level of the operating divisions. Thus, by contrast to less diversified firms which may centralize their manufacturing R&D activities, this company tends to distribute them; however, budgetary review for major capital equipment purchases and development projects continues to take place at the corporate level.

5 Further delays were encountered as the site for the RAC was moved to a production facility 20 miles away.

6 In briefly discussing the implications of a change in approach to new technology, we walk gently into a somewhat speculative realm. We do so partially out of concern, once again, that the empirical research on which this is based is limited to a single industry. We also tread lightly, but speculatively, because to date there have been few efforts in the unionized sector of the United States of the magnitude we are suggesting.

7 Future research will undoubtedly have to encompass related aspects, including financial strategy, cost accounting, resource planning, equipment purchasing, etc.

8 The author is presently undertaking a broader study which will substantially expand the analysis of organizational decision-making around new technology to include a cross-section of unionized and non-unionized manufacturing industries.

9 The present political climate at the federal level is not especially conducive to the

establishment of technology centers comparable to those in Sweden and Norway (cf., Martin 1987).

10 See Joyce (1985) for a discussion of one union's approach to the issue.

REFERENCES

Adler, Paul
1986 "Technology and Us." *Socialist Review.* (Jan-Feb): 67-96.

Barley, Steven S.
1986 "Technology as an Occasion for Organizational Structuring: Evidence from Observations of CT Scanners and the Social Order of Radiology Departments." *Administrative Science Quarterly.* 31:78-108.

Beer, Michael, Bert Spector, Paul Lawrence, D. Quinn Mills and Richard Walton
1985 *Human Resource Management.* New York: Free Press.

Braverman, Harry
1974 *Labor and Monopoly Capital.* New York: Monthly Review.

Burawoy, Michael
1985 *The Politics of Production.* London: Verso.

Chen, Kan, Joe Eisley, Jeffrey Liker, Jack Rothman and Robert J. Thomas
1984 *Human Resource Development and New Technology in the Auto Industry.* Paris: Center for Educational Research and Innovation, Organization for Economic Cooperation and Development.

Cole, Robert E.
1979 *Work, Mobility and Participation.* Berkeley: University of California Press.

1987 "The Macropolitics of Organizational Change: A Comparative Analysis of the Spread of Small-Group Activities." In C. Sirianni, ed., *Worker Participation and the Politics of Reform.* Philadelphia: Temple Univ. Press, pp. 34-66.

Cornfield, Dan
1987 "Labor-Management Cooperation or Management Control." In D. Cornfield, ed., *Workers, Managers and Technological Change.* New York: Plenum, pp. 331-54.

Cutcher-Gershenfeld, Joel
1987 "The Collective Governance of Industrial Relations." Doctoral Dissertation, Industrial Relations Section, Sloan School of Management, MIT.

Dahrendorf, Ralf
1959 *Classes and Conflict in Industrial Society.* New York: Free Press.

Davis, Louis, and James Taylor
1976 "Technology, Organization and Job Structure." In R. Dubin, ed., *Handbook of Work, Organization and Society.* Chicago: Rand-MacNally, pp. 379-419.

Donaldson, Gordon, and Jay Lorsch
1983 *Decision-Making at the Top.* New York: Basic.

Edwards, Richard
1979 *Contested Terrain.* New York: Basic.

Emery, Fred, and Einar Thorsrud
1976 *Democracy at Work.* Leiden: Martinus Nijhoff.

Francis, Arthur
1986 *New Technology at Work.* London: Oxford Univ. Press.

Guest, Robert
1982 "The Sharonville Story: Worker Involvement at a Ford Motor Company Plant." In R. Zager and M. Rosow, eds., *The Innovative Organization.* New York: Pergamon, pp. 44-62.

Hershizer, Brian
1987 "Union Officials Assess the Labor Movement and Labor-Management Relations." *Labor Studies Journal* 12(1): 26-47.

Hirschhorn, Lawrence
1984 *Beyond Mechanization.* Cambridge, MA: MIT Press.

Howard, Robert, and Leslie Schneider
1987 "Worker Participation in Technological Change: Interests, Influence and Scope." In C. Sirianni, ed., *Worker Participation and the Politics of Reform.* Philadelphia: Temple Univ. Press, pp. 67-94.

Joyce, John T.
1985 "Codetermination, Collective Bargaining and Worker Participation in the Construction Industry." In T. Kochan, ed., *Challenges and Choices Facing American Labor.* Cambridge, MA: MIT Press, pp. 257-70.

Katz, Fred
1965 "Explaining Informal Work Groups in Complex Organizations." *Administrative Science Quarterly* 10: 204-23.

Katz, Harry
1985 *Shifting Gears: Changing Labor Relations in the U.S. Auto Industry.* Cambridge, MA: MIT Press.

Kelley, Maryellen
1986 "Programmable Automation and the Skill Question." *Human Systems Management.* 6(3): 223-41.

Kelly, John
1982 *Scientific Management, Job Redesign and Work Performance.* New York: Academic.

Kochan, Thomas A., Harry Katz and Nancy Mower
1984 *Worker Participation and American Unions.* Kalamazoo, MI: Upjohn Institute.

Kochan, Thomas A., and Michael Piore
1985 "U.S. Industrial Relations in Transition." In T. Kochan, ed., *Challenges and Choices Facing American Labor.* Cambridge, MA: MIT Press, pp. 1-14.

Kochan, Thomas A., Harry Katz and Robert McKersie
1986 *The Transformation of American Industrial Relations.* New York: Basic.

Kuttner, Robert
1986 "Unions, Economic Power and the State." *Dissent.* (Winter): 33-44.

Liker, Jeffrey, David Roitman, and Ethel Roskies
1987 "Changing Everything All at Once: Work Life and Technological Change." *Sloan Management Review.* 28(4): 29-47.

Liker, Jeffrey, and Robert J. Thomas
Forth-coming "Prospects for Human Resource Development in the Context of Technological Change." In D. Kocauglu, ed., *Handbook of Technology Management.* New York: Wiley.

Macy, Barry
1980 "The Quality-of-Worklife at Bolivar: An Assessment." *Monthly Labor Review* (July):\ 41-43.

Martin, Andrew
1987 "Unions, the Quality of Work, and Technological Change in Sweden." In C. Sirianni, ed., *Worker Participation and the Politics of Reform.* Philadelphia: Temple Univ. Press, pp. 95-139.

Noble, David
1984 *The Forces of Production.* New York: Alfred Knopf.

Parker, Mike
1985 *Inside the Circle: A Union Guide to QWL.* Boston: South End Press.

Pettigrew, Andrew
1973 *The Politics of Organizational Decision-Making.* London: Tavistock.

Piore, Michael, and Charles Sabel
1984 *The Second Industrial Divide.* New York: Basic.

Sahal, Devendra
1981 *Patterns of Technological Innovation.* Reading, MA: Addison Wesley.

Shaiken, Harley
1985 *Work Transformed.* New York: Holt, Rinehart, Winston.

Shimada, Haruo
1985 "The Perceptions and the Reality of Japanese Industrial Relations." In L. Thurow, ed., *The Management Challenge: Japanese Views.* Cambridge, MA: MIT Press, p. 42-66.

Shimada, Haruo, and John Paul MacDuffie
1986 "Industrial Relations and Humanware." Sloan School of Management, Working Paper #1855-88, MIT.

Simmons, John, and Willam Mares
1982 *Working Together.* New York: Knopf.

Sirianni, Carmen
1987 "Worker Participation in the Late Twentieth Century: Some Critical Issues." In C. Sirianni, ed., *Worker Participation and the Politics of Reform.* Philadelphia: Temple Univ. Press, pp. 3-33.

Slaughter, Jane
1983 *Concessions and How to Beat Them.* Detroit: Labor Education Research Project.

Solomon, Janet
1987 "Union Responses to Technological Change: Protecting the Past or Looking to the Future?" *Labor Studies Journal.* 11(3):51-64.

Thomas, Robert J.
Forth-coming "Blue Collar Careers: Meaning and Choice in a World of Contraints." In M. Arthur, B. Lawrence, and T. Hall, eds., *The Handbook of Career Theory.* New York: Cambridge University Press.

1988 "Participation and Control: A Shopfloor Perspective on Employee Participation." In S. Bachrach and R. Magjuka, eds., *Research in Organizational Behavior.* Greenwich, CT: JAI Press.

1987 "Who's Behind Technological Change? Three Case Studies of Decision-Making Around New Technology?" Working Paper, Sloan School of Management, MIT.

Trist, Eric
1981 "The Sociotechnical Perspective." In A. Van De Ven and W. Joyce, eds., *Perspectives on Organizational Design and Behavior.* New York: Wiley, pp. 19-75.

U.S. Department of Labor
1985 "Quality of Work Life: AT&T and the CWA Examine the Process after Three Years." Washington, D.C.: Bureau of Labor-Management Relations and Cooperative Programs, U.S. Department of Labor.

Utterback, James
1971 "The Process of Technological Innovation within the Firm." *Academy of Management Journal.* 14(1): 75-88.

Van Maanen, John, and Steven S. Barley
1984 "Occupational Communities: Culture and Control in Organizations." In B. Staw and L. Cummings, eds., *Research in Organizational Behavior.* Greenwich, CT: JAI, 6: 287-365.

Walton, Richard
1981 "Establishing and Maintaining High Commitment Work Systems." In J. Kimberly, R. Miles, et al, eds., *The Organizational Life Cycle.* San Francisco: Jossey-Bass, pp. 208-90.

1987 *Innovating to Compete.* Beverly Hills, CA: Sage.

Wells, Donald
1983 *Unionists and "Quality of Working Life" Programmes.* Rexdale, Ontario: Centre for Labour Studies.

Whyte, William F.
1961 *Men at Work.* Homewood, IL: Dorsey Press.

Witte, John
1980 *Democracy, Authority and Alienation at Work.* Chicago: University of Chicago Press.