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Programmed Automation and Skill Requirements

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Introduction

During the nineteenth century America industrialized. New machines expanded the productivity of workers and America developed Into one of the world's leading manufacturing nations. In the twentieth century the technology of mass production and assembly lines evolved. America grew into an Industrial giant. Until the last two decades competition in the U.S. marketplace was more like an oligopoly, with companies trying to sham the domestic market among themselves with limited competition. Cost-; of labor, materials. energy, and machines were roughly equivalent for all the companies in a given industry (Reich. 1983).Then came increased foreign competition. The massive entry of foreign-made products into our domestic markets has changed the picture dramatically. For more than two decades, foreign made products that meet or exceed our standards for quality, performance, and style have been entering the U.S. market in increasing quantities. Today, America imports 29 percent of her cars. 40 percent of her vacuum cleaners, and 100 percent of her cameras and video cassette records. Foreign productivity and Ingenuity, along with low production cost, are now challenging the preeminence of American Industry even in our domestic fronts. Today certain sectors of American Industry am bankrupt or dying. In the last decade, more than 1000 companies have closed their doors and two million manufacturing jobs have been lost (WGHB, 1985).

In recent years. a new revolutionary force of computer driven Programmed Automation (PA)promises greater productivity. Improved quality, reduced costs, and more manufacturing flexibly. It ranges from computer aided design to computer integrated manufacturing. By the early 1970's many companies installed computers for batch processing of financial records and printing payroll checks. The computer started to revolutionize the control of offices and service organizations. They became cost effective for large organizations. For example, file New York Stock Exchange improved it-, productivity by 400 percent after installing their computerized data and order processing system (WGBH, 1985). During die year 1988, more than 10 million computer terminals were in use in offices across the nation (Kutscher, 1989).

Since manufacturing is extremely complex, computers, were seldom used in production until die mid 1970's (Reich, 1983). Then in the mid '713s came die age of microprocessors, and computers passed watershed (Schmitt, 1083). Computers became smaller, cheaper and increasingly more powerful to host a wide variety of new applications which might help rejuvenate American industries. Computer automation appeared independently within each area of manufacturing ranging from product design, process design, product testing, fabrication, assembly, material handling, inspection, to planning and control. They are commonly known a-, islands of automation. However, the total integration of these islands of automation still has a long way to go (Skinner, 1985).

Computer aided design (CAD) systems are now used extensively in die manufacturing industry. For example, General Motors Corporation are currently using more than $100 million of CAD

systems to support their product design and engineering activities. The computer terminal population in their design and engineering department has grown from 62 in 1980 to 3000 in 1986 and to over 6000 in 1990.

During the 1908s computer controlled robots became common fit America's workplaces. Robots requiring no coffee breaks, safety regulations, or unions have already replaced some of America's 20 million blue collar workers (Fullerton, Jr., 1989). Most of the robots have been installed by large manufacturer-, such as General Motors, John Deere, IBM. Chrysler, Ford Motors, and General Electric, whose managements are willing and able to invest millions of dollars in new technologies. These robots, are primarily used in spot welding, spray painting, and other hazardous operations, (Hunt. 1983). However, robots are not the key to programmed automation. They are only a peripheral item. Automation experts believes that the greatest advantage of computer automation comes from replacing people and paper with totally computer integrated manufacturing (Skinner, 1985). Effects of this technology are as far reaching as its promises. Many new jobs will be created and many old jobs will become obsolete. Moreover, there will be a drastic change in the way American workers., work today. Many of the jobs they have now will become obsolete by the year 2000. This paper attempts to examine the effects, of this new technology on the employment patterns in the United States. The ideas presented in this paper are based upon a number of field interviews, a survey. results from previous case studies, and information from documents published by government and private research organizations as cited in the reference.

Changes In Labor Content of Work

A Delphi survey of many company executives and experts in this field. reveals that the adoption of PA technologies has been perceived to be critical to the long-term survival of American industries by The role of adoption has been dependent on human responses to technology and the way if has been employed (Srikanth, 1987). Whenever significant changes occurred in manufacturing technology, there had been an impact on the number of' workers needed for a given level of output, the skill requirements, and die relationship among members of die workforce. No doubt, programmed automation (PA) technologies which include computer aided design (CAD). computer aided manufacturing (CAM), computer aided material handling (CAMH), artificial intelligence (AI). computer aided inspection and quality control, computer aided process planning (CAPP), computer aided production planning, and finally computer integrated manufacturing (CIM) can significantly reduce the labor content per unit of output. Therefore, if production volume does not increase, labor displacement is bound to occur. Displacement refers to forced changes in the type of job, job location, or workgroup within the same company or to another company, or changes resulting in unemployment. Table I illustrates the decrease in level of labor requirements in a typical production process based on a survey of 100 manufacturers in the U.S. In this survey, the manager of the production facilities were specifically asked to provide the percent decrease in labor content in production processes directly attributed to the introduction of programmed automation technologies. In many situations labor requirements for a particular production task did not decrease, but output increased significantly resulting from use of fewer production units for a given level of output. The figures in table I are adjusted accordingly for comparison purposes. For example. if a

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company double% its output with the same number of employees, its. labor re(itfirement has declined by 50 percent. One of the companies surveyed

Table I
Percentage Decrease in Labor Content in
Typical Production Process Due To Programmed Automation.

Type of Manufacture	Sample Size	Type of Process Assembly/Discrete	Percent Decrease in Labor Content
All Assemblers/Subassemblies	20	Assembly Line	40 to 90
Automobile Assembly	5	Assembly Line Process'	50 to 80
Automobile Subassembly	10	Assembly Line Process	70 to 90
All Discrete Manufacturers	80	Discrete Production	35 to 90
Automobile Parts	40	Discrete Production	40 to 90
Electronics Paris	20	Discrete Production	501090
Metal Working Machinery	20	Discrete Production	35 to 60

indicated that they had reduced their workforce dramatically from 15,000 to 2000 with programmed automation. In another company programmed automation (PA) resulted in eight times the output of the older process. Most of the companies surveyed have only one or two facilities using PA and some have long-range plans for expanding PA technologies across the firm. The estimates in table I refer to the number of direct production workers and do not reflect the total plant population.

Workforce Displacement

Displacement will also occur in almost all Job areas front supervision to clerical. It is likely that there will be fewer factory supervisor and foremen (Lond. 1985). With programmed automation and improved data communication technology, it will be flexible for supervisors to oversee large production units. Thus. the level of output per supervisor will increase while the number of workers supervised will be decreased (Fullerton, 1989). Similar displacement will occur in the area of manufacturing support. Teleprocessing information all the way through from design to scheduling will make the factory paperless in the long run and will virtually remove the specialized staff functions of production schedulers, dispatchers, expediters, and inventory controllers (Leonlief, 1985). PA will also depress, the staff functions involving data gathering

and analysis, and transaction processing, both at plant level and at higher levels of corporate structure (Personick, 1989). With corporate executives becoming more and more skilled in the use of computer interfaces, their need for staffs for gathering and analyzing data will be significantly reduced. This will also reduce the bureaucracy in the corporate decision making process (Lund, 1985).

Programmed automation (PA) technologies creates enormous potential for change in the use of workforce. By eliminating specific tasks and by contributing to major changes in manufacturing processes and organization, PA will not only depress the number of jobs available in manufacturing, but also motivate shifts in the mix of personnel and in the tasks sought from employees. PA will directly or indirectly affect all types of personnel: clerical, production, technical, and professional (Denny and Fuss, 1983). Whether it will generate increased aggregate national unemployment will depend not only on these displacement effects, but also on other factors such as the level of production volume (which depends on consumer demand and foreign competition), economic conditions, and the number and type of individuals seeking jobs (Bednarzik, 1983). PA will also provide employers with choices about the number mid types of workforce they employ. And the outcome of those choices will determine future staffing patterns and employment levels in firms and industries. The U.S. automobile industry exemplifies this situation. During the recession of the mid ‘70s and early '80s, the U.S. auto makers, laid off a large number of workers. Because of increased use of PA technologies, they are unlikely to hire to prior early 1970’s peak level even with increased sales volume in recent years. On the other hand, PA technologies may help preserving many jobs by providing competitive edges to many domestic companies in fighting foreign competition. A study conducted at New York University Leontief Duchin, in 1984 suggests that given the Impact of PA technologies on labor requirements in manufacturing., education, health care, and offices. and given the employment generated by increased production volume and PA equipment and production, significant increase in unemployment is not likely to occur in this century. The Office of Technology Assessment (OTA, 1983) also shares the view that use of PA technologies is expected to grow at a faster pace, but without large increase in national unemployment during this century. These two studies assume that a strong economy will follow along with increased production volume and reduced foreign imports. But increased growth in foreign imports, foreign sourcing of parts and subassemblies, and rapid implementation of labor saving PA technologies have started depressing local or regional employment at least temporarily in areas dependent on mature Industries. The East North Central region of the United States is likely to experience increase in labor displacement due to its association with the automobile industry not only because of increased use of PA technologies but also due to increased foreign competition and foreign sourcing of parts and subassemblies (Kutscher, 1989). Similarly. projected drastic cut in defense expenditure is expected to slow down defense oriented production resulting in sluggish employment situation in the Western and the South Eastern regions of the United States at least temporarily (Fullerton, 1989).

Changes In Skill Requirements

Increased experience mid improved technical capabilities and diminishing costs of PA technologies will undoubtedly increase the use of PA technologies (hiring 199(h. Changes in employment patterns will depend on the changes in the tasks that people will do. changes in the skill requirements, and changes in die ways managers assign those tasks to workers trained for different occupations (Hansen et. ai., 1984). Two types of impact on skills should he considered: (1) changes in the nature of the skill requirements, and (2) the distribution of skill levels. 'Me nattire of skill requirements changes when a worker has to interact with a production system in which computers control operations of machine,,;, flow of materials and inspection of jobs, and at the same time communicate with other machines, staffs, and even managers. The distribution of skill levels refers to die changes in the relative numbers of jobs. at various levels in the organization and whether such changes will affect personal growth, advancement, and upward mobility.

At least six important skills are required for production using PA technologies. They are: (1) Conceptualization or abstract thinking, (2) visualization or ability to develop abstract mental patterns, (3) understanding of die manufacturing process, (4) analytical and statistical inference capability, (5) verbal communication, and the most important. (6) sense of high degree of maintaining close contact with materials and machines, role of workers will be to monitor die process. The removal of workers from physical contact may go so far as to transfer the workplace from the machine area into a remote control room. This trend will follow in all stages of production from primary processes through fabrication mid assembly. Similar trends will occur for other forms of manufacturing jobs such as scheduling, dispatching, expediting. inspection, and materials handling (Johnston, 1987).

As computer integration proliferates and expands in scope, workers need to understand how the production fits together, rather than simply working with one of its part. In the past mechanization resulted in division of labor when the whole work was broken into a series of relatively simple Wks, and each worker was assigned to one of these small task. Often, workers had no idea about how the whole system works (Rosenthal, 1982). On the contrary, with PA technologies a production worker will carry responsibilities for several stages in the production process and will understand how all such responsibilities fit in the whole system. Thus, PA technologies offer an exceptional latitude in designing jobs. However, the distribution of needed skills within a given workforce will depend upon the management policy. The discretionary aspect in the designing of jobs will allow management to maintain and control the distribution of skills to match the desired goals of the organization. In conventional manufacturing, (here has been a reasonably broad spectrum of jobs ranging from "entry-level" to those requiring "high degree of skill and proficiency" (Fadem, 1982). Displacement of jobs due to PA technologies is not likely to affect all levels, in a plant. The jobs which are the prime target of PA technologies are those which do not require high skills and are of fixed location in nature. While those requiring a high degree of skills, geographic mobility, multiplicity of tools, non-repetitive tasks, problem solving in relatively unpredictable situations. and continuous use of visual and tactile sensing are difficult to automate. However, with recent development in sensing techniques and expert systems design, these jobs are becoming increasingly vulnerable to PA technologies (Kutscher, 1989).

Projection of Employment Pattern in the future

PA technologies brings distinctions between occupational categories and present vast opportunities for restructuring jobs (Vansid, 1984). Table 2 and 3 represents the effects of PA technologies on employment pattern In the United States and in manufacturing Industries in the U.S. respectively. Among occupational groups, engineers and technicians are becoming prominent, while machine operators, and clerical personnel are becoming vulnerable to displacement. Engineers are central factors to the implementation of PA technologies because they contribute to both the production and use of PA. They develop them, produce them, and work with them. Total employment of engineers in 1980 was over 1 million, including about 580,000 employed in manufacturing. In 1982, nearly 590,000 engineers, were employed in manufacturing industries with total of 1.2 million in all industries (Kutscher, 1984). In 1988, total number of engineers employed in all Industries was 1.41 million, including about 790,000 in manufacturing (Bureau of Labor Statistics, 1989). The growth of engineering activities caused by PA technologies will not only raise engineering employment among user firms, but also it will rise in other service industries (Hunt, 1993). By the year 2000, total engineering employment has been projected by the Office of Employment Projections, Bureau of Labor Statistics to be 1.76 million, Including about 960,000 in manufacturing (Silestri and Lukasiewicz, 1989). National Academy of Engineering forecasted A shortage of 113,000 electrical and computer engineers by 1992 based upon forecast of engineering graduates and employment targets by 815 manufacturers employing over 736.000 employees (National Academy of Engineering, 1984). National Science Foundation has predicted from a study on Defense and Civilian industries, a similar shortage of electrical, computer and aeronautical (NSF, 1988).

Among other occupational groups, technicians will become more prominent with the expansion of PA technologies. Because, due to shortage of engineers. technicians will be assigned to perform tasks otherwise performed by engineers. Technicians employed in industries range from CAD draftsman to computer programmer-,. In 1980 combined employment of engineering technicians, and computer programmers was about 1.3 million, and about 508.000 in manufacturing. In 1982 the total industry and manufacturing levels were 1.5 million and 518,000 respectively. In 1988, total employment of technicians and computer programmers grew to 1.8 million. including about 660.000 in manufacturing. Total employment of technicians and computer programmers. in all industries is projected to be 2.3 million, including about 8.10.000 in manufacturing in the year 2000 (Bureau of Labor Statistics, 1989).

As in the case of engineers, the trend in industries may also shape the employment opportunities for technicians. The expansion of PA technologies is expected to alter interactions between manufacturers and suppliers. This has already happened in Automobile and Aerospace industries. This trend could diminish the demand of drafters among suppliers. This may happen hi die categories of programmers with die development and storage of more canned programs (Fullerton, and Tschetter, 1983). Since technicians can perform tasks which were considered professional and high skilled, PA is likely to make the substitution possibilities more obvious and numerous, in favor of technicians.

Production and related workers, are the overall largest occupational group in manufacturing and are the most vulnerable ones to displacement. Bureau of Labor Statistics (1989) defines this broad category as "all skilled, semiskilled, and unskilled workers performing machine and manual tasks involving production, maintenance, construction. repair, material handling, and power plant operations". In 1980, there had been 14 million production and related employees in manufacturbig industries. They are mainly concentrated in Machinery (1.52 million), Electrical mid Electronics Equipment (1.25 million), and Transportation Equipment (1. 19 million) industries, where PA technologies have been heavily introduced (NSF, 1982). it is important to recognize that there are factors, other than PA which are instrumental to the decline in employment of other occupational groups. Foreign competition has been instrumental to lost sales and lost production volume in many industries resulting in lost production and related jobs. Similarly, increased foreign sourcing of components and subassemblies by many U.S. manufacturers in recent years has significantly depressed domestic employment. While production jobs in mature industries are declining steadily, Bureau of Labor Statistics reported creation of unskilled jobs in other growing industries through the 1980s showing a slight net gains in this category. in 1988. total of 16 million production mid related jobs have been reported in this category (Bureau of Labor Statistics. 1989). However, such gains has been attributed to the fair growth in economy and business and favorable reemployment opportunities in growing industries. In 1990sjobs In 11% category are expected to decline in growing industries as well as in declining ones, generally because of widespread technological changes and is projected to be15.0 million in the year 2000 (Bureau of Labor Statistics, 1989). For example, the occupation of assemblers and fabricators is expected to decline by 116,000 jobs in declining industries from 1990 to 2000. Numbers of workers in this occupation also are projected to decline by 3.0 million jobs in growing industries. Displaced workers who face perhaps the most unfavorable reemployment prospects In the same occupation are those In occupations that are highly concentrated in a few declining Industries. For example, the apparel industry is projected to have a large employment decline by 172,000 jobs during this decade (Silvestri and Lukasiewicz, 1989).

The expansion of PA technologies will increase the role of mechanics, repairmen and installers (MRI) In manufacturing industries because of high cost of PA equipment and the risk of production stoppage due to equipment malfunction. In IM there were 1.2 million MRI workers in all industries. including 696,000 in manufacturing (Fullerton and Tschetter, 1983). During the 1980s demand in computer repairmen grew to 89.4 percent as compared to an average 19.1 percent in MRI category. In 1988 total employment In MRI categories in all Industries has been reported to be 4.8 million, including 1.62 million in manufacturing. Those numbers are expected to grow to 5.4 million and 1.91 million respectively in the year 2000 (Bureau of Labor Statistics. 1989). PA will also have a major impact on skill requirement for MRI category. Improved diagnostic technologies, and modular design of equipment will lower the skill requirements for many MRI tasks. On the other hand, more combinations of mechanical, electrical and electronic features in PA equipment will demand increase in breadth of skill for MRI operations.

PA will have severe impact on clerical workforce in manufacturing In the long run most probably in the next decade. In 1980 there was a 2.3 million clerical workforce in manufacturing which shrunk to 2.2 million In 1982. In 1988 total number of workers employed in this category in manufacturing was 1.8 million. The growing use of office automation will reinforce the displacing effects of PA in manufacturing resulting in accelerated decline in employment in this occupation. PA will reduce significantly the "paper trail" that follows materials and work in process; and with automated material handling and storage, and automated record keeping, the jobs of production clerks, .storekeepers, expediters, material handlers, inspectors, and payroll clerks are most likely to diminish rapidly in the year 2000 (Bureau of Labor Statistics, 1989).

PA technologies will change the way of managing factories. The new technology will substantially change die job of supervisors and middle managers, shifting the focus; front being watchdogs and disciplinarians to planning, training, and communicating (Skinner, 1983). In 1980 there were 7.56 million managers in all sectors, including 1.19 million in manufacturing accounting for 6.58 percent of total manufacturing employment. Nationwide. The employment of managers has been growing in all economic sectors. Even during the recession of 1990s. In 1982, there were about 7.70 million managers., nationwide in all sectors and 1.26 million managers in manufacturing. Among them, there were 705,000 blue collar supervisors and 67,000 clerical supervisors, and the rest were upper level management (Skinner, 1985). in 1988 the number of managers in manufacturing grew to 4.0. million, while the same for managers in all sectors grew to a record high 12.10 million, and projected to be 14.76 million in the year 2000 (Bureau of Labor Statistics. 1989). PA technologies has already started changing the mix and the numbers of managerial personnel. It will support growth in upper management rank. The push for so called top-down control facilitated by increased integration of databases will inherently increase the r8le of upper management. On die other hand, the increased computerization of data collection and data transfer activities is expected to lower the demand for supervisors and middle managers. This will also reduce the number of levels of management hierarchy and the organization will become more flat.

Summary and Conclusion

Displacement of jobs will be the principal long-term effect-, of programmed automation (PA) technologies as summarized in table 2 and table 3. PA technologies are designed to reduce labor hours requirement in production. They are sold as labor substitutes. But whether or not the total employment will decline will depend upon many other factors such as changes in foreign competition, foreign sourcing of parts and subassemblies, production volume. and general economic conditions of the county. Slower growth in labor force, increased production volume, and limited use of PA technologies are likely to buoy employment in manufacturing industries in the early 1990s. However, regional and local employment may become depressed in those areas dependent upon mature industries and particularly textile and automotive industries.

PA technologies will blur distinctions between occupational categories and present vast opportunities for restructuring jobs. Engineers and technicians will be in demand for the next decades, because they develop, design, produce. install. and maintain the PA technologies. On

die other hand, production and clerical workforce will be the most vulnerable to other hand, production and clerical workforce will be the most vulnerable to PA technologies. Employment in these occupations will degenerate rapidly.

PA technologies will also change substantially the jobs of supervisors, middle managers. and top management. Managers will be spending more time on decision making than watch-dogging and disciplining employees. With computer integrated information processing, decision making will be more centralized using more top-down control as compared to what happened In the past. This will also decrease the number of levels in the hierarchy of an organization with more span of control resulting in more responsibilities. The differential growth of occupations due to growth and decline in various industries has a variety of implications for the job market expected through the PA. Workers in occupations that are expected to decline in growing industries as well as in declining ones will have potential displacement problems, particularly because of widespread technological changes. This paper deals only with potential Job losses Implied by projections of Bureau of Labor Statistics and other published literature. The projections were based upon expectation of moderate growth of economy and no attempt has been made to account for the effects of business cycles on worker displacement.

In factories of the future, the employer-employee relationship will require a greater degree of mutual trust than what has been evidenced in the past. Workers are to be given more responsibilities involving expensive equipment and processes. A relationship of trust is reciprocal in nature. Companies in which this mutual trust does not exist are likely to experience difficulties In reaping the benefits of PA technologies. Given a history of conflict resolution through confrontation rather than cooperation, it is not yet clear how the U.S. manufacturers are going to mad the challenge of PA technologies. To avoid .much confrontation, many companies have consciously located their new automated plants in locations where there is no union (Lund, 1985). A path of confrontation will paralyze our factories. On the other hand. a non union environment will bring in-equitability in sharing of the fruits of the new technology and rack of protection of workforce from capricious management practice. Therefore, unions and management must sincerely work together to forge the path of programmed automation towards the progress of the nation and the mankind as a whole.

Table 2
Effects of Programmed Automation on Employment Paftern
in the United States in All Sectors in Millions

Category	**1980**	**1982**	**1988**	**2000***
Engineers	1.10	1.20	1.41	1.76
Technicians & Computer Programmers	1.30	1.50	1.80	2.30
Maintenance, Repairmen & Installers	1.20	***	4.90	5.40
Managers and Supervisors 7.56 7.70	12.10	14.76		

*** 1982 employment data for MRI category was not available

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Projection in the year 2000 was based upon moderate growth of economy

Table 3
Effects of Programmed Automation on Employment Patter in Manufacturing industries in the United States in Thousands

Category	**1980**	1982	1988	2000
Engineers	580	590	790	960
Technicians & Computer Programmers	508	518	660	810
Maintenance, Repairmen & Installers	696	1,200	1,910	
Managers	1,190	1,260	1,300	1,600
Operators & production jobs	14,000	***	16,000	15,000
Clerical jobs (dispatchers, etc.)	2,120	2,200	1,800	1,790

*** data not available
* Projection in the year 2000 was based upon moderate growth of economy

Source: Bureau of Labor Statistics

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