SOCIAL EUROPE

New technology and social change — Manufacturing automation

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DIRECTORATE GENERAL FOR EMPLOYMENT, SOCIAL AFFAIRS AND EDUCATION

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Supplement on NEW TECHNOLOGY AND SOCIAL CHANGE — MANUFACTURING AUTOMATION

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EDITORIAL

This issue of New technology and social change focuses on the social aspects of manufacturing automation. The piecemeal introduction of automated equipment in production has continued for many years; attention is increasingly being concentrated on the seemingly imminent prospect of attaining the fully automated factory, where robots or machines will take over most human manual jobs.
The spreading use of electronic programming and control in mechanical equipment, and the improved ability to combine and interface different pieces of equipment make the automated factory a not-too-remote possibility. However, many technical problems still remain to be solved, and the examples of flexible manufacturing systems already in operation, some of which are briefly presented in the following pages, are for the time being few and rather experimental.
Nevertheless, the shape and layout of factories are changing: a number of processes, that have always been carried out by human labour, are being automated; even work tasks that are not directly part of the production line, such as design, are being completely changed, undergoing in many respects a transformation similar to that of production jobs. Even more important from the point of view of mangement and workers alike is the different type of work organization that automated equipement implies or makes possible. The integration of information technology into production equipment makes it possible to attain at the same time greater flexibility in each part of the process and increased control over the process as a whole.
The assembly line, the conventional image of the traditional and rigid factory layout of most engineering productions, may become a thing of the past; the long discussed "death of taylorism" may actually be taking place.

The effects on employment are likely to be important, both quantitatively and qualitatively. Quantitative effects are felt at a distance, since we are not witnessing a radical, sudden change, but rather a gradual introduction of automation in individual processes.

Robots and automated machines nevertheless eventually replace workers in a number of tasks, with sizeable labour displacement effects, particularly in large, labour-intensive sectors.

On the other hand, the jobs being abolished are in many cases unhealthy, unpleasant and repetitive, and the prospect of many presently low-skilled workers being turned into machine-controllers marks a definite improvement in working conditions. As in most other new technology sectors, the final outcome will largely depend on how work organization is reshaped, and how human resources are utilized.

The aim of the texts presented here is not to provide a comprehensive overwiew of the situation in the Community Countries, but simply to put forward some material for information and discussion. It should be recalled that the Commission of the European Communities is actively involved in promoting research and development in manufacturing automation, notably through the Esprit programme. One of the Esprit sub-programmes, in fact, is addressed to Computer Integrated Manufacture: work in this sub-programme relates to the total requirements of manufacturing activities, from the planning and design stage to real-time control of production. In December 1985, the Council adopted the Esprit work programme for 1986. It will include projects in the following fields: integrated system architectures, computer-aided design and engineering, computer-aided manufacturing, flexible manufacturing systems applications (1).
In addition, the Commission recently analysed the situation and future of advanced manufacturing equipment in the European countries, with the aim, among others, of identifying the need for equipement standardization (2).

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(1) For details of each sub-programme, see Draft Council Decision adopting the 1986 work programme for the European Strategic Programme for Research and Development in Information Technologies : ESPRIT, COM (85) 602 final.
(2) Advanced Manufacturing Equipment in the Community, COM (85) 112 final.

The first article presented in this issue, prepared by the Directorate-General for the Internal Market and Industrial Affairs, outlines the main conclusions of this analysis, with regard not only to the industrial aspects, but also to the employment implications.

The other articles in the following pages look at the situation and, more specifically, at the social implications from the point of view of each Member State (1). They present a brief description of the diffusion of the technology; give account of studies carried out in each country on the effects on employment and work organization; outline the main policy measures addressed to the sector, and the positions of the two sides of industry (2).

The Commission hopes that the publication of this material will help the circulation of information and will contribute to the debate on the development of the sector, which is crucial both for the technological advancement of Europe and for industrial relations.

J. DEGIMBE

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(1) As this publication is based on information given by national correspondents during the pre-enlargement period, Spain and Portugal are not included. Greece has not been included owing to the very limited amount of material available on the subject.

(2) The national articles are summaries of more extensive - unpublished surveys, which may be obtained on request.

USUAL ABREVIATIONS (E - F - D)

CAD	:	Computer Aided Design
CAO	:	Conception Assistée par Ordinateur
CAD	:	Computergestützter Entwurf
CAM	:	Computer Aided Manufacturing
FAO	:	Fabrication Assistée par Ordinateur
CAM	:	Rechnergestützte Fertigung
CAD/CAM	:	Computer Aided Design/ Computer Aided Manufacturing
CFAO	:	Conception et Fabrication Assistée par Ordinateur
CAD/CAM	:	Verknüpfung von computergestütztem Entwurf und computergestützter Fertigung
CAE	:	Computer Aided Engineering
IAO	:	Ingeniérie Assistée par Ordinateur
CAE	:	Computergestützte Bearbeitung; rechnergestützte Produktanalyse
CAPP	:	Computer Aided Process Planning
PAO	:	Planning Assisté par Ordinateur
CAPP	:	Computergestützte Planning
CIM	:	Computer Integrated Manufacturing
PIO	:	Production Intégrée par Ordinateur
CIM	:	Computerintegrierte Fertigung
CNC-Machine Tool	:	Computer Numerical Control
MOCN	:	Machine-Outil à Commande Numérique
CNC	:	Computergesteuerte Werkzeugmaschine
FMS	:	Flexible Manufacturing System
AFF	:	Atelier Flexible
FFS	:	Flexibles Fertigungssystem
N.C. Robot	:	Numerical Control Robot
N.C. Robot	:	Robot à Commande Numérique
N.C. Robot	:	Numerisch gesteuerter Roboter

ADVANCED MANUFACTURING EQUIPMENT
AND THE AUTOMATION OF INDUSTRY

On 26 March 1985. the Council of Ministers approved a Commission communication on advanced manufacturing equipment (COM(85) 112 of 21.3.1985) offering an in-depth analysis of the technological, structural and financial consequences of advanced production technology on business, allied to a discussion of the human implications of the march towards the factory of the future. That analysis formed the basis of a series of recommendations for a Community approach to the issues raised by industrial automation.

The aim of this article is to focus attention on the purely human considerations involved in the introduction of advanced manufacturing equipment as they emerge from the Commission's analysis. But before going further into the detail of that analysis, a prefatory glance at the current state of manufacturing technology and spread of advanced production equipement throughout the European Community might be in order. Advanced manufacturing equipment falls into five broad categories:

- Advanced machine tools;
- Industrial robots;
- Flexible manufacturing cells, systems and transfer lines;
- Computer aided design (CAD);
- Industrial data processing and other forms of advanced equipment.

I. The Production and Spread of Advanced Manufacturing Equipment in the Community

1. Advanced machine tools

Advanced machine tools cover a broad spectrum of equipment ranging form electrodischarge machines, through laser machine tools to rapid production machines. For convenience's sake, therefore, the term "advanced machine tools" will be used in this article as shorthand for any form of numerically-controlled (NC) machine tool.

Production of NC machine tools (units)			
	1975	1980	1983
Japan	2,182	22,052	26,398
USA	4,136	8,856	8,000
West Germany	1,085	4,743	8,000
United Kingdom	739	1,240	1,800
Italy	800	2,700	3,000
France	500	1,100	1,300

Source: JETRO, IPA, CECIMO

Japan has achieved a spectacular increase in world market share since the middle of the last decade, primarily with two particular types of machine: machining centres and compact NC turning lathes. Japan has invested heavily in mass producing standardised versions of both categories of machine, enabling them to cut their production costs to levels approaching half those of their European competitors.

Rate of Dissemination of NC Machine Tools		
	Year	NC Machines as % of all machine tools
USA	1983	4.7
Japan	1981	2.9
West Germany	1980	2.2
United Kingdom	1982	3.3
France	1980	1.6

Source: MTTA

What these figures do indicate, however, especially in the light of the discrepancies between the dates to which they relate, is that no single country seems to have a particularly commanding lead in the use of NC machines.

2. Industrial robots

The term "robot" tends to be used somewhat loosely, particularly in Japan. For our purposes, a robot essentially means a programmable manipulator with a degree of multitask capability, which can be programmed to accomplish a variable sequence of movements. Even this, however, emcompasses a wide variety of robots from the basic "learning" robot (executing a sequence of tasks pre-specified by an operator and stored in its memory) to the "intelligent" robot capable of adjusting and modifying its operations according to sensory feedback from its working evironment.

Estimates of the Robot Population in Selected Countries

	1978	1980	1981	1982	1983	Annual average growth 1980-1983
West Germany	450	1,200	2,300	3,500	4,800	41%
United Kingdom	125	371	731	1,152	1,753	47%
France	NA	580	790	1,385	2,010	36%
Italy	NA	400	450	790	1,800	46%
Total 4 countries	NA	2,551	4,253	6,827	10,363	42%
Japan	3,000	6,000	9,500	13,000	16,500	29%
USA	2,500	3,500	4,500	6,250	8,000	23%
Sweden	800	1,133	1,700	1,300*	1,900*	NA

Source: OECD, British Robot Association and Association Française de Robotique Industrielle

(*) Data revised downwards following a change of definition.

After a comparatively slow start, the pace at which robots have spread throughout European industry has quickened in recent years.

To put these bald figures in true perspective, however, they must be set against the overall figures for employment in industry as a whole.

Number of Robots per 10,000 Industrial Workers
(NACE 2/4)

	1978	1980	1983
West Germany	0.5	1.4	6.3
United Kingdom	0.2	0.6	3.4
France	NA	1.1	4.1
Italy	NA	0.7	3.4
Japan	2.3	4.4	11.8
USA	1.1	1.6	3.9
Sweden	7.8	11.0	20.3(*)

(*) Data revised downwards following a change of definition

This shows that Sweden and Japan remain significantly ahead of the field, although the Community as a whole has caught up and overtaken the United States.

Production of industrial robots within the Community has expanded appreciably in recent years, largely due to an increasing commitment to robotic systems within the automotive industry (mostly manufactured by the car-makers themselves). International trade in robots remains both low and slow, due to the narrowness of the potential robot market and the imperative of a local presence with maintenance capabilities.

3. Flexible manufacturing cells, systems and transfer lines

In contrast to conventional inflexible systems such as hard automation transfer lines which require huge volume production, so-called flexible production systems allow parts to be produced in lots varying form one to hundreds to thousands. Automation of low- and medium-volume batch production has become a real possibility.

Flexible systems speed up production rate (by reducing the volume of work-in-process) and enhance the manufacturer's ability to respond and adapt to changing market requirements (by holding down stocks and capturing markets). Such systems may vary in degrees of flexibility, complexity and cost, according to whether they are:

- flexible manufacturing cells: consists of a group of several machines (machine-tools with or without robots), interlinked but working in a fixed sequence directed by a control program (normally in batches from 20 to 500 parts);
- FMS (Flexible Manufacturing Systems): again comprising a cluster of machines, but directed by a software-based control system enabling parts to be processed in re-programmable sequences at optimum efficiency (using a computerised data processing component 10 times that of a manufacturing cell) and requiring a highly sophisticated parts carrying system (normally operating in batches of 50 to 2,000 pieces);
- flexible transfer lines: these are basically rigid lines in which each station is numerically-controlled and all are linked to a central computer which can instantly direct changes of position or dimensioning. In contrast to conventional lines where only one type of part may be machined, a flexible line works on a small family of parts, but in larger batches of 1,000 to 10,000 pieces.

Flexible Systems: Installed Base and Market

Installed Base (units, mid-84)	France	Italy	UK	GFR	Total EEC	US	Japan
Cells	15-20	15-20	15	20-30	100+	100+	100+
FMS	4	3	4	12	25	15	25
Flexible Transfer lines	NA	3	2	3	10	20	8
Market							
($M, early 1980s)	10-15	10-15	15	15-20	60-80	75-100	50-75

Source: Estimates of the Boston Consulting Group

At present time, the EEC, the USA and Japan are routhly neck and neck in the race towards the automatic factory (largely due to major European successes in making up lost ground at the beginning of the 1980s).

However, given the length on stream, and the central importance of maintenance facilities, a strong local presence is essential to the sale of FMS systems. Which is why most of the systems installed in Europe have been fitted for European manufacturers.

4. Computer-Aided Design (CAD)

CAD has experienced virtual mushroom growth in recent years, with the market for CAD technology expanding at a rate in excess of 30 - 40 % a year. And yet Europe displays only a grudging acceptance of CAD compared with the commitment displayed by the USA and Japan.

Estimates of CAD Utilization (1982)

	Number of CAD Systems	Percent of GDP
France	562	1.2
West Germany	375	0.6
United Kingdom	620	1.6
Sweden	208	2.4
USA	6,600	3.5

Source: CADCAM International (August 1984)

The international CAD market is overwhelmingly dominated by a strong American presence, as the following table clearly illustrates :

Shares of suppliers to the European CAD market (%)

Supplier	France (82)	Germany (81)	U.K. (81)
Applicon (USA)	21	10	3
Computervision (USA)	36	32	29
IBM (USA)	NA	NA	12
Other (USA)	5	18	20
Secma (F)	12		
Matra (F)	6		
Siemens (D)		8	
Racal (GB)	11	7	15
Compeda (GB)			6
Ferranti (GB)			2
Quest (GB)			10
CIS (GB)			2
Total local manufacturers	23	11	36
Total European manufacturers	38	40	36
Total American manufacturers	62	60	64

Source: CADCAM International (August 1984)

5. Industrial data processing and other forms of advanced equipment

Upstream of the actual manufacturing sequence, computer-aided design which, as the preceding section shows, enables the manufacturer to organize his production process for optimal efficiency, can be linked to computerized planning functions (raw materials and components control systems), while downstream, specific customer orders can also be directly tied into the computer-controlled production process. A striking example in this respect is offered by FIAT's newly-installed system, where an order placed with a dealer automatically triggers the assembly of the model ordered.

The entire economic management of the company's business - ranging from accounts to commercial and financial management - is also computerised.

Clearly, the benefits derived from computerisation of this order will vary with the individual circumstances and position of the company. The computer system installed by the German company Heidelberger Druckmaschinen paid for itself within three years in more efficient booking of orders alone. The independent accountants Arthur D. Little reported that stocks had been reduced by one-third on average, with errors and stock-outs virtually eliminated. There were also associated benefits in terms of direct and indirect labour costs, the elimination of late deliveries and an all-round improvement in the standards of customers service.

Significantly enough, some 80% of all the industrial and scientific computers in use in Europe are American-made.

Finally, let us not overlook the range of specialised machines, custom-designed for specific industries as part of automated systems for the manufacture of furniture, automatic sewing and knitting machines for the clothing industry, and automatic cutting and sewing machines for the footwear and garment industries.

II. Human Resources

1. The level of employment

Assessements of the impact of automation on levels of employment tend to come to widely varying conclusions. To take just one example, estimates of the number of jobs displaced by the robotization of the workplace range from 0.5 to 6 jobs per robot.

There are many reasons underlying such an apparently wide discrepancy. Firstly, there is the technical reason that a robot system's factory-floor performance may fall far short of the claims made for it by the developers. This is particularly true of complex systems, whose labour-saving potential is clearly illustrated by the following table.

Comparison between YAMASAKI's Minokamo plant (4 inter-linked FMS) and a conventional plant of similar capacity

	Minokamo	Traditional
Total machine tools	43	90
Total employees	39	195
of which: - operatives	36	170
- control (supervisors)	3	25
Machining time (days)	30	91
Surface area (m2)	6,600	16,500

Source: VDI - Z (January 1984)

In practice, however, a number of problems remain(workpiece handling, machine tool control, hardware and software reliability) which tend to increase geometrically with the complexity of the system and which may prevent the pre-defined goals from being reached, particularly in the early stages of flexible automation.

In the longer run, however, as systems become increasingly dependable, the benefit of hindsight should help companies to achieve something like promised performance levels.

It must be made clear, however, that technology is only one of the factors involved, and it must not be taken out of context.

Finally, and perhaps most importantly, analyses often betray a hazy understanding of the central problem - the result of confusing the microeconomic analysis of the individual firm with the macroeconomic analysis of the broader economy as a whole.
Taking the individual firm as the base line, it is clear that investing in advanced production technology not only enhances the productivity of labour (thus reducing the company's total labour requirement) but also sharpens that company's competitive edge, bringing it an increased market share and causing it to expand production, with a secondary ripple effect on levels of employment. The danger is that this will lead to a marked under-estimate of the true level of job displacement in case studies or surveys dealing exclusively with companies having introduced advanced equipment, on the reasonable assumption that such "entrepreneurial innovators" will be among the more dynamic businesses. This leads to the conclusion that, in manufacturing industry as a whole, job losses attributable to advanced equipment will be mainly centred in companies which have not flexibly automated and who have witnessed their market share recede as their competitiveness has diminished.

To date, advanced equipment has been introduced piecemeal, with comparatively little effort made to achieve true computer integrated manufacture. But as increased integration of advanced equipment leads to greater productivity gains, it should also have an equal opposite effect on employment, with the rate of job displacements accelerating markedly as the integration process gathers pace and breadth.

In conclusion, if we consider the medium- and long-term future of manufacturing industry from a macroeconomic angle, the outlook would seem to point ot a very high level of job losses in the manufacturing sector. This is confirmed by an IPA survey conducted in March 1984 on assembly operations (one of the most labour-intensive industrial activities) in six leading sectors (1) of the German manufacturing industry. It concluded that automation could lead to the disappearance of up to 250,000 of the 650,000 assembly jobs covered by the survey - almost 40%.

Are we to deduce from this that advanced equipment poses a real threat to jobs ? The answer can only be a qualified "Perhaps" since all the foregoing analysis is very much dependent on "all other things being equal" and takes no account of:

- the creation of fresh jobs by the new technologies themselves. We must not overestimate the importance of this, however, since the production of high technology goods does not necessarily generate high levels of direct jobs (2). Nevertheless, it does offer a sound basis for future prosperity;

- the fact that a number of functions will be externalised as certain tasks - most commonly machine maintenance - cease to be firm-specific and are outsourced to sub-contractors, shifting the jobs in question to the service sector;

- <u>but most of all the second-order expansionary effects</u> that the input of productivity improvements in manufacturing industry will have on output, investment and hence the creation of jobs, not only in the manufacturing sector itself, but also in the broader economy.

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(1) Mechanical and electrical engineering, car manufacture, steel framed structures, precision, optical and ancillary instrument engineering, office machinery, information processing machinery.

(2) High technology industries have created only 6 million new jobs in the USA out of a total for all industries of 35 million since 1965.

For example, Professor Leontief's extremely detailed study on the overall impact of automation on employment in the USA by the year 2000 concludes that automation will not lead to a significant increase in the level of unemployment provided the necessary changes in skills, sectoral distribution and geographic pattern of jobs can be successfully managed.

A few statistics offer a convincing illustration of the breadth of the impending changes. The French Bureau d'Information et de Prévisions Economiques (BIPE - Information and Economic Forecasting Office) predicts that around one worker in four in French industry will be affected by the need for re-skilling brought by the influx of advanced equipment over the coming decade. This, concludes the BIPE, will call for two and a half times the present level of effort being put into continuing education. The West German federation of mechanical engineering - the VDMA - recently claimed that the present rapid advance of CAD/CAM technology will require around quarter of a million workers to be retrained - 100,000 in the machine building sector alone.

For widely differing reasons, both the USA and Japan are currently better placed than Europe to successfully manage the changes in work tasks heralded by the advent of advanced equipment.

The USA possesses the not inconsiderable advantage of a highly flexible and (particularly geographically) mobile labour force, while Japan's high-pressure, intensely industry-oriented educational system has given it a highly literate workforce with a greater aptitude for acquiring the generally higher level skills essential for tomorrow's industrial world.

2. New skills and functional flexibility

It must be stressed that not only the use, but also the production, of automated manufacturing equipment calls for a multi-disciplinary approach to the problems posed - particularly that of achieving the necessary fusion of mechanical and electronic engineering with data communications technology (what the Japanese call "mecatronics" - now a central plank of the country's social and industrial policies).

The shortage of technicians and engineers possessing the necessary kaleidoscope of skills for information-based manufacturing systems has already made itself felt in Europe and could well prove a bottleneck to the spread of advanced equipment - a possibility pointed up by recent surveys in the United Kingdom and West Germany.

A further aspect of the cross-trade working that the automation of industry will bring involves the erosion of the rigid demarcation between product engineers and production engineers. This will come about as the result of increasingly closer links between new product development and the design of new manufacturing processes - both under the pervasive influence of CAD techniques.

Both in Europe and the USA, production engineers have traditionally played secondary role to the more highly-regarded product engineers. This is not the case in Japan, where a process of industrialisation which is largely a melting pot of concepts imported from abroad has conferred equal status on product and production engineers alike. This gives Japan a clear edge at a time when industry must be focussing its efforts on its production processes and the process/production link.

3. The organisation of work

Refashioning the traditional views of the production process and product design will also involve a radical re-thinking of factory-floor functions, and hence the whole organisation of work.

In contrast to the now established forms of work organisation, hallmarked by assembly lines, job breakdowns and specialisation around repetitive operations, flexible automation actually throws the situation into reverse with:

- multi-disciplinary skills replacing fragmentation and specialisation

- broadly-defined group responsibilities substituting for narrowly defined individual-specific tasks (groups of workers assigned to a cluster of machines);

- as operative tasks are replaced by control duties, so the physical burden of work will give way to a more exacting intellectual content.

This radical upheaval in the organisation of work will be accompanied by demands for ever-increasing flexibility from the workers.
In most cases, complex automation systems must run virtually non-stop, and even where they can operate unattended (unsupervised by a human controller or "caretaker") for several hours at a stretch, new solutions will still have to be found, especially with regard to working hours.

M. Graham

MANUFACTURING AUTOMATION AND SOCIAL CHANGE - AN OVERVIEW (*).

Early conjectures about the so-called "factory of the future" believed that concern for social aspects was irrelevant to the field of manufacturing: all activities directly or indirectly related to this field would be carried out "automatically" - i.e. without any human intervention.

Public views on the "factory of the future" have since matured. One has ceased to visualize totally deserted factories and understood that factories in the future are more likely to be "minimally manned" or "restrictively manned" - as certain professional associations have stated.

Hence, our concern is not to present any technologically feasible end-state of technological change but to describe and debate experiences of the social effects of manufacturing automation.

Manufacturing automation is not, however, a turn-key system ready to be installed but a succession of applications of a number of advanced manufacturing technologies. Let us briefly introduce the most relevant of these technologies.

Manufacturing Automation Technologies.

In recent years there has been a very rapid spread of a number of advanced manufacturing technologies in workshops. The most spectacular of these new machines, machine systems, tools and aggregates are undoubtedly the computer numerically controlled machine tools (CNC) and the robots.

(*) Prepared by Anders J. HINGEL, Institute of Organization and Industrial Sociology, Copenhagen School of Economics and Social Science.
For an explanation of technical terms related to "manufacturing automation, see the section: "Manufacturing Automation Terminology".

The number of robots has increased by 49% in the U.K., by 37% in the Federal Republic of Germany and by 45% in France between end 1983 and end 1984. Robots were first introduced in the car industry - which now has almost 50% of all robots - but have increasingly been introduced in other industries, e.g., electrical engineering, mechanical engineering, metal-working industry, and the household appliances sector.

However, robots and advanced machine-tools are only the most conspicuous novelties in the workshops. Of equal importance to manufacturing automation are the developments concerning transport systems, storing systems, measuring equipment, setting-up tools as well as changes in product designs and materials. Nor are advanced technologies being introduced only in the workshop. In the design and construction departments, computer-aided systems are becoming more and more common. Computer-aided design systems, CAD, as well as computer-aided engineering systems, CAE, were first applied in the aeronautics industry, but are now being introduced in other sectors (mechanical and electrical engineering, electronics, shipbuilding, architecture, etc.). The number of applied CAD systems in the EEC is, however, relatively low and it is especially in the bigger companies that these systems have been introduced. In France for example, 60% of companies employing more than 80 designers have introduced CAD systems, whereas only 6% of companies employing less than six designers have installed such equipment.

The interconnection of the design, construction and process planning activities with those of manufacturing into a socalled computer-integrated manufacturing system, CIM, will logically be the ultimate technological step to be taken.
For the present, however, we can take note of the setting-up of flexible manufacturing systems, FMS. They are manufacturing systems involving a certain number of numerically controlled machine tools which are linked together by means of robots, automatic transport systems, communication networks, etc. - all controlled by a central computer.

The systems installed up till now under the heading of "FMS-systems" vary considerably as to number of machine tools connected, degree of production flexibility and integrative capacity.

According to the national reports there are by now about 80-90 flexible manufacturing systems in the EEC Member States.
The number of installations is expected to increase rapidly. In the case of the UK, 14 FMS systems have been set up, but 40 new projects are to be launched and have been approved for public financial support.

With this brief introduction to the relevant technologies as a background, let us turn to the main subject: the social effects of manufacturing automation.

EFFECTS OF MANUFACTURING AUTOMATION ON EMPLOYMENT.

In the field of employment effects, while a number of research results on specific cases are available, it is more difficult to arrive at an intrinsic understanding of the changes that are taking place.
However, the public debate on whether new technology has positive, negative or neutral effects on employment levels has to a large extent been characterized by preconceived opinions and has often been subject to ideologically and politically biased arbitration.

Before presenting an overview of the national experiences concerning the employment effects of manufacturing automation, it is necessary to outline the complexity of the field.

A Complex Issue.

Most of the earlier assessments of employment effects predicted very serious negative impacts resulting from the introduction of new technologies such as robots, numerically-controlled machine tools (NC and CNC machines), computer-aided design systems (CAD) and computer-aided manufacturing systems (CAM) etc. Nevertheless, most of these employment forecasts took into consideration only the direct effects of new technologies on the number of employees' tasks and from this point mechanically extrapolated the impact on employment levels. The substitution of manual "tasks" by mechnization or automation does not, however, imply the substitution of "jobs" - tasks can be, and are, re-organised between jobs - any more than the substitution of "jobs" implies dimissals of employees - employees can be, and often are, transferred to other jobs in the company.

Further more, the direct effects of manufacturing automation technologies on the number of tasks, which mostly are of a negative order - although certain new tasks emerge in maintenace, service and supervision - have definitely to be weighed against the fact that a number of indirect effects are induced.

Schematic Overview of Direct and Indirect Employment Effects of Manufacturing Automation

DIRECT EMPLOYMENT EFFECTS

In companies introducing manufacturing automation technologies.

Negative employment effects :	due to the automation of tasks previously carried out by blue- and white-collar workers, technicians, etc.
Positive employment effects :	because a number of new tasks are related to manufacturing automation technologies

INDIRECT EMPLOYMENT EFFECTS

In companies introducing manufacturing automation technologies.

Positive employment effects :	due to the expected increase in production and sales based on more competitive products (higher product quality, improved delivery services, lower prices of products because of lower production costs, etc.)

In companies producing manufacturing automation technologies, services and software.

Positive employment effects :	due to increased sales and production (it should not, however, be overlooked that these companies often are major users of new technologies)

In companies not introducing manufacturing automation technologies.

Negative employment effects :	due to the fall in product competitiveness and the expected fall in sales and production (relative fall in product quality and the relatively high prices and production costs)

As can be seen from the schematic overview above, a certain positive effect on employment is based on the fact that manufacturing automation can influence product quality and especially production costs in the user companies. Production and thereby employment levels may potentially grow in these companies.

The main positive effect on employment is, however, to be found in the companies producing manufacturing automation technologies: the robot producers, CAD/CAM producers, software houses, etc. These companies will anturally experience increasing production and employment because of the growth of their product markets.

The unknown factor when estimating the employment effects of manufacturing automation is mainly its effects on employment in companies which for one reason or another do not apply the newest and most efficient production techniques. These companies may experience a relative fall in product quality and relatively too high production costs, which could make their products less competitive on the market. Falling sales, production and employment levels could be the result. Yet one should not overlook the fact that "technology" is not the sole factor that determines the competive strength of a company's products. It may be the critical factor determining labour productivity in specific processes but technology management is the art of finding the optimum technology-mix and not a blindfolded introduction of state-of-the-art technology.

Apart from these direct and indirect effects on employment levels, one should be aware of the impact on economic acitivity in society in general of increasing levels of investment in manufacturing automation. Two sets of economic relationships are of relevance. First of all, increasing investments could stimulate economic activity in all sectors and not only the activity of technology producing companies, as discussed above - this is the so-called "technology multiplier effect".

Second, the "income and price effect" tells us that manufacturing automation could result in falling prices and increased real incomes, which would both stimulate the economy. These two sets of economic relationships are expected to cause higher levels of economic activity in society, and thereby, under certain conditions, create employment.

As mentioned above, most studies on the employment effects of manufacturing automation concentrate on only one or two aspects and cannot therefore pretend to present a total evaluation of any positive, negative or neutral employment effects of manufacturing automation. Let us present some of the national experiences in the field concerning "negative" and "positive" employment effects.

Some Negative Effects on Employment.

The effects on employment of introducing robots in production have been studied in numerous surveys. Most of these have mainly been concerned with the direct employment effects in the companies using robots.

A British study (1) found evidence of job displacement in two out of three companies where robots had been successfully introduced. The employment effects, however, vary strongly form case to case. Much depends on which production and work practices the robots replace. If the robots replace automatic machines and devices the employment effects will naturally be minimal. If they replace manual work, the employment effects will on the contrary be stronger depending on the previous levels of work efficiency.

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(1) FLECK, J. : "The employment effects of robots" in Proceedings of the 1st International Conference on Human Factors in Manufacturing, 3-5 April 1984, IFS Publications Ltd/North Holland.

In spite of differences in company experiences, it is nevertheless possible to draw some quantitative conclusions about the employment effect of the introduction of robots, i.e. the average ratio of displaced jobs per robot introduced.

The above-mentioned British study found that between zero and six workers were displaced by robots, but that the average ratio was about 2.6 workers when the use of shiftwork was included in the calculations (1.4 workers excl. shiftwork).
In Germany, it is estimated that between one and 2.5 workers are displaced by the introduction of one robot, whereas in Italy the average ratio is considered to be 2.25 (1)

If, on the basis of an average of the above-mentioned ratio - i.e. about 2.2 workers displaced per robot introduced - we were to calculate the total number of workers displaced in robot-user companies in the EEC Member States, we would find that the 20,500 robots introduced to end 1984 have displaced more than 45,000 workers.

These displacement ratios are expected to increase during the coming years. A German researcher (2) expects the ratio to increase up to eight workers displaced per robot, whereas an Italian study (1) predicts an increase in the ratio to three before the end of the 1990's.

The average number of workers displaced by robots has until now, been marked, to a large extent by the massive use of robots in the automobile industry (welding, coating, handling, etc.). The expected increase in the ratio of displaced workers will mostly be due to the fact that robots in the coming years will be extensively introduced in new and more labour intensive sectors such as

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(1) PROSPECTA Srl. : "Technologia e lavoro, La prospettiva robotica" in Quaderni di industria e sindacato n° 6, 1981.

(2) SCHNEIDER, R. : "Arbeitsbedingungen und Arbeitsplätze" in AFA-Information vol. 34, January/February, pp. 108-110, 1984.

Very little experience has as yet been gained of the employment effect of other manufacturing automation technologies. The most advanced systems like flexible manufacturing systems, FMS, are too recent to draw clear conclusions. However, according to reports, such systems have not yet presented evidence of any strong job displacement (Bessant/Haywood, 1985). The same is true of the employment effects of CAD/CAM systems. These systems have to date only had limited employment effects according to experiences in Denmark (1) and in Germany (2).

Some Positive Effects on Employment.

The positive employment effects derive mainly, as mentioned above, from the production of manufacturing automation equipement, from software and from services.

According to FLECK, 39% of jobs created in the UK through the application of robots in industry have been created in the robot-producing companies. A further 28% of new jobs are created in "sales, consultancy and installation" activities, and 15% in "research and education". By 1984, between 1,400 and 1,700 new jobs were created in these sectors in the UK, according to estimates.
In France, it is reported that the producers of robots have increased employment by 8% per year since 1980, i.e. about 1,200 new jobs between 1980 and 1984.

One should not overlook the fact that whereas the direct displacement of jobs in technology-using companies is a strictly domestic phenomenon, the creation of new jobs in technology-producing companies takes place on a cross-national level.

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(1) Teknisk Landsforbund : Anvendelse af CAD/CAM, Copenhagen, 1984.
(2) IG METALL : Einsatz und Auswirkungen neuer Technologien in Plannung und Konstruktion, CAD/CAM, Frankfurt, 1984.

The importance of this can easily be illustrated by referring to the national balance of trade in specific high-technology fields: e.g. 67% (1984) of the robots installed in the UK are imported; 50% in France and about 100% in Belgium, Denmark and Ireland. As to computer-aided design (CAD) systems, 64% of the systems are imported into the UK; 77% are imported in France and 89% in the Federal Republic of Germany.

As long as the major share of the high-technology market is held by procedures outside Western Europe, the largest job creation capacity of manufacturing automation will be activated elsewhere. About two-thirds of the European market in computer-aided design systems and terminals are, for example, held by American producers (Computervision, IBM, Applicon etc.).

Manufacturing Automation and the Net Employment Effect.

With the knowledge available, it is rather difficult to evaluate the net employment effect of manufacturing automation. We could refer here to other studies that have concluded for example "there is no evidence that technological change has contributed significantly to the current high levels of unemployment" (OECD, 1982) or to a study which found that in the UK, only 5% of the total decrease of employment in manufacturing industry during the period 1981-83 was due to the introduction of microelectronics in products and processes (1).

Nevertheless, although information technology in general and manufacturing automation in particular may have had only marginal aggregated employment effects until now, one has to be aware of the very important changes in employment levels that certainly take place at company and sectoral levels.

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(1) NORTHCOTT, Jim, PETRA Rogers : "Microelectronics in Birtish Industry: the Patterns of Change, PSI Publications, London, 1984.

EMPLOYMENT EFFECTS OF MANUFACTURING AUTOMATION						
Study	Country	Technology	Sector	Period	Employment effects	Remarks
Fleck (1984)	UK	Robots	Users	Up to 1984	2,000 jobs displaced	Estimate on the basis of 30 case studies
			Producers, Services etc.		Creation of 1,400 to 1,700 jobs	
Chenard/ Pino (1984)	F	Robots	Producers	1980-1983	General employment in the companies studied increased by 1,200 jobs (+ 31%)	Case studies of 50 companies
Régie Renault	F	Robots	Automobile sector	1985-1990	18 % of jobs will be displaced by robotics	Company forecast
Wolfsteiner (1983)	D	Robots	Users	In the future	Potentially displace about 400,000 jobs	
Prognos AG (n.a.)		Robots	All sectors	Up to 1990	170,000 - 500,000 jobs lost	
Enrietti (1984)	I	Manufacturing automation	Automobile sector (FIAT factories)	1970's	1,500 blue-collar workers displaced by automation	Case study
				1980-1984	1,400 blue-collar workers displaced by automation	
IPA (1983)	D	Manufacturing automation	Engineering	1982-1992	4,000 jobs lost (2.5%)	% of total employment in the sector
			Automobile		8,700 jobs lost (6.7%)	
			Electrotechn.		58,000 jobs lost (20.3%)	
			Instruments		2,900 jobs lost (10.4%)	
			Office mach. and computers		1,300 jobs lost (8.7%)	

Ref. : Fleck, J. (1984) "The employment effects of robots" Proceedings of the first International Conference on human factors in manufacturing, IFS Publications Ltd, North Holland; Chenard, A; Pino, A. "La situation de l'emploi dans le secteur robotique" Programme AMES-CREI, Paris; Wolfsteirner, M. "Einfluss der Robottechnik auf Beschäftigung und Tätigkeiten" in IAB-Mitteilingen 2/1983; Prognos AG "Technischer Fortschritt, Auswirkungen auf Wirtschaft und Arbeitsmarkt" Materialbank I; Enrietti, A; Ferri, P; Silva, F. "Impact of microelectronic "new technologies" on the automobile industry", 1984 (mimeo). IPA-Erhebungen GfAH, July 1983.

The above table shows among other estimates that more than 20% of jobs in the electrotechnical sector will be displaced by manufacturing automation between 1982 and 1992; that 18% of the jobs in the Renault car factories will be displaced by robots during the five remaining years of our decade; that robot producers in France have increased employment levels by 31% between 1980 and 1983.

The employment effects of manufacturing automation take different forms according to the automation strategy applied by the company. Until recently, automation in industry was almost exlusively directed towards single "islands" - i.e. limited parts - of the manufacturing process. This situation can be expected to change. Companies will increasingly be urged to adapt total company automation plans in order to fully exploit the rationalization potential of manufacturing automation. These developments will have a strong influence on employment effects in user companies, where displacement of tasks and jobs will be more likely to cause dismissals in producer companies, in software and consultancy companies, which are largely the promoters of such company automation strategies; and not least in companies not applying automation strategies that will be confronted with the full rationalization capacities of manufacturing automation and hence with fierce competition.

EFFECTS ON QUALIFICATIONS AND SKILLS.

Manufacturing automation is more a question of knowledge and competence than of hardware. Lack of available qualifications, in the companies or on the labour market,is in fact the ultimate factor limiting the implementation of advanced automated systems of manufacturing. It is therefore in the fields of qualification and skill demands and in education and vocational training that we will see the most important social change.

Two developments in the field of qualification and skill can be detected when manufacturing automation is implemented.
We can first of all observe a change in the relative importance of specific professional groups and work tasks.
Secondly we can observe the altering of the qualifications of professions and the emerging of totally new ones. The first type of change is short term and instantly observable in companies introducing manufacturing automation technologies. The latter is a medium- and long-term change and will be the critical and challenging condition for further automation in production.

We are provided with numerous accounts of the change concerning the relative importance of specific professional groups and work tasks. In general one expects that manufacturing automation will decrease the importance of professional groups like: stroemen, painters, welders, metal founders, semi-skilled workers and hands, skilled workers at machine tools and the technical production management. On the other hand, the relative importance of the following professional groups will be increased : skilled maintenance workers, highly qualified machine-tool operators, highly skilled workers for control and regulation of automated systems and for setting up tasks, control board supervisors and engineers. Within the professional group of engineers one expects an increasing demand for very highly qualified and specialised design engineers working with CAD systems, and a growing demand for more generally qualified engineers whose functions will mainly consist of designing variants or original products.

The changing relative importance of direct workers and maintenance workers in FIAT and Alfa Romeo		
	Before robots were introduced	After robots were introduced
FIAT		
direct workers	70 %	10 %
maintenance workers	17 %	70 %
others	13 %	20 %
ALFA ROMEO		
direct workers	-	a.30 %
maintenance workers	-	a.60 %
others	-	a.10 %

Source : Merli, R. (1984) "Il robotgate nella produzione della FIAT Uno" Modello Robot, Raffaello Merli (ed.) Ediesse, Rome.

The most significant change in the car industry occurs when the number of "direct workers" and "maintenance workers" is modified. The table above, which shows the changes in two Italian car factories after the introduction of robots, (the so-called robotgate system had been introduced), illustrates clearly the importance of the effects on skills and qualification demands.

These changes in the relative proportion of specific professional groups and work tasks will be followed by a much more sweeping change. As mentioned above, manufacturing automation will create demands for totally new qualifications and skills.

There will be considerable pressure to break down professional barriers and change traditional job profiles. Here, the maintenance craft worker will be the centre of attention. Automated systems are especially costly when standing idle ... and must therefore be repaired rapidly when they break down. In order to have the necessary skills and qualifications always available, demand will develop for a multiskilled workforce which combines a number of technical skills related to automated systems (mechanical, electrical, pneumatic fields, etc.).

A demand for new crafts is developing - but which new crafts ?
A British study of automated systems in industry suggests that five new craft occupations may emerge (Cross, M., 1984) :

- Craft Technicians : who are trained in a range of skills : electronics, hydraulics and diagnostics;
- System-Specialised Craftsmen : who are trained in understanding the integrated plant as a whole;
- Machine-Specialist Craftsmen : who can do all necessary tasks involved in a single piece of equipment;
- Dual Trade Craftsmen : who have acquired a skill in a second trade (a mechanical fitter trained in electrical work);
- Cross-Trades Craftsmen : who have learned additional skills within their original trade (an electrician learning electronics).

The move towards this type of new crafts and trades will demand greater flexibility in the labour market and will challenge industrial relations in all countries.

This manufacturing automation does not only call for sufficiently qualified computer scientists. Of much more importance is the generalization of computing knowledge in all trades relevant to the running of automated production systems. It will be in this latter field that major efforts will have to be made in training and education.

EFFECTS ON ORGANIZATION METHODS.

The prevailing level of qualifications and skills is, as discussed above, a decisive factor in the successful introduction of manufacturing automation. In this respect the ability to adapt the organisation of management and production to the specific demands of the new mode of manufacturing is of particular importance.
Yet managers are considered to be insufficiently aware of the importance of such a need.

The range of organizational choices is believed to be relatively broad in relation to advanced manufacturing technologies.
However, certain well-established modes of organisation counteract the optimum application and exploitation of the production potential of these new production systems. This is for example the case of the traditional compartmentalization in large organizations and the excessive fragmentation and specialization of tasks. Scientific management, "taylorism", is thus not believed to be a mode of organization suited to the demands of advanced manufacturing technologies.

The main question, however, remains to be answered : what are the distinctive characteristics of an adapted mode of organization ?
It is now generally accepted that no "one best way" exists and that there is no deterministic relationship between the type of technology and the mode of organization: as mentioned above, the range of organizational choices is believed to be wide. Nevertheless certain lessons can be drawn from the expected demand for new types of crafts.
The introduction of a highly qualified cross-craft workforce could indicate modes of work organisation with delegation of power and responsibility and the widespread use of teamwork.

EFFECTS ON HEALTH, SAFETY AND GENERAL WORKING CONDITIONS.

A fairly early study on work accidents caused by robots found an average of one accident per year for every 40 robots introduced in production (1). If the current incidence of accidents proves to be on similar levels, more than 500 accidents were caused by robots in 1984 in the EEC Member States.

Although accidents under certain circumstances do occur, one should not overlook the fact that manufacturing automation technologies - primarily robots - have been applied in industry in such a way that physically strenuous dangerous and hazardous tasks have been eliminated. In general, manufacturing automation is reported to have had positive effects on working conditions. However, much depends on the work organization.

A case study of workers working with robots concluded, for example, that working conditions deteriorated because of: - an intensification of work; - a reduction in job content; - a reduction of workers' freedom to decide where and when to take action; - an increasing commitment to work cycles; - a reduction in opportunities for personal contact; - growing monotony; - and increased demands on attention and perception due to extended control and supervisory work functions (2).

The most significant general change in working conditions produced by the introduction of manufacturing automation appears to be the increasing prevalence of mental strain. Work activities are largely characterized by monotony and social isolation - all factors known to cause stress.

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(1) CARLSON, J. et als. : Industrierobotar och Arbetsolycksfall, Kungl. Tekniska Högskolan, Stockholm, 1980.

(2) ILO : The Social-Economic Impact of New Technology, Geneva, 1985.

MANUFACTURING AUTOMATION AND INDUSTRIAL RELATIONS.

In order to draw a maximum of benefit from the application of manufacturing automation as regards competitiveness, employment, qualifications and working conditions, technological change has to be carried out on the basis of a genuine dialogue between the social partners. These are the principles that most European employers' and trade union organization have followed when setting up rules and developing practices in the field according to each national tradition and industrial relations system:

- in Denmark and Belgium the social partners have concluded national technology agreements which lay down framework-rules on information, consultation and co-determination rights;
- in Italy common practices have been spreading as a result of a few technology agreements in bigger companies which set the pattern for other firms;
- in the United Kingdom widespread fragmented bargaining has created practices; and numerous plant-level agreements on the introduction of new technology have been concluded;
- in the cases of France and the Federal Republic of Germany, statutory regulations have provided works councils with information rights and a say in the field.

Owing to the very different national industrial relations contexts it is impossible to present "common" experiences in the field. One should nevertheless stress the fact that these "first generation" dialogues between the social partners on the introduction of new technologies are developed with reference to the application methods and social effects of such technologies as: NC machines, CAD terminals and robots.

These are some indications that the introduction of more advanced manufacturing systems - FMS and CIM - will challenge the present industrial relations system heavily.

MANUFACTURING AUTOMATION - A FALSE DAWN ?

Are we in fact only experiencing a "false dawn" of manufacturing automation (Financial Times, 14 May 1985)?

It is a fact that a relatively large number of projects concerning the installation of advanced manufacturing systems (FMS, CIM, CAD/CAM etc.) have failed. Experiences show that the more advanced the technology, the higher the risks of failure. A director of a British company producing advanced manufacturing systems considers that the successful introduction of these technologies is being held up by a combination of a lack of management awaremess and competence, and technological oversell (ibid.).

Very advanced systems are however being successfully installed, and forecasts predict a strong growth in all technological fields of manufacturing automation. Future factories will thus have introduced these new technologies extensively, but it can nevertheless be expected that manufacturing will be carried out using a successful mix of more traditional and more advanced manufacturing technologies.

Anders J. HINGEL.

BELGIUM *

I. Technical and Economic Aspects of Automation

1. The extent of industrial automation

The principal results of an investigation of the application of CAD/CAM in Belgian companies are as follows (1) :

- Of the approximately 1,200 industrial companies and design offices surveyed, 115 answered positively, showing their interest for this technology (9.6 %).

- The answers come especially from the metalworking sector (iron and steel industry, mechanical and electromechanical industries) (41%), followed by the electronics and electrical industries (15%) and the engineering industry (13%).

- 56% of the companies and design offices replying to the survey already use a CAD/CAM system, 15% contemplate installing one very soon and 29% are studying the various possibilities of automating their production.

- Among the companies already equipped with automatic manufacturing systems, 30% use a CAD system, 36% a CAM system and 34% an integrated CAD/CAM system.

The number of industrial robot installations is increasing rapidly in Belgium, with 9 new installations in 1979, 28 in 1980 , then 184, 119 and 153 in 1981, 1982, 1983 respectively.

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* Summary of a report by Mr P.M. BOULANGER - ADRASS - Ottignies, Belgium.

(1) KOVATCHEV, Y., LECOQ, H., PINTELON, L. : "Guide de la CAO-FAO", ECOPRESS BICREA, 1984, p.375.

The total number of robots installed amounted to 514 robots in 1983 and estimates for 1984 are close to 700. These figures put Belgium in 4th position in the world with regard to the rate of robotization (number of robots compared with industrial employment).
It should be noted that the great majority of industrial robots are concentrated in the car industry: 58% (1983) (1). However, recent developments testify to an increasing penetration of robotization in other industrial sectors.

Only half a dozen companies in the Flemish region, and the Belgian CATERPILLAR subsidiary in the Walloon region, have adopted flexible cells. In general, even where they do exist, flexible cells are limited to "simple workshops consisting of a limited number of machines, generally of two types, manufacturing a limited number of parts" (2).

2. Production

The main suppliers of CAD/CAM "turn-key" systems are APPLICON, CALMA COMPANY, COMPUTERVISION Corp. and INTERGRAPH Corp. They are all American-owned.

There are a large number (18) of computer manufacturers present on the CAD/CAM market, including Control Data, Data General, Digital Equipment, Harris, Hewlett-Packard, IBM, ICL, Olivetti, Prime, Siemens and Tektronix. Here again, there are no Belgian companies in the list, even though Siemens has a few production and research units in Belgium.
On the other hand, three Belgian software companies are present on this market.

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(1) "Pourquoi et comment robotiser", in ATHENA N° 5, November 1984, p.13.

(2) COENJAERTS, T.: "Vers l'usine de demain" in INDUSTRIE N° 1, March 1984, pp.42-59.

As regards robotization, the situation is more confused. A certain number of Belgian robot manufacturers do exist, but they seem to be running into substantial difficulties in finding markets for their products.

According to Mr Van der Horst, a specialist in robotization at FABRIMETAL (Federation of Metalworking Industries):
"We are ten to fifteen years behind traditional manufacturers who are considerably more powerful than we are. Furthermore, the market is flooded. I believe in the future of robot production in Belgium, but only in specialized sectors and for applications which are too specific to attract the large companies" (1). The future for Belgian researchers and manufacturers probably lies in perirobotics , i.e. in the development and the construction of peripherals: sensor devices, for example, and gripping and handling units.

3. Foreign trade

There are currently no customs or tax statistics available to allow us to evaluate the coverage rate in this sector. The information on producers which we have just been using leads us to suppose that we depend almost 100 % on foreign countries for the supply of CAD/CAM, robotization of FMS equipment.

(1) COENJAERTS, T. (1984) op.cit.

II. The Social Impact

1. Impact on employment

In 1982, the Fondation Travail-Université (Work-Univeristy Foundation) published a dossier entitled "Face aux nouvelles technologies" ("Towards new technologies"), in which various authors prestented their prognoses for the future (1). According to these authors, the introduction of CAD/CAM will affect 2,800 draughtsmen in the following branches: electronics, automobile, aeronautics, shipbuilding, engineering, architecture and design offices.

In the short run, if productivity increases lead to a reduction in current working hours of between 25 and 80 %, the authors estimate that we can expect job cuts of about 1.5 to 3 %, i.e. 420 to 560 lost jobs. N.C.M.Ts. (numerically controlled machine tools) will affect 35,000 jobs in the aeronautics, mechanical engineering, electrical engineering and electronics sectors. These permit labour savings of 50% and in the short-term we can expect the loss of 800 jobs (2.3%) (2).

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(1) VALENDUC, G., LAFFINEUR, J.: "Face aux nouvelles technologies", Dossier N° 7 of the Fondation Travail-Université, pp.79-81, Brussels 1982.

(2) The forecasts are made by applying, to Belgian data, calculations of productivity increases for 8 major categories of technical innovation in France by PASTRE, O., MEYER, D. and TRUEL, L. in "Informatisation et Emploi", La documentation française, 1981. These figures refer exclusively to the short-term effects, i.e. up to 1985 (the study was published in 1982).

The introduction of robots, programmable automatons and minicomputers for use in mass production can be expected to affect unskilled workers in the motor car, general mechanics, electronic components, foundry, woodworking, furnishing and plastics industries, in other words approximately 120,000 persons. Productivity increases can be expected to range from 30 to 50% for robots and from 20 to 30% for programmable automatons, involving the loss of 10,000 posts. Lastly, process automation will affect 140,000 unskilled workers in almost all industrial branches using continuous processes. Here, we already have figures: in chemistry and oil, productivity rose between 1965 and 1974 and will rise at a considerably more rapid pace in the future. We can expect the loss of about 10,000 jobs.
All in all, industrial automation could involve in the short run something like 22,000 job losses. In addition, simulations carried out by the State Planning Office (Bureau du Plan) using the SERENA econometric model lead to more pessimistic forecasts. An assumed increase in productivity of 4% a year in industry would cause a further annual reduction of 13,000 to 17,000 jobs compared with the reference simulations.

It should be noted that this study was run twice, after the first results were judged too extreme because they forecasted a productivity increase of 8% per year, following the introduction of micro-electronics. This assumption was replaced by that of a less severe technological shock distributed over 10 years. Nevertheless, even in this case, the conclusions of Bureau du Plan are not very optimistic: "On the whole, the application of micro-electronics gives rise to a high level of job losses, implying a worsening of public sector deficit. The effect on the rate of growth of the ecomony is minimal" (1).

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(1) VANDENBROECKE, F.: "Une brusque accélération du rythme de l'évolution technolgoique, quelques simulations", Conseil National de la Politique scientifique. Interdisciplinary working party on micro-electronics 16.03.82, 14 p.-13.

However, it is in industry that the negative effects should be felt the least, since the productivity increase will improve the competitiveness of Belgian industry on foreign markets and at the same time its trade balance. However, "the very weak improvement of the industrial balance of trade emerging from this simuation should keep us from being too optimistic on this point. Indeed, taking into account the relative weakness of the Belgian capital goods sector, the application of micro-electronics could prove import-intensive" (1).

2. Impact on work organization

It is unanimously recognized that the introduction of CAD/CAM or of flexible manufacturing systems and, to a somewhat lesser extent, robotization, implies profound, widespread changes in companies' work organization. This is indeed one of the reasons why employers hesitate to become involved in such a radically innavative process. To quote one commentator, CAD/CAM solutions assume a total reorganization of a company, start-up periods are very long and the related costs prohibitive (2).

The personnel director at Ford-Genk showed - at the T-Day conference on the problems ofn new technologies - how the introduction of automation blew apart existing communications structures.

Previously, worker interaction was limited to the immediate work environment; with the advent of automation workers enter into contact with a larger number of individuals and especially members of the hierarchy with whom they have had no previous contact.

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(1) Ibid.

(2) "Evolution CAD/CAM en Belgique", Paninformatic N° 57, Oct. 1984, p.23.

But, more than anything else, automation has made possible an entirely new type of organizational structure characterized by the setting up of semi-autonomous workgroups which develop an authentic team spirit, and in which the presence of a leader is not experienced as the imposition of hierarchical structures (1). The trade unions, referring to research carried out abroad, or to simple assumptions, expect that the application of new computer-based technologies to industrial production will encourage the development of part-time working and recourse to subcontracting, as well as the development of different kinds of short-term constracts.
A frequently expressed fear is that the machine will impose its rhythm on the worker as well as contributing to strenthening the centralized control of productivity.

3. Education and vocational training

The lack of training - whether amongst engineers, workers or at top management level - is often invoked to explain the weak presence of the new information technologies within industry. Several initiatives have been taken to obviate this effect. At the level of workers and intermediate technicians, the Dutch-speaking department of the National Office of Employment (ONEM) has implemented a training and recycling programme in robotization and CAD/CAM which has been a great success. The French-speaking section of ONEM contemplates setting up a similar programme in the near future.

At the higher level the Flemish region has set up post-graduate training, within an inter-university framework, aimed at engineers. Several French-speaking universities also offer part-time courses in robotization and CAD/CAM.

(1) "Samenleving en technologie", E.R.V. berichten 41 - December 1983.

In the same way, the Free University of Brussels has organized a new "robotics" orientation course within its specialist automation progamme. Teaching is spread out over 2 years and includes 270 course hours, 30 hours of seminars, 315 hours of practical work and 120 hours of projects. This cycle is offered to civil and industrial engineers already working in companies.

In the same spirit the Institut Supérieur de Commerce St-Louis held for the first time in 1985 a specialist course in "Robotics management" as part of its "Management of technological innovation" programme.
These courses are aimed equally at engineers, company managers, R&D managers etc. We would point out that all these initiatives are extremely recent.

III. Government Programmes to Promote Automated Production

1. Promotion of R & D

Belgian government action in the R&D sector is exerted through various channels : financing of universities
special research programmes
joint university-industry programmes

Although the Minister for Scientific Policy has just initiated a "correction plan" to increase the share of GNP devoted to scientific research, this will primarily benefit the universities and will not specifically focus on research in the field of manufacturing automation.

With regard to special research programmes managed by the Programming Department of the Ministry of Scientific Policy, we should mention the "Action plan for microelectronics technology".

It should be noted that manufacturing automation does not figure particularly highly as the total budget for robotics is only BF 100 million, out of a total budget of BF 2,665 million. Robotics represents thus 3.75% of the amount committed.
In this context, it should be pointed out that the programme strictly speaking only deals with robotization, leaving out other industrial automation technologies. CAD/CAM is developed only within the framework of R&D for application in the design and production of integrated circuits (1).

It was the fact that a certain gap was noted at the level of development of CAD/CAM as well as CIM and FMS which led the Higher Council for Scientific Policy (Conseil Supérieur de la Politique Scientifique) to state that there is an urgent need for R & D investment in the following areas (2):

"- flexible and integrated forms of automation and robotization of industrial processes, including:
- numerical control of all kinds of machines;
- robots for use in assembly and finishing operations;
- integrated design, production and management information systems (CAD/CAM and CIM) with corresponding research on their social effects;
- intelligent systems (adaptive systems, intelligent systems and expert systems);
- development of sensors and microprocessors;
- automated continuous processing control systems, quality control systems and test systems".

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(1) Ministre du Budget, de la Politique scientifique et du Plan: Programme d'action dans les technologies basées sur la micro-électronique" 30 October 1982.

(2) Conseil National de la Politique Scientifique: "Politique de recherche en micro-électronique et ses conséquences sociales" Brussels 1983, p.95.

IV. Social Groups

1. Employers' policies

In general, the employers' associations (Fédération des Entreprises de Belgique, Union Wallonne des entreprises, FABRIMETAL, Vlaams Economisch Verbond) act as technical and financial advisors to theirs members in the area of production automation.

In the Flemish region, the employers' organizations have financed the foundation of an association called FLORA (Flemish Organisation for Robotics and Automation) responsible for the promotion and development of automated production technologies and for the integration of the various activities of companies in the Flemish area which are able to contribute to the development of the Flemish robotization and industrial automation industry.

2. Trade union policies

The trade unions do not have any policies specifically adapted to the area of automated production, but rather a generalized series of claims in the area of advanced manufacturing technology, covering both robotics and office automation.

The main aim of the trade-union organizations remains the utilization of the productivity gains generated by the new technologies in view of the reduction of working hours, and the obtention of technology agreements in the various companies concerned prior to the introduction of the advanced technology.
So far this trade-union strategy seems to have borne fruit, at least in companies which have already introduced robotization, since, in the motor industry in particular, robotization has not led to any dismissals and has even, as at Volvo in Ghent, led to the creation of a certain number of jobs.

On the other hand, the demand for negotiations prior to any investment decision has not been met. Negotiations have remained limited to a posteriori negotiations on the social effects of the technological investment which has already been decided on.

3. Collective agreements

The introduction of automated production requires the application of collective agreement N° 39 on information and consultation on the social effects of the introduction of new technologies. This agreement applies to all companies in the private sector employing an average of at least 50 workers.

The information and consultation procedure (Article 2(1)) involves two successive phases; initial information on the nature of the new technology, the economic, technical and financial factors behind its introduction and the nature of its foreseeable effects on employment, organization and working conditions (changes of job functions or dismissals are two examples of types of social consequences on which information has to be given).

The second phase of consultation with the workers' representatives covers only the social effects and not the decision to introduce the technology. This procedure is mandatory: "when the employer has decided on an investment in a new technology and when this decision has important collective consequences with regard to employment, work organization or working conditions" (Article 2(1)).

The clause covering these important consequences stipulates that at least half the workers of a particular professional category have to be affected by the introduction of the new technolgy.

DENMARK*

I. Technical and economic aspects of manufacturing automation

1. The spread of manufacturing automation

The first Danish flexible manufacturing system was set up in September 1984 at the Technical Institute outside Copenhagen. It is a demonstration system aimed at aiding private companies in their development projects in the field (1).

In fact this new FMS system is one of three systems which it is planned to introduce over a number of months. Before the end of 1986 two private companies are expected to introduce FMS systems in Denmark. This concerns the companies DANFOS and GRUNDFOS.

However, if one applies a less restricted definition of flexible production systems and therefore includes not only flexible production "systems" but also flexible production "units" and "cells" - i.e. smaller "islands" of production flexibility - it is estimated that there are at present five flexible production units and about 15 flexible production cells. The five most advanced production systems can operate unmanned for 3-5 hours (2).

One of the technological steps towards a flexible system of manufacturing is the interconnection of computer aided design, CAD, and computer aided manufacturing, CAM, the so-called CAD/CAM systems. Computer aided manufacturing is widely spread in Danish industries. Numerically controlled machine tools and robots have experienced a rapid growth. There are about 80-90 robots in Denmark in 1985. As to CAD systems, one can observe a

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*Summary of a report prepared by Dr. ANDERS J. HINGEL, Institute of organization and industrial sociology, Copenhagen Schools of economics and social science, Copenhagen.

(1) Ingeniøren N° 39, 28 September 1984, p. 7.

(2) Christian Clausen "Informationsteknologiske muligheder og problemer indenfor det mellemtekniske arbejdsområde" in Teknisk Landsforbund "Udredningsprojekt: Informationsteknologiske muligheder og problemer indenfor det mellemtekniske fagområde. Copenhagen, November 1984, Annex 4, p. 6.

similar rapid introduction in industry. However, the interconnection of the CAD and CAM systems demands software and availability of skills and competence which are difficult to obtain in specific cases. CAD/CAM systems are therefore expected to spread relatively more slowly than was forecast a few years ago and than could be expected on the basis of the technologies presently available in Danish workshops and offices.

As to the precise number of CAD/CAM systems set up in Denmark, contradictory information can be found in the professional press and among experts. One source counted 32 CAD/CAM systems introduced by March 1983. But more recent estimates find that 15 CAD/CAM systems will have been introduced in Denmark by 1985 (1). All depends on how restrictive the definition is that one applies.

The mechanical engineering industries have been most active in the field, according to an expert consultant (2).

The shipyards were among the first to introduce CAD/CAM in Denmark. AALBORG VÆRFT had already set up CAD/CAM systems in 1976. However, the possibilities of these new technologies can also be seen in other industrial branches.

In the clothing industry, it is estimated that about 70 companies have "access" to CAD/CAM facilities (3).

In the electronics industry some of the bigger companies have been pioneers in the field of CAD/CAM application. Companies like GNT, B&O and STORNO have thus introduced CAD/CAM with their numerical control assembly systems.

In the building trades CAD/CAM systems are also about to be introduced.

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(1) Teknisk Landsforbund "Anvendelse af CAD/CAM", Copenhagen, 1984; Børsen Data, N° 1, 1985.
(2) Børsen Data, N° 1, 1985.
(3) Berglinske Weekend, 1-7 March, 1985.

In the state and municipal sectors, it is expected that CAD/CAM systems will be applied to a number of activities related to town-planning, projecting, etc. (1).

These figures show that only a very limited number of these key technologies (CAD, CAM, FMS) have been introduced in Denmark. The systems set up to date are still mainly at the pilot stage of application.

2. Estimated future diffusion

If the counting of the number of present systems of CAD/CAM in Danish industry and services has proved to be fairly imprecise, then the estimates of the future diffusion of these technological systems are almost only of a speculative nature.

On the basis of international comparisons, a Danish professional association believes that genuine flexible manufacturing systems and total integrated CAD/CAM systems will not be widely applied in the Danish industry. It is expected that the widest application will be mainly "partly integrated CAD/CAM systems" and "partial solutions in the field of FMS" (2).

3. Industry and domestic production

It is extremely difficult to present an overview of domestic production and industry in the fields of CAD/CAM, FMS and CIM. No statistics have been found on the national production of these technologies.
Companies developing advanced manufacturing systems are few in number and generally small.

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(1) Teknisk Landsforbund, (1984) op.cit.

(2) Teknisk Landsforbund "Udredningsprojekt: Informationsteknologiske muligheder og problemer indenfor det mellemtekniske fagområde, Copenhagen, 1984.

4. Trade and trade balance

Most of the major American producers of CAD/CAM systems are present on the Danish market: COMPUTERVISION, INTERGRAPH, CDS, IBM, DIGITAL, PRIME and HEWLETT-PACKARD. These companies market larger systems (DK 1.5-5 mill.). Smaller systems are sold by APOLLO, ICL, NAE and OLIVETTI. About 40 agencies for CAD/CAM systems are estimated to be presently working on the Danish market (1).

II. SOCIAL IMPACTS

1. Impact on employment

The general consequences of CAD/CAM for employment levels have not been subject to any surveys up till now in Denmark. The expectations are extremely vaguely formulated. For example:"We can to a certain extent hope that the introduction of CAD/CAM will not directly lead to any dismissals" (2).

Some information is available on short-term, direct effects on employment in companies that have introduced these technologies.

In the case of the GRUNDFOS plant in Bjerringbro (2,500 employees) which produces pumps, and which has introduced a CAM/CAM system with five graphic terminals, the management claims that the effect of the technological change is: efficiency, increasing production levels and no decrease in employment levels. According to both trade union and management statements, cuts in employment levels have not been discussed at any stage of the negotiations on the introduction of the CAD/CAM system. In fact, some recruitment has taken place. It was agreed by the social partners in the company that, owing to the relatively large investment (DK 7 mill.), the CAD/CAM system should be operated in two shifts. However, it turned out to be difficult to find volunteers for the second shift, so new personnel was recruited.

(1) BørsenData No 1, January 1985.

(2) Teknisk Landsforbund "Anvendelse af CAD/CAM", Copenhagen, 1984.

Grundfos expects that the present levels of employment will be maintained in the coming years although certain work functions, like assembly work, will be automated. The number of tool-makers will for example be constant up to 1990 (about 150) (1).

2. Impact on skills and qualifications

The introduction of CAD/CAM and more advanced automated systems is expected to result in more abstract, standardized and uniform machine operating tasks. This development will certainly imply changes: for example, the tasks of a constructor will change from working with drawings and models to working with symbols. Such a development has in fact already taken place in certain industries due to the specificity the products: it is the case of the major part of the electronics industry. In other industries the change will take place in direct relationship to the introduction of CAD/CAM systems - for example in the public sector, in the building trade and in the engineering industry.

The skills required for specific CAD/CAM systems will mainly depend on the organization of work in each company. The immediate consequences for skill structures in companies introducing advanced technological systems will therefore depend on the social context and the acceptance of individuals. The experience from the introduction of numerically controlled machine tools can illustrate the problem. The craft workers often considered that unskilled workers would take over their worktask when NC-machines were introduced and that it would be necessary to defend their traditional worktasks. However, skilled workers often refused to stand by NC-machines as operators. One expects a similar development in relation to the introduction of CAD/CAM (2).

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(1) Måneds Børsen, October 1983: Jydsk Teknologisk Institut, Teknologisk Institut "UPS - Produktionssystem: Virksomhedscases", Copenhagen, 1984.

(2) Dorde Kohler, Kurt Mathisen "Der er mange misteltene i CAD/CAM", in Måneds Børsen, October 1983, p. 60-61.

The general medium and long-term development of competence and qualifications in relationship to manufacturing automation is clearly not unequivocal. Some specialized work-functions carried out by technicians will be automated and some demands for highly skilled engineers or craftsmen will disappear. One can already observe a falling demand for draughtsmen. On the other hand new worktasks like programming, system maintenance, etc., will emerge (1).

3. Impact on work organization

The experiences of the above-mentioned Grundfos case offers some hints of the organizational problems involved in the introduction of CAD/CAM systems. The system was initially decentralized, the therminals being distributed to each division to enable staff to be trained in their use. The decentralized organization of CAD/CAM system proved to have some undesirable effects in the introductory phase. The operators were isolated from one another and had to solve operating problems alone. Further, the possibility of contacting other operators and users of the system depended on the individual decision of each head of department. In addition, the need to standardize the designing activities, which is a necessary basis for exploiting the technological possibilities of the CAD/CAM system, was not satisfied because of the lack of control over individual constructor activities. On the basis of these experiences the CAD/CAM system in Grundfos was reorganized and centralized. All terminals related to designing tools and machines were gathered in one room.

These experiences in the introductory phase of a CAD/CAM system can obviously not be generalized. Further, they do not give any guidelines for the type of work organizations in later stages of introduction.

If the above-mentioned "partly integrated CAD/CAM systems" and "partial solutions in the field of FMW" are adopted as future technological

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(1) Teknisk Landsforbund "Udredningsprojekt: Informationsteknologiske muligheder of problemer indenfor det mellemtekniske fagområde", Copenhagen, 1984.

solutions to the Danish industrial structure, different levels of technology will coexist within a single workshop and/or plant. This situation will create specific organizational problems of production, personnel, power relationships, etc.- all problems to which insufficient attention has been paid until now.

4. Impact on working conditions, health and safety

Manufacturing automation for an increasing number of employees means working with visual display screens, VDUs. All the work environment problems related to this type of work situation are therefore relevant. Let us not repeat here the results of the numerous surveys published in SOCIAL EUROPE (1), but only briefly mention that the majority of VDU-operators experience some kind of health problems: i.e. strained muscles, visual discomfort, stress, etc. Research on the issue of health hazards and VDUs is, however, not conclusive.

The problems of working conditions change qualitatively according to the stage at which, for example, a CAD/CAM system is being introduced. According to professional observers, there are three steps (2):

1. The introductory phase of a CAD/CAM system	characterized by practical problems with the system
2. The early phases of production	characterized by ergonomic problems of working conditions
3. Normal production by CAD/CAM	characterized by psycho-social work environment problems

With high levels of automation, individual isolation and non-activity become major elements of strain. According to the production director of Grunfos in Bjerringbro such passive worktasks "destroy both the soul and the body of the workers" (3).

(1) See Supplement on New Technologies and Social Change: Office Automation. *
(2) Arbejdsmiljø og Samfund No 3, 1984, p. 12-15.
(3) Dorde Køhler, Kurt Mathisen "Grundfos lægger kortene på bordet", Måneds Børsen, October 1983, p. 64-66.
* Office for Official Publications of the European Communities, L-2985 Luxembourg.

Only a reorganization of the worktasks in the company can solve the problem.

5. Education and vocational training

A Committee has been set up by the Minister of Education in order to evaluate the "present needs in technical schools for training in the technical use of computers". The Commission concluded in a preliminary report that:

> "There exists an urgent need for revising the content of the education (of technicians), so that the educational system and the related vocational training courses are up to date as regards the development of computer technology". (1)

It has recommended that teaching in the following subjects should be integrated in the courses of technical schools: computer-aided design, computer-aided manufacturing, datacommunication, computer-based control and regulation, administrative control systems, fault finding and maintenance.

The Committee further recommends that training in foreign languages should be reinforced. English in particular is considered to be a necessary language to master. The subject of general mathematics is also put forward as a subject to be modified so that it satisfies the requirements of new technology.

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(1) Undervisningsministeriet "Relstedudvalgets rapport om behovet for undervisning i teknisk anvendelse af edb i de eksisterende teknikeruddannelser", Betænkning No 1011, Copenhagen, 1984.

III. GOVERNMENT POLICY IN THE FIELD OF MANUFACTURING AUTOMATION

1. Promotion of Research and Development

The Technological Development Programme which was launched in January 1985 and will run over four years is aimed at promoting information technology in the main industrial sectors in Denmark. The budget of the programme amounts to DK 1,525 bn.

Since the proposal for launching the programme was put forward (December 1983), a number of working groups have published so-called catalogues of suggestions on promotional activities in a number of industrial sectors as well as in the public sector. The final report points out a number of specific fields which should be promoted. The following are relevant to our subject in the present paper: sensors, control and steering systems, small-scale technology and manufacturing automation (1).

IV. SOCIAL GROUPS

1. Policies of Employers' Organizations

Denmark has a long tradition of cooperation between employers' organizations and trade unions. In the iron and steel industry in particular, the two sides have carried out a number of projects on the future prospects of the industry. The first "future research project" was carried out in 1978.

A new cooperation project involving the Employers' Organization in the iron and steel industry, JA, and the Central Organization of Metal Workers, CO-Metal, in cooperation with the Technical University in Denmark, DtH, has recently been launched. Its aim and its designation is Development of Production Systems - Udvikling af ProduktionsSystemer, UPS. The project should result in the development of new principles for production layout and control.

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(1) Teknologistyrelsen "Oversigtsnotat vedr. Forprojekt til det Teknologiske Udviklingsprogram", Copenhagen, 1984.

Its basic production philosophy goes against the traditional efforts of optimizing the efficiency of single processes: instead the production should be considered, evaluated and developed as one total process. Another result of the project will be the definition of an "ideal plant" which could be modified in relation to the technological and economic resources available (1).

The Employers Organization in the metal industry, JA, has launched an awareness campaign among its members on the basis of the first result of the UPS-project. This is the so-called "Yes to production" campaign (JA til produktion), which involves development projects in about 60 companies.

The Danish Employers' Organization, DA has taken up the ideas of the UPS-campaign and launched a number of conferences and courses under the headline "Renewal from within" (Fornyelse indefra).

2. Trade union policies

Trade unions' and employees' influence on the introduction of new technologies is regulated by collective agreements between the two sides of industry. This is the case both in the private and public sector.

The major agreements in the field are the Cooperation Agreement of 1977 and its additional agreement: - the "Technology Agreement" -, which was concluded in 1981. The Technology Agreement obliges the employer to inform the co-operation committee - or a special sub-committee on new technology - of the introduction of new technology before its implementation. This information should include the employers' evaluation of possible consequences of the change. The agreement further gives the cooperation committee a consultation right as to the development of principles for vocational training activities. The agreement does not give any employment guarantee to the wage earner but only stipulates the companies' obligation to search for replacement jobs within the company for the employees displaced by new technology.

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(1) Erik Ohrt "Fra Jernets fremtidsprojekt til produktionssystemer", CO-Metal - Information for tillidsmænd, September 1984.

Both the employers' organization and the trade unions consider technological change as "important subjects of cooperation". It should, however, be noticed that the Technology Agreement has been strongly critized by the trade unions and that the agreement was denounced in January 1985 and will be renegotiated.

THE FEDERAL REPUBLIC OF GERMANY*

I. Technical and Economic Aspects of Automation

1. The spread of automation

Whilst NC and CNC machines have already been in fairly widespread use for some time in the Federal Republic, the process of integrating so-called "production cells" into flexible manufacturing systems is moving ahead extremely slowly. Depending on the definition used, the number of flexible manufacturing systems currently operating in the Federal Republic is estimated at between 30 and 50, which is notably lower than in either the US or Japan.

The slow rate of propagation of flexible production systems in the Federal Republic is in particular due to the fact that German firms initially concentrated on automating small batch production (1). The demands made on such flexible manufacturing systems are very high and highly complex; development costs and risks are considerable and in any case defintely higher than for the kinds of systems generally installed in the US and Japan. This leads us to suspect that German experience of such machines has been more negative than that in other countries, which in turn has dampened the eagerness of companies to introduce such systems.

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* Summary of a report by Prof. Dr. Jürgen Reese, Institute for Economic Sciences (Institut für Wirtschaftswissenschaften), University of Kassel, FRG.

(1) "Der Einsatz flexibler Fertigungssysteme, Technische, einführungs-organisatorische, wirtschaftliche und arbeitsplatzbezogene Aspekte". Study paper published by the Fraunhofer-Institut für Systemtechnik und Innovationsforschung, Karlsruhe, the für Arbeitsmarkt- und berufsforschung, Nurenberg, and the Institut für Werkzeug-maschinen und Fertigungstechnik, Technische Universität Berlin,1982.

The market in the Federal Republic for interlinked numerically controlled machine tools is estimated at 14,000 units for prismatic and 10,000 for rotating-symmetrical workpieces. However, because of the above-mentioned difficulties, it is estimated that only 1,000 to 2,000 systems will be installed by 1990. As these systems require a considerably higher level of integration with the particular company's product range and production conditions than, for example, single cell solutions and robots, we can expect most of them to be developed initially by firms from within the Federal Republic.

The largest proportion of the 7,000 or so robots currently installed in the Federal Republic is to be found in the automobile industry. Their use in the mechanical engineering and electrical technology industries is also increasing relatively rapidly (1). Even if estimates of the spread of robot technology differ widely, it is realistic to expect their number to have reached 30,000 by 1990 (2). According to estimates made by the US Department of Commerce, the share of the world robot market held by German robot producers has grown from 6% in 1980 to 10.4% in 1985. We do not expect this share to change significantly between now and 1990.

At the present time, CAD systems are more or less as widespread as robots, although the growth rates for CAD, both as a result of technical developments as well as their considerably greater market potential, are well above those of robots (estimated at 40 to 50% a year for CAD systems). This strong growth in the market is attracting a substantial number of foreign producers to the Federal Republic.

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(1) STEINMÜLLER, P. : Industrieroboter - Einsatzmöglichkeiten und Voraussetzungen, in : Fortschrittliche Betriebsführung Und Industrial Engineering, 1982, N°2, p.60 ff.

(2) SCHNEIDER, R. : Roboter, Arbeitsbedingungen und Arbeitsplätze, in : AFA-Informationen, Vol. 34 (January/February 1984) pp.3-22.

2. Industry, Domestic Production, Trade and Trade Balance

The CAD/CAM market develops so fast that reliable data on the latest situation are not available. The "Industrie-Anzeiger" listed nearly 130 new firms offering CAD/CAM systems in West-Germany in 1983 (1). There are certainly several hundred producers today. Several major producers are branches of US companies like IBM and Computervision. The top five serve nearly two thirds of the market.

Compared with the CAD/CAM market, the number of robot producers is much smaller. The Volkswagen company as one of the largest users manufactures the robots itself, and so do some of the other major users of more specialized systems. On the other hand, there is a growing number of firms which are specialized in highly standardized robots. Table 1 shows an estimate of the German share in world robot production.

Table 1

Robot Production: Market Shares (%)

	1980	1985	1990
USA	13.6	12.9	21.5
Japan	51.5	62.3	45.6
FRG	6.0	10.4	9.7
France	2.7	1.5	1.6
UK	2.7	5.8	14.6

Source: U.S. Department of Commerce
The Robotics Industry, Washington D.C.
1983, p. 20,21

Flexible production systems, unless designed for mass production in large and medium-sized firms should be specially tailored for each user.

1) Industrie-Anzeiger, 106. Jg. (1984), N°. 71, 5.9.1984, p.89.

All of the 30 to 50 installed systems have been developed for special purposes; a team drawn from different producers in the electronics sector, software firms and representatives of future users was set up to pursue these ofbjectives. It seems clear that foreign companies will have problems in this field. Conversely, German producers have little chance of getting into foreign markets.

II. The Social Effects of Automation

1. Effects on unemployment

With the current high rate of unemployment (more than 2.5 million), the main talking point whenever industrial automation is discussed is its effect on employment. In numerous publications, productivity increases obtained by various industrial automation technologies are converted into personnel reduction figures. For example, one CAD system is said to cut two jobs and one robot to cut between 1 and 2.5 jobs.
Prognos AG estimates that computers will give rise to job losses between 170,000 and 500,000 (1).

These productivity increases are in part counterbalanced by the creation of new jobs in the production, maintenance and repair of automated machinery as well as the growing design and production requirements as demand grows for increasingly complicated products providing more and more optimal solutions in terms of loading capacity and conservation of resources. Scientific analyses of the creation of the number of workplaces created by automation are available only for the first factor. As regards the second factor, studies carried out some time ago by the Institute for Job Market and Professional Research (Institut für Arbeitsmarkt und Berufsforschung) show that dismissals are particularly rare in companies which keep abreast of technological developments in their particular production area.

So far there are no scientific and defintive statements available on the net effect on employment of industrial automation. For this reason the Federal Ministry of Research and technology took the initiative in summer 1984 and commissioned research in this area from a number of institutes and experts.

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(1) Prognos AG : Technischer Fortschritt, Auswirkungen auf Wirtschaft und Arbeitsmarkt, Material Volume I, p.311.

2. Effects on training and working conditions

Despite considerable controversy about the effect of new production technology on working conditions and training requirements, there is no final, clear, and scientific answer to this question. Two of the most hotly debated questions are the disqualification hypothesis and the polarization hypothesis. In the case of CAD, most case studies and quantitative analyses are unable to confirm the polarization hypothesis, which states that workers affected by the use of such technology tend to split into two groups : a group of less qualified workers and a group of more qualified workers. Rather it is looking more and more as if increasing levels of technology are giving rise to two more clearly defined groups of specialists on the one hand and generalists on the other, both of which are reliant on the other. As the use of the material has become more varied, so construction engineers too are forced to use computers in addition to the drawing board.

3. Effects on organizational structures

Meanwhile in the automated production area we seem to be seeing a Taylorization effect, i.e. an increasing division of labour. The typical work organization which tends to evolve consists of one very well trained mechanical engineer in charge of a group of operators. Comparing this kind of organization with that of production cells, we can observe an increase in supervision along with a decrease in the level of responsibility and automation of most of the workforce. Working conditions are further complicated by the fact that increasing automation of production necessitates the increasing introduction of standard production times. Certain authors observe that this taylorization is not necessarily linked to the introduction of new production techniques, but is caused rather by old-fashioned management concepts of job organization.

4. Education and vocational training

Increasing automation of production is leading to changing basic and further educational requirements, which are only very slowly being integrated into the traditional educational system. Medium- and large-sized companies at the forefront of new production technology have sufficient resources to provide the basic and further training for their workforces. This training takes the shape - depending on the size of the company and the educational requirements - of both in-house training as well as sending workers to special training establishments, such as those run by companies in the electronics industry. However, we frequently hear the criticism from the employee side that these institutions offer only a very narrow "on-the-job training", which only goes to tie the worker against his will to his particular specialized work station and does not allow him really to get to grips with the underlying technology (1).

For this reason there is a need from the employee side for independent educational establishments, beginning with improved preparation for new technologies in the state schooling system right the way through to training establishments which employees can attend during sabbaticals. Looking at the education and training area as a whole, it can be said that the publicly organized educational system is very slow-moving and cumbersome in adapting its curricula

(1) Einsatz und Auswirkungen neuer Technologien in Planung und Konstruktion CAD/CAM, ed. by Industriegewerkschaft Metall, Frankfurt a.M., 1984.

III. Politics and Automation

Ever since the political leaders in the Federal Republic became aware in the late sixties of the need to catch up with other countries in the key data processing technology industries, more and more money has been poured into data technology. This financial support is distributed via the traditional research support institutions, sometimes with greater emphasis on political and economic criteria, and at other times with greater emphasis on scientific criteria. In the seventies the Federal Government promoted among other things the development of industrial automation directly in cooperation with several "project carriers" by means of three consecutive DP promotion programmes, followed by several detailed programmes and since 1984 the overall "data technology" programme. This particular technology is also receiving direct backing from the work humanization programme, which is also being carried out via a project carrier.

The Federal Government provides indirect support in the form of partial or total financing of organizations specialized to a greater or lesser extent in the research and development area. These include the so-called major research institutes, in particular the Society for Mathematics and Data Processing (Gesellschaft für Mathematik und Datenverarbeitung), the Max Planck Society for Basic Research (Max-Planck-Gesellschaft für Grundlagenforschung) as well as the Institute for System Technology and Innovative Research (Institut für Systemtechnik und Innovationsforschung) and the Institute for Production Facilities and Construction Technology (Institut für Produktionsanlagen und Konstruktionstechnik). And finally the German Research Community (Deutsche Forschungsgemeinschaft) has received a DM 100 million grant for six research projects in this area which it was already financing out of its own funds in the industrial automation area in an amount of appoximately DM 20 million per year.

The lion's share of grants for the development of new production technology comes from the Federal Government's New Production Technology programme, with a budget of DM 530 million between 1984 and 1987. To this we must add a futher DM 160 million for CAD development. Together with grants under other programmes the amount of public support for research and development in the industrial automation area must run to between DM 200 and 300 million per year. This also includes grants from individual states which, given the growing competition amongst federal states to attract future-looking industries, are on the increase. Since a sizeable proportion of the above-mentioned promotion money is in the form of top-up grants, we can assume that this public money is matched by approximately a further DM 100 million of provide investment capital.

Both the Federal and the State Governments are being very restrained in the use of regulatory machinery to deal with the effects of new technologies. Their basic position is that management and unions are in a better position than the legislators to develop and agree on up-to-date and industry-specific solutions to new problems.
Other than "traditional" work legislation, no new regulations in respect of more recent developments in the industrial automation field have been made, nor are there serious plans to introduce any.

Nonetheless the government is involved indirectly in a number of ways in the social adjustment system: the Company Constitution Law (Betriebsverfassungsgesetz) and a Co-determination Law (Mitbestimmungsgesetz) enable both sides of industry to negotiate compromise solutions at all levels.
Secondly the so-called "Early Retirement Ruling" (Vorruhestandsregelung), issued in 1984, has contributed, albeit to a very limited extent, not only to an easing of the labour market but also to changing the age structures in companies in favour of younger workforces better able to cope with new technologies.

IV. Associations

1. Policies of the employers'associations and trade unions

Whilst employers' associations and in the majority of cases chambers of commerce are continuously calling for unlimited rationalization and modernization of all economic sectors in the light of the needs of international competition, the unions take a more discriminating approach: on the one hand they recognize the overall economic necessity and the social advantages of technical progress as well as its role in the humanization of work. On the other hand they reject the negative results of technology in the factory and find themselves, given the need to combat unemployement in the difficult position of trying to have all workers share equally in the benefits of productivity improvements (1). Based on this state of affairs the German Trade Union Association (Deutscher Gewerkschaftsbund) decided in May 1984 among other things to demand a reduction in working time (hours per week; days per year and years per working life), the introduction of an overall Government employment programme, the provision and improvement of research into the effects of automation as well as further training facilities for employees (2).

2. Policies of the political parties

The position of the Christian Democratic Party (CDU) and the Christian Social Union (CSU) are largely identical to those of the employers' associations. The Free Democratic Party (FDP) differs from them mainly in its more restrained attitude towards government promotion of research. The Social Democratic Party (SDP) supports the demands of the German Trades Union Confederation and most individual unions.

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(1) KNEVELS, P. : Industrieroboter im Spannungsfeld der Sozialpolitik - Standpunkt der Arbeitgeberverbände, in: Leistung und Lohn N°158/159, February 1985;
Technischer Fortschritt und Technik-Kritik, ed. by Bundesverband der Deutschen Industrie, Cologne, February 1984.

(2) Neue Informations- und Kommunikationstechniken, series Arbeit und Technik, ed. by the DGB, Düsseldorf.

In particular we note that statements by rank and file members put a greater emphasis on the macroeconomic need for economic modernization via government support of research and development and do not limit their horizons to the immediate interests of employees, as is the case with the German Trade Union Confederation. "Social acceptability" has become the standard formula used by the Social Democratic Party. The political group with the most negative attitude towards technological progress is the Greens who speak openly of nil growth as a political goal. However, their customary distinction between conventional and alternative technology is not completely unrelated to concepts of socially acceptable technology found in the programmes of the Social Democratic Party and the German Trade Union Confederation. The best way to formulate this is possibly to say that whilst the Social Democrats and the German Trade Union Confederation want new production technology to be governed by employee-favourable regulations, the Greens demand the development of completely alternative technologies.

The general reserve of successive governments in the area of legal and technical standards - which provide them with an incomparably more effective way of intervening in depth into the process of industrial automation - goes to demonstrate the relative irrelevance of party programmes in this particular policy area. Of all the more importance are the agreements negotiated year by year between management and unions, both on a national basis and in hundreds of different companies. Countless individual as well as a large number of industry-wide agreements have contributed sustantially to the "humanization" of technological progress. The most spectacular agreement in years, following a strike lasting several weeks, was the general reduction of the working week from 40 to 38 1/2 hours. Perhaps this is the first opportunity we have of testing empirically whether the reduction of working hours really does provide an effective weapon in the fight against unemployment.

3. Collective agreements

There have been several agreements to protect labour against rationalizatic ("Rationalisierungsschutzabkommen") in the last few years, few of them in sectoral agreements, many of them at single firms' level ("Betriebsvereinbarungen"). In general, these agreements are not accompanied by disputes on employment levels, because the implementation of manufacturing automation is mostly connected with the intention to expand production. Thus, employees are only displaced within the firm.

On the other hand,firms which are restricted in the dismissal of employees are less able and ready to employ new people. Obviously such a strategy turns out to be a sort of closed shop with detrimental consequences particularly for the youth. From the very beginning of the high unemployment at the end of the seventies the trade unions demanded a reduction of working time. The so-called "59er Regelung" was a first step in this direction. According to this agreement between the trade unions and the employers' organizations a 59 year old employee could retire without a considerable loss of income: the employee was dismissed and paid by the unemployment insurance till the age of 60, and the employer paid in the meantime the premiums of the annuity insurance so that the pension after 60 was not diminished. The agreement was superseded by a legal regulation (58er Regelung) in 1984.

FRANCE *

I. Technical and Economic Aspects of Automation

1. The extent of industrial automation

A summary given below in tabular form shows that the automation of production processes in France, which has already been under way for a number of years, is still far from complete and involves a very wide range of factors, which will be analysed in further detail in this article.

TABLE 1 : AUTOMATION OF PRODUCTION PROCESSES AND INVESTMENTS - FRANCE - 1980 (in millions of francs)

Types of systems	Total investment	Investment in automation equipment and software	% of total investment
Data systems, processing industry	1 600	Industrial computers.programmable automatons: 800	50 %
Machine tools	3 700	NC machine tools: 500	13.5 %
Machines for the agro-foodstuffs industry	3 000	Machines for automated production lines: 200	6.7 %
Miscellaneous industries	3 000	Machines for textiles, shoe, printing industries: 200	6.7 %
CAD/CAM	200	200	
Handling equipment	4 000	150	3.8 %
Packing, assembly	1 500	150	10.0 %
Plastic/rubber	700	100	14.3 %
Robots	100	100	
Foundries	400	(of which 0.28% in automated systems) 50	12.5 %
Miscellaneous (including engineering studies)	1 400	1 000	71.5 %
TOTAL	19 600	3 450	17.1 %

Source : Ministry of Industry. Internal memorandum

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* Summary of a report by Mr BERTRAND QUELIN; Centre de Recherche en Economie industrielle (C.R.E.I.) Université Paris-Nord.

Despite the central role it is called to play in the automation process, the rate of penetration of the CAD is still weak in relation to the potential market. In France there are 140,000 draughtsmen, working in approximately 50,000 design offices (of which 16,000 in the industrial sectors). The use of CAD equipment depends on the size of the design office and of the level of turnover. In 1983, only 5% of offices employing fewer than 6 persons and 20% of those employing between 11 and 20 persons used CAD devices. On the other hand, close to the half of the offices with more than 50 persons had such a device.

Although modest, the French CAD/CAM market totalled nearly 363 million francs in 1982. Over the period 1983-85, the growth rate of the total amount of machinery installed is estimated at 40%. However, in the absence of suitable French equipment, the French market remains dominated by American producers.

1978 marked the start of the development of automated production cells. This device, which allows tools to be changed automatically during the machining of a single unit, supplements the numerically controlled machine tools (NCMT). The latter, particularly suited to the manufacturing of small and average batches, are still few and far between in France. Obtaining figures is a sensitive matter, as most NCMTs are imported. Faced with this situation, the French government set in motion a national "machine tools plan" in December 1981. This plan envisaged the growth of the total number of NCMTs from 10,500 in 1980 to 26,500 in 1985, i.e. an average annual growth rate of 45%. However, overestimation of demand and insufficient attention to the evolution of automation led to the failure of this plan. Btween 1981 and 1983, world production dropped back by 29.5% and many French producers refused to take part in the industrial regroupings desired by the public authorities. For the plan to succeed, the latter should have linked the national machine tools plan with a robotics plan for the development of flexible cells (NCMTs and robots) and flexible systems.

According to A.F.R.I. (French Association for Industrial Robotics), representing companies employing 2,010 "programmable robots" and "intelligent robots", France occupies since June 1983 the second place in Europe and the fourth in the world, with a growth rate of annual deliveries of 46%.

The sovereignty of the motor industry and the importance of spot welding characterize the current use of robots in France (see table 2). In the future, the other mechanical industries, in particular the metals conversion, electrical engineering and electronics industries, will account for an increasing share of robot use.

In the nineties, thanks to the progress achieved in the field of the detecting elements, assembly robots will automate nearly 15% of small batch assembly jobs, 20% of average batch assembly jobs and approximately 30% of mass-production assembly jobs.

In France, the development of genuine automated production systems has taken the form of flexible manufacturing systems. Controlled in real time by a central computer, and integrating NCMTs and automated production cells as well as programmable handling systems, the flexible workshop provides an answer to the requirement for integrated automation. Since 1981, the spread of this kind of automation has accelerated. At the end of 1983, there were a dozen installations of this kind in France.

TABLE 2: PENETRATION OF ROBOTIZATION BY INDUSTRIAL SECTOR IN FRANCE 1980 - 1983 (in % of total installed systems)

Sectors	1980 (1)	1982 (2)	1983 (2)
Mechanics	8%	19%	19.1%
Electrical and electronics industries	11%	5.6%	6.1%
Data processing	n.d.	0.6%	1.0%
Automobile and transportation equipment	60%	45.7%	47.7%
Aeronautical, naval, space engineering	1%	7.0%	5.8%
Metal converting (incl. mining)	11%	7.8%	8.1%
Energy production (incl. nuclear)	-	1.1%	1.0%
Food and drink	-	1.2%	2.8%
Paper-paperboard, printing	-	3.5%	4.7%
Research - education	-	3.3%	3.2%
Miscellaneous	9% (3)	5.1%	7.5%
TOTAL	100%	100.0%	100.0%

(1) Source: DIEBOLD (1981)
(2) Source: AFRI (1984) (programmable robots and intelligent robots
(3) of which: rubber-plastic; ceramics-refractories; wood-furnishing

By offering an answer to the need of rapid adaptation to cope with changing of parts and tools and sudden changes in production tempo, the flexible workshop offers a compromise between productivity and flexibility.

TABLE 3 : PRINCIPAL FLEXIBLE PRODUCTION INSTALLATIONS IN FRANCE - 1983

Companies, sites	Industrial sector	Production processes	Project supervision	Cost	Install. date
Renault industrial vehicles. Bouthéon	HGV industry	Machining of gearbox casings	Renault machine tools	45 million 1979 francs	1982
Citroen Industrie, Meudon	Automobile	Machining of prototype parts	Automatique industrielle	45 million francs	June 83
Ford Bordeaux	Automobile	Machining of gearbox clutch shafts	Ernault-Somua	15 million	Sept 83
Matra-Jaeger Caen	Automobile equipment	Final assembly of dashboards	Jaeger	7,4 million francs	Feb 82
Peugeot Cycles Dannemarie	Cycles, motor bicycles	Machining of reduction motor casings	Peugeot Cycles AID	20 million francs	Oct 83
AccoUnelec Orléans	Electrical industry	Machining of alternator frames and platforms	Mandelli	11 million francs	1983
Thomson CSF Pessac	Electronics	Insertion of electronics components	Thomson CSF (TITN)	10 million francs	Sept 83
Télématique Le Broc-Carros	Electrical construction	Testing, distribution and forwarding of programmable robots	Télémécanique		Nov 81
Caterpillar Grenoble	Public Works equipment	Machining mechanically welded superstructures for public works	Renault machine tools		1984
P.P.M. Poclain Montceau-les-Mines	Handling equipment	Mechanical welding of crane caissons	PPM		June 83
Aerospatiale Bourges	Aeronautics	Mechanical machining of propeller bodies and fittings	Aeronautique+SAGEM+ participations of CERT-ONERA		2nd half 84

2. Production and foreign trade

Launched in 1969, the production of robots in France devolves round a single industrial pole: Régie Renault. Although several other industrial groups such as MATRA and SCHLUMBERGER have particular skills in certain sectors of the "automated production" chain, only the RENAULT group covers the whole of this area and possesses the necessary international size. As regards robotizaion in the strict sense of the word, RENAULT is far ahead of all other producers with its annual production of 120 robots in 1982 and a turnover of 103 million francs.
The company's goal is an annual production of 400 robots by 1985. RENAULT has also became the lead company in the major A.R.A. (Advanced robotics and automatics) public programme.

The C.G.E. (Compagnie Générale d'Electricité) group also has a few important trumps. Its ALSTHOM subsidiary has concluded trade and technical agreements with Japanese companies, in particular in the field of assembly robots. MATRA is a group with an electronics vocation. In addition to its high level of skill in electronic components and robotized mini-assembly, the MATRA group possesses a very broad international marketing network.

In 1982, the total value of production in this field amounted to 8,000 million francs of which 300 M.F. for robots, 1,200 M.F. for industrial informatics and 5,000 M.F. for advanced design machines.

This industry includes more than 130 companies with approximately 200,000 employees. But there is a deep-seated imbalance due to the high level of imports: 50% for robots and nearly 90% for CAD/CAM.
In 1982, 65% of all automated production machinery was imported. The public authorities have decided to reduce the penetration of foreign producers on the domestic market by 10% and to increase the share of French equipment on the world market.

Like all other European countries, France has developed three main kinds of public support: research assistance (20 million for the A.R.A. programme, investment support (500 million for the MECA process and 8 thousand million for the Industrial Modernization Fund) and subsidies (2,300 million) for the reorganization of the machine-tools sector (cf. part III).

II. Social Impact

1. Impact on employment

To evaluate the specific impact of sequential automation equipment on employment, we must distinguish between: employment in automation equipment manufacturing companies and employment in companies using automation equipment.

- CREI has carried out a study of employment amongst French robot manufacturers. Overall employment amounts to 5,100 persons (1). Of a total of 50 firms taking part in the study, 34% have between 100 and 500 employees; 60% have fewer than 100 employees. As we can see, the average workforce of individual French manufacturers is relatively small. Between 1980 and 1983, the number of jobs in companies producing automation equipment grew form 3,900 to 5,100: i.e. an average growth rate of 8%. 1983 employment figures break down as follows: 20.8% in R & D, 65% in production and 14.2% in marketing. Finally, an increase of 1% in the number of robots installed in France corresponds to a 0.34% increase in employment. The greater the increase in the coverage of the needs of the French market, the greater the number of jobs created.

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(1) CHENARD, A. - PINO, A. : "La situation de l'emploi dans le secteur robotique"; C.R.E.I., Paris, Nov. 1984. We nust remind readers that we are talking here about jobs created directly by the development of robotization. The level of job creation encouraged by productivity gains obtained by the increased use of robotization (much more) is not taken into account in this study.

- The introduction of automation equipment has a direct effect on the manpower needs of user companies. Overall, Régie RENAULT expects that, out of 100 jobs in the automobile industry, 18 will disappear by 1990 because of productivity improvements. Moreover, in the design area, the CAD is leading to manpower savings averaging between 30 and 50%.

In France, the only complete study on employment among users (1) expected that between 1980 and 1985, NCMTs would do away with nearly 4,000 workstations, robots and automatons with more than 50,000 workstations, and automated processing machinery with approximately 50,000. However a final assessment remains to be made. We must certainly not neglect the indirect effects on employment (which are more difficult to measure): the productivity increases resulting from a more thoroughgoing automation of production manifests itself in terms of an improvement in the market share of the company in question and thus, in the long term, allows for the creation of a large number of jobs. The initial disappearance of workstations will then necessarily be followed by the creation of jobs due to increased competitiveness on the world market.

However, it appears:

- given a constant market growth rate, automation exerts a high pressure towards manpower reductions;
- that the ability to create new jobs depends on the coverage of the French market and the speed of the introduction of automated equipment into industrial structures.

The effects of this reduction are certain and immediate, whilst the positive effects, which are certainly more important, are conditional on other factors and are situated further into the future.

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(1) PASTRE, O.; MEYER, O.; TRUEL, J.L.; ZAMADER, R. : "Informatisation l'emploi: Menace ou mutation ?", Documentation française, Paris, 1981.

2. Impact on job functions

In this field, it is difficult to generalize, as each technology has its specific social consequences.

- In robot manufacturing companies, engineers, technicians and skilled workers represent nearly 76% of the total workforce (14.1%, 19.4% and 42.2% respectively). This distribution shows clearly the degree of sophistication of job functions and by extension the training requirements of companies in the "automated productions" area.
- In the CAD field, the generalized use of tracing tables will do away with the job of implementation draughtsmen. The jobs of archivist and those connected with the printing and reproduction of plans will also disappear gradually. Two other tendencies are becoming apparent: CAD does not lead to the recognition of new job categories and has a tendency to subdivide existing categories into several levels.

- In the automated production field, the principal jobs which are disappearing are the following:
  - semi-skilled workers and hands, storemen and handling staff, painters, welders and foundry staff;
  - skilled machine operators;
  - technical production management staff.

The jobs which are growing in importance are those of maintenance mechanics, highly skilled machine tool operators, technicians employed in the control and regulation of machine tools, work organization staff and engineers, At the same time, we can observe an increase in the relative importance of monitoring - control - guidance functions. This evolution goes hand in hand with the development tasks related to automated systems.

3. Impact on work organization

- CAD can be adapted to various forms of organization. In France, the introduction of CADs is most frequently by way of the creation of specialist operator functions distributed throughout the design office and working upon request. Companies are looking for fast and cheap implementation, even though this does not make for good mastery of all the possibilities of CAD by company personnel as a whole.

- A recent study in the robotics area presents the modification of the work organization in 4 automated workshops at Régie RENAULT (1).
In the first workshop, we find the complete hierarchic line of command of the old workshop together with the old classification system.
In the second workshop, the hierarchical line of command has been reduced to three levels, with the appearance of a new job function: "confirmed automated machinery operator". The main conclusion of the report is that there is no "strict line of cause and effect between robotization and organization systems".
Automated workshops are the target of major restructuring, with training holding a central place. Company strategies oscillate then between two extremes:

- exclusion via dismissals, early retirement, recycling or:
- an integration strategy by the creation of new job functions (such as the "confirmed automated machinery operator" mentioned above), bringing together manufacturing and maintenance within a single job function.

Flexible workshops form a key area of technological and social experiment. The Régie RENAULT workshop at Bouthéon is designed to operate on a three-shift basis, with 3 persons per team: two for loading and unloading the parts onto the pallets and one workshop technician. The CITROEN flexible workshop at Meudon functions on the basis of three teams: two day teams and one night team. Parts are machined in automatic mode by the system.

(1) CORIAT, B. : "La robotique à la Régie Renault", Révue d'Economie Industrielle, N° 24, 1983.

The new structure will require major changes in qualifications, a significant reduction in the numbers of direct operators, and the creation of jobs in programming, monitoring and maintenance.

TABLE 4 : COMPARISON OF JOB STRUCTURES IN A FLEXIBLE WORKSHOP AND IN A COMPARABLE CONVENTIONAL WORKSHOP - FRANCE - 1983

Flexible workshop

Team Functions	Day 1	Day 2	Night	Total
Presetting Loading Unloading	1	1	-	2
Returns and complaints	4	3	-	7
Operations monitoring	1	1	1	3
Control	1	1	-	2
Maintenance	2	2	-	4
	9	8	1	
Programming				10
Preparation of plates				4
Set-up				1
Total				33

Conventional workshop

Function		Number of persons
Preparation, planning, minor programming		6
Machining		50
Control		6
Follow-up of the parts		3
Cleanliness		2
Handling		3
Maintenance		3
Total		73

Source : Automatic Industrielle

4. Impact on working conditions

Robotization tends to withdraw human beings from direct contact with the product being processed by multiplying safety measures and decreasing the necessary operational interventions. The new work organization generally involves an increased isolation of individuals. The mental strain is particularly heavy on workers who have exchanged manual activities. Isolation, noise, and the sense of not being in control of the system often create a sense of work monotony. Lastly, the multiplication of VDUs in the workshops leads to increased visual fatigue and muscular pains. Programming becomes more and more complex and the necessary level of abstraction increases. Skills required change totally.

CAD demands less sensorial and motor activity but also accentuates the tendency towards more abstract work. Information density, "flashing lights" and the time taken waiting for results all go to increase significantly operator tension and nervous fatigue.

The development of automated production involves more and more single-station work and an increasing number of shifts, in particular night shifts, in order to reduce equipment pay-off times.
Régie RENAULT has launched an experimental week-end shift.
These developments affect in particular the mechanical industries, in which night work has, until now, been very limited.

5. Education and vocational training

Whenever new technologies are launched, equipment manufacturers play a very important training and advisory role, by organizing training courses and by training their own specialists, who are in turn prepared to travel.

To facilitate changes in job functions, robotization training has to be offered to the employees concerned and recycling programmes arranged for workers losing their jobs. Robotization training programmes have been set up at universities and technical colleges, inclucing precision mechanics, hydraulics and data processing. For the beginning of the 1985 educational year, the government has provided 10 to 15% more first-year places in engineering schools and university technology institutes. This measure meets the needs of manufacturers and users (such as the motor industry) who are looking for electrical mechanics with a Baccalaureat and two additional years of qualifications (BTS, DUT) following the Mission Robotique's estimate that 500 persons with a "Bac + 2" were needed for automation to be successful.

There are few user-specific programmes available. We should, however, note the creation in 1984 of a technology training centre for workers in the automobile industry, offering recycling to employees affected by automation, thereby avoiding their total exclusion from the workforce. The first training cycle began in April 1984 and is expected to last for 8 to 10 months.

III. Government Programmes to Promote Automated Manufacturing

1. R & D promotion

Several research programmes are directed towards manufacturing automation. These break down into three categories of national projects:

- Three projects offering the essential basic tools:
  - . the ARA (automatics and advanced robotics) programme,
  - . the AMES (automation and economic and social changes) programme,
  - . the components programme.

- Two horizontal programmes:
  - . pilot flexible manufacturing systems,
  - . management of the production flow.

- Automated production development projects:
  . automation in the textile, clothing and shipbuilding industries,
  . machine tool automation,
  . agricultural robotics.

Among this group, the ARA programme plays an important motivating role. Launched in 1981 under the aegis of the General Research Delegation (Délégation Générale à la Recherche), it received the support of the Informatics Agency (Agence de l'Informatique) in 1982 and now brings together 40 research teams (with a total of 200 researchers) working in four main areas: robotics and assembly, mechanics and technology, flexible workshops, remote control operating. Its start-up budget amounted to 20 million francs funded by a programme contract with the Research Support Fund (Fonds d'aide à la Recherche).

2. Industrial policy

Affirming the key role of automated manufacturing leads to prioritizing two types of activities: the strengthening of industrial structure and the improvement of the economic and social environment.

- The public authorities decided in 1981 to launch a national Machine Tool Plan costing 2.3 thousand million francs over 3 years. This plan envisages company development contracts, the regrouping of manufacturers into "poles", the implementation of a public contract programme of 400 million F a year over 3 years and finally the organizationof NCMT training schemes.

The Industrial Modernization Fund was set up in 1983 to mobilize savings for investment in advanced technology. In 1982, the amount of support voted by the government amounted to 50 million for DAP (Development of automated production), 120 million for MECA (advanced design machines and equipment), 2.5 thousand million in the form of subsidized loans and 42.5 million for development contracts.

- Mastering the production of automated capital goods is a top industrial policy priority. The Informatics Agency is currently carrying out awareness campaigns aimed at SMEs. The Paris Chamber of Commerce and Industry and AFRI have launched a joint information campaign entitled "Successful robotization".

AFRI has also set up regional technological networks. Moreover, the public sector competitive companies are being used to encourage other companies to introduce automation within the framework of company plan contracts. In this way the public authorities are endeavouring to create the necessary mechanisms and free up the necessary financing in order to successfully mobilize the different social partners involved.

IV. Social Groups

1. Employers' policy

The two principal reasons invoked by industrial companies for introducing automation are: reducing labour costs and improving competitiveness. Faced with the present economic crisis, French employers give priority to rapid and highly capital-intensive automation. The two constraints mentioned by employers are those of flexibility and competitiveness. They are much more afraid of loss of jobs due to delayed automation than the less massive loss of jobs involved in early automation.
The general philosophy of French employers can be summed up as follows: "There is no room for compromise between computerization and employment. A company boss cannot refuse the advantages offered by new informatics tools" (1).

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(1) SARRE, A.C. : "L'informatisation des entreprises françaises dans les années 80", Institut de l'entreprise, Paris, Nov. 1980.

2. Policy of the trade unions

In the area of industrial automation, a general consensus prevails: the introduction of industrial automation has to go hand in hand with a new organization of production.

The CFTC demands "open and honest discussion about the repercussions on employment". The CGT favours "discussions on the role of employees in the design of automated systems, and "that the question of work content be taken into account" in discussions to be held at a national level (1). Force Ouvrière (F.O.) prefers round-table negociations at company or sectorial level to national planning, even on a non-compulsory level, of industrial automation (2).
The CFDT has developed proposals "to permit employee control of robotics investments. These claims cover in particular the negotiation of goals, the control of research and the control of industrial policy.
This trade union demands that priority be given to the least human workstations.

3. Collective agreements

The "Auroux" laws, promulgated in 1982, compel companies to hold information meetings and joint worker-management discussions at the Company Committee (Comité d'Entreprise) level. Moreover, collective bargaining began at the national level in 1984 on the "flexibility of the labour market". The stakes are high: the modernization of the production apparatus and a more flexible functioning of the labour market against trade union demands for work sharing and control of the conditions for the introduction of automated systems.

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(1) Economic and Social Committee, Opinions and Reports N° 9, April 1982, p.380.

(2) UCC-CFDT : "Robotique: objectifs économiques et sociaux", Futuribles, N° 64, March 1983.

Henceforward there is a common basis of negotiations: everyone realizes the necessity of robotization. However the economic crisis cannot be be disassociated from the crisis of work organization. Automation is one element of factory reorganization which the crisis has brought to the surface in its wake. Indeed, industrial automation systems involve a whole new control/time economy in the production process.

The crisis has begun to call into question the continued usefulness of certain job categories and has increased the precariousness of employment. The flexibility arising from this increased precariousness making possible the implementation of a new wage policy.

As we have seen, the implementation of new technologies involves the provision of detailed information to employees and their representatives. Employment, work organization and training are all at stake.
Will increased automation enable us to find jobs for everyone ?
Historically, in France, the State always intervened in employer-worker relations. In the training area, it has to do its utmost to avoid the exclusion of certain employees as a result of automation. And in the continuing education area, the creation of car workers training centre (CFTA) in 1984 is a first example of a path which must be pursued further. Lastly, government intervention is required in order to facilitate agreements at company or sectoral level, particularly in the motor industry. Action from the public authorities, as well as pressure from employees, are needed in order to force companies to accompany their restructuring plans with measures to reclassify their workforces or train them for new trades.

IRELAND *

I. TECHNICAL AND ECONOMIC ASPECTS OF MANUFACTURING AUTOMATION.

1. The Spread of Manufacturing Automation.

Ireland is a small country and has a small industrial base in relation to other European countries. The level of high technology industry in the country is low and firms involved are mainly multinationals.

The level of awareness of the new technologies being developed in manufacturing automation is somewhat greater in the foreign-owned firms than in the indigenous Irish firms. These former firms have a greater exposure to developments because of their associations with parent and sister plants elsewhere. The Irish-owned companies on the other hand are operating in a very small market environment and thus are not as sensitive to changes in the new technologies.

Irish-owned firms also tend to view the capital expenditure required in many automation projects as being prohibitive. However, with the reduction in cost of computer hardware, specifically microprocessors, even the smaller manufacturer can now contemplate automating the manufacturing process.

Industry in Ireland has been fairly cautious in adopting Computer-Aided Design techniques.
Although the numbers of firms who are using this technology is not large, the major firms as well as the high technology product firms have made a start in this area. As to Computer-Aided Manufacturing, a survey carried out in 1981 by the National Board for Science and Technology (NBST), found that Stock Control, Production Planning and Scheduling and Management Information were well established computer applications in Irish manufacturing firms (1).

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* Summary of a report prepared by Professor M.E.J. O'KELLY, L. BRENNAN and F. FINNAN, Department of Industrial Engineering, University College, Galway.

(1) National Board for Science and Technology : "Microelectronics, The Implications for Ireland", 1981.

A survey (covering 80 companies) carried out in 1982 by the Computer Users Association (1) to investigate the extent to which IBM-users implemented MAAPICS (an integrated production data collection system), indicated that only 5% of the companies surveyed have implemented the Production Control and Costing Modules compared to 17% who had implemented Inventory Management Modules.

The most significant difference between companies with low and high technology products is to be found in the use of computers for Production Planning and Control. In overall terms 49% of the participating firms use the computer for this application. There are few companies who use the computer for more advanced manufacturing applications such as Design Calculations, Material Requirements Planning and Process Control. The impact of the computer on Process Control has been very limited in Ireland.

A 1982 report published by the National Board for Science and Technology (NBST) (2) concluded that levels of application of robots and NC Tool Machines in industry were low by international standards. The report also concluded that existing CNC capacity was less than fully utilised, according to yet another report (3): "The low level of CNC machines in Irish industry would seem to indicate that the first fully developed FMS in Ireland will not be in place before 1990".

2. Estimations of Future Diffusion.

A survey (covering 328 establishments) was carried out in the field of future diffusion by the Confederation of Irish Industry in August 1984.

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(1) Computer Users Association, "Implementing MAAPICS Modules - A Structural Approach", 1982.

(2) National Board for Science and Technology, "Computer Numerical Control in Ireland", 1982.

(3) J. BROWE et al., "Robotics and Automation in Batch Manufacture", National Board for Science and Technology, 1984.

The survey revealed that one in every five of the firms surveyed either uses or is planning to use computer aided design within the next two years (see table 1). Judging by the stated plans of the firms involved there will be a 25-30% increase in the number of applications of information technology per firm per annum over the next couple of years (1).

TABLE 1 : Number of firms using or intending to use CAD/CAM within two years.

	A USING	B TO USE WITHIN 2 Years	C TOTAL A + B
Computer Aided Manufacture*	40	30	70
Computer Aided Design	22	37	59
TOTAL	62	67	129

Source : Confederation of Irish Industry, 1984

II. SOCIAL IMPACTS.

1. Impacts on Employment.

Official thinking in this country draws heavily on the National Board for Science and Technology's 1981 Report on the impact of microelectronics (2). This Report argued that the capacity of the technology to destroy job opportunities was mainly confined to traditional types of industry.

(1) Address by LIAN CONNELLAN, Director General, Confederation of Irish Industry at the ICADA Exhibition, October 1984.

(2) National Board of Science (1981) op.cit.

These types of industries do not exist to any great extent in Ireland because of its late industrialisation. In Ireland, according to the official consensus the significant changes will come in the nature of work, the structure of organisations and the patterns of careers.

Today, in certain reports, massive job losses are being forecast as a result of the electronic transfer of funds in finance, distribution and retailing, and CAD/CAM techniques which could transform small-batch and customised manufacturing into a low employment zone (1).

2. Impact on Skills and Qualifications.

There have been many calls for more forward planning in response to the information technology versus unemployment problems. It is felt that there will be a widespread elimination of unskilled assembly and clerical jobs but that this can be balanced with new opportunities for skilled work if our education and training systems can be adapted to meet them. The challenge will be to provide recurrent training for everyone - job training may become a continuous function throughout one's career (2).

3. Education and Vocational Training.

In the past 20 years, as a part of a major endeavour to promote industrialisation in the country, Ireland has made great advances in the development of its technical education facilities. In the 1970's nine Regional Technical Colleges (R.T.C.) and two National Institute for Higher Education (N.I.H.E.) were established throughout the country. These colleges were seen as being specifically concerned with providing courses aimed at filling gaps in the industrial manpower structure particularly in the technician and technological areas.

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(1) J. STERNE, "Computers and Unemployment", Technology Ireland, Vol. 8, N° 6.

(2) Adress by B. O'MALLEY, National Microelectronics Application Centre, to Conference on Programme for Economic and Technological Forecasting.

The gradual automation of manufacturing and the introduction of the computer into other areas has led to an increase in the demand for training in computer topics.

The educational system in Ireland has been seen as a resource for national and economic development. There are many formalised links between education and industry with consequent effects on curriculum development and research and development activities. Because Ireland has succeeded in attracting many highly sophisticated industries to locate in Ireland, the level of technical training at its technical training institutes has had to keep pace with the level of technology involved. A number of industrialists have stated that one of the attractions of Ireland is the availability of a skilled as well as a young labour force.

III. GOVERNMENT POLICY IN THE FIELD OF MANUFACTURING AUTOMATION.

1. Promotion of R & D.

Two major publications have, in recent years, noted and criticised the low level of Research and Development activity in Ireland's manufacturing industries. The Telesis Report (1) ("A Review of Industrial Policy") and the NBST (National Board for Science and Technology) publication "Microelectronics, The Implications for Ireland" (2) were both of the opinion that the Information Technology Industries in Ireland are concentrating mainly on assembly and manufacturing type operations.

The Irish Government has subsequently taken a number of initiatives to provide a comprehensive research capability particularly related to micro-electronics. The National Microelectronics Research Centre (M.R.C.) was established with Government assistance at University College Cork in 1983. In addition to the carrying out of research work for industry and government agencies, post-graduate training is one of its major functions.

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(1) National Economic and Social Council, "A Review of Industrial Policy", October 1982.

(2) op.cit.

The recently published Government plan "Building on Reality 1985-1987" (1) recognises that Irish Industry will have to compete in an international environment of relatively slow growth but rapid technological change. The Government's industrial policy, set out in the White Paper published in early 1984, places a greater emphasis on marketing and tech ology acquisition in the allocation of incentives. Support will also be directed towards more highly skilled jobs and towards helping Irish firms keep abreast of the up-to-date technologies such as CAD and CAM systems.

IV. SOCIAL GROUPS.

1. Policies of Employers' Organizations and Trade Unions.

To date no strong policies have been adopted by Employers' Associations. In general they have tended to issue general guidelines about the introduction of new technologies to their members.

The Federal Union of Employers (FUE) considers that technological change should be regarded as but one form of change, others being work or job content, working methods and re-organizations. The FUE advises individual companies proposing major technological changes to negotiate a specific agreement covering the following aspects :

(i) Reduction, if any, in employment levels;
(ii) Adjustments to rates of pay;
(iii) Hours of work;
(iv) Training or retraining of workforce and
(v) Health and Safety. (2)

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(1) Building on Reality 1984,1985 - 1987, Government Publication, 1984

(2) Federal Union of Employers, "Change and Technology - Supplement to FUE Bulletin", September 1982.

The Irish Congress of Trade Unions (ITUC) set up a Committee on New Technology in 1979 and has issued guidelines to trade union negotiators (1). The Committee undertook a very useful review of technology agreements in other countries.

The Irish Transport and General Workers Union (ITCWU) has issued a "Discussion Document on New Technology in Ireland" (2). In it the ITGWU states that the introduction of new technology raises questions in relation to industrial and economic democracy, disclosure of company information and appropriate legislation. As far as New Technology Agreements are concerned the union would be seeking -

(i) Wherever possible, full job security for an existing workforce as a pre-condition of the introduction of new technology;

(ii) Adequate training and retraining facilities for workers affected by the introduction of new technology;

(iii) Full union participation in all aspects of health and safety prior to the introduction of new technology.

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(1) Irish Congress of Trade Unions, Annual Report 1980.

(2) Irish Transport and General Workers Union, "Discussion Document on New Technology in Ireland, 1981.

ITALY *

I. TECHNICAL AND ECONOMIC ASPECTS OF MANUFACTURING AUTOMATION.

1. Production and Diffusion

The Italian market for industrial automation is characterized by a remarkably different situation on the demand and supply sides. Domestic demand is rather weak, and it has been strongly influenced by general macroeconomic conditions. The upsurge of investment in 1979-1980 was sustained by a considerable effort on the part of firms to move towards flexible manufacturing. In the following years of low growth of industrial production, investment stagnated and the market for industrial automation grew at slower pace than before. It has been estimated that in 1982 total sales amounted to 1,335 billion lire; a provisional estimate for 1983 gives a figure of 1,500 billion lire (1).

The market for the automated factory is much more limited than the market for industrial automation in the more comprehensive definition. The largest component is that of numerically controlled machine-tools, which in 1985 is estimated to amount to 375 billion lire. The total extension of the market for the automated factory is estimated to be around 700 billion lire in the same year.
As far as flexible manufacturing systems are concerned, the figures would amount to 110 billion lire for robot systems and machining modules, and to 70 billion lire for flexible manufacturing systems proper.

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* Summary of a report prepared by BRUNA INGRAO, Dipartimento di Scienze Economiche, University of Rome.

(1) CASTELLANO C., "Il settore dell'automazione industriale", L'industria V, N° 2, aprile-giugno 1984, pp. 215-241.

Computer Aided Design and Engineering.

A very detailed survey of the Italian market for CAD/CAM systems was published in 1983 (1). This survey estimated that in 1982 the number of CAD/CAM systems installed was 145 including turnkey, inhouse and host computer systems. The number of installed work-stations was much higher, i.e. 1,500 in 1982 with a proportion of 2.4 work-stations per system.

By 1981 around 50 new systems were installed per year: the rate of new investment in CAD/CAM systems is forecast to grow by 1985 to 215 new systems per year. The eighties seem to be a period of fast growth for the Italian market in computer-aided design. The forecast of the value of demand will be sustained by the rapid diffusion in new industries and the service sector. The survey estimated that 90% supplies come from foreign countries, first of all the United States, but also France, the Federal Republic of Germany and the U.K.
In 1982 around 40 firms supplied complete CAD/CAM systems in Italy, most of which were subsidiaries of foreign firms that do not manufacture in Italy but simply market the products of the parent companies.

Robots.

A very detailed survey of the Italian robot market (2) came to the following conclusions   Italian robot industry is small in terms of the number of firms and the size of the market but in the last seven years it has acquired a remarkably good competitive position and a high technological level. FIAT, the car company, began to produce robots in 1972 for both welding and painting to renew its own production technologies.

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(1) Reseau, "Tecnopolis, Dossier Elettronica", December 1983.

(2) CAMAGNI R. (a cura di), "Il robot italiano : Produzione e mercato della robotica industriale", Edizioni Il Sole - 24 ore 1984.

The supply extended in the seventies with new entrants in the market, but a wider supply and a stable group of suppliers did not evolve until the end of the seventies.

It has been estimated that in 1983 there were around 30 firms supplying industrial robots; not considering producers of simple pick-and-place devices, the estimate gives a figure of 18 suppliers, most of which are very small firms. With a few exceptions, firms specialize in one or two classes of dedicated robots; they usually design and assembly the robot, but parts are contracted out (1).

The high technology and improved supply which emerged in the late seventies had a positive impact on the balance of trade, which from 1978 showed a growing positive balance.

Up to 1982, 900 robots had been produced in Italy: 300 were spot-welding robots, 200 handling robots, 140 assembly robots, 120 painting robots, 20 measure robots, 5 seam-welding robots and 120 other types. The quality of the supply may be seen from the large number of firms supplying robots with computerized numerical control or direct numerical control (around 28% and 17% respectively).
On the demand side a wide divergence appears between the massive pilot experiences of a few large companies in the car industry and in the household appliances industry and the rather slow process of diffusion in the industrial environment at large.

Small- and medium-sized firms have lagged behind for a variety of reasons: lack of financial resources, lack of knowledge, huge costs associated with the introduction of robots and the radical change in the layout of the factory which is required for this major innovation.

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(1) SIRI, "Stato attuale e prospettive della robotica in Italia", the Second National Conference, Milan 26 - 28 March 1984.

(2) CANAGNI (1984), op.cit.

A survey conducted in 1982 gave a census of 1,200 robots installed, with a large prevalence of spot-welding robots (500) and handling-robots (200). Assembly robots are still in the first stage of diffusion.
In 1983 the new detailed survey gave a figure of 326 new robots installed, including only robots produced in Italy. The same survey estimated than more than 43% of these new robots were in the car industry; the figure goes up to more than 55% if we include the whole vehicle industry. Around 17% of new robots have been installed in the mechanical engineering industry, 19% in the electronics industry. Percentages for all other industry are very low, but it is noticeable that robots made their appearence in a wide range of industries, including the most mature ones (e.g. furniture, textiles).

Flexible Manufacturing Systems.

IRI, the state-owned industrial conglomerate, controls a number of companies in the robotics market and in the market for flexible automation systems.
A new industrial group was created in November 1983, the Selenia-Elsag group, with four companies in the market for flexible automation systems: Elsag, from whom the group orginated; Dea, a robot-producing company; Saimp, a company supplying machine-tools and machining centres; Selenia Autrol, a new company to develop and market CAD systems. The electronics division of Ansaldo was also included.
A year later, this strategic priority was confirmed by an agreement signed with IBM Italia, to establish a new company, Elsag-IBM, to be active in the factory automation field. The idea was to combine the experience of the Elsag group in flexible automation with IBM's electronic technologies.
The Elsag group, with around 1,500 employees, is the largest group in flexible automation systems after Comau, the FIAT subsidiary.
Other Italian suppliers are the two independent companies, Mandelli and Berardi. It should be noted, however, that as soon as we look at flexible automation systems and cells, the extent of the market drops to very low figures.

A very detailed survey of existing installed systems and cells, for instance, gave the following estimates for the stocks of FMC and FMS installed by Italian firms (updated 1983) Conau 3 FMS; Mandelli 2 FMS and 1 FMC; Berardi 2 FMS. The same survey estimated a higher rate of growth in demand in flexible manufacturing modules and cells than in systems (1).

II. SOCIAL IMPACTS

1. Impact on Employment

We emphasized at the beginning that flexible automation technologies include systems of varying degrees of complexity, from individual robots or numerically controlled machine-tools to pilot experiments with computer integrated manufacturing. The direct impact on employment of this wide range of technologies may be weaker or stronger depending on the automation strategy chosen: whether it is a global automation strategy aiming at complete, highly sophisticated and automated systems with a minimal requirement of direct labour; or a step-by-step strategy aimed at introducing an island of automation within the factory or even at introducing only single automated machines.

There is evidence of a move towards a global automation approach in large car companies: in the eighties, the impact on employment will be much more noticeable than the relatively mild impact caused by the first robots introduced in the seventies.

A trade union study, based on official FIAT sources, estimated that the Robotgate system in welding, at standard rates of production, reduces the number of welders by more than 47% with a higher impact in body welding (- 56%) than in side-panel welding (- 35%) (2).

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(1) RESEAU, "L'automazione flessibile", Milano, 1984

(2) MERLI R., "Il robotgate nella produzione della Fiat Uno, Modello robot", Ediesse 1984, Roma, 1984, p. 200.

Similar figures have also been estimated for the introduction of robots in the Alfa factory at Pomigliano d'Arco. The data collected in the motor vehicle industry where the process of automation is well established may give a somewhat distorted view of the global impact on employment of new flexible automation technologies.
The evidence is much less clearcut in small- and medium-sized firms or whenever management projects are limited in scope and ambitions.
This is, for instance, the case in the wide area of applications of numerical control in the mechànical engineering industries.

In 1981, a study estimated that in the years 1981-1985 the rate of substitution of direct work per robot would be 2.25; in the following five years the rate was estimated to grow to 3.0 workers per robot. The same study evaluated the reduction in direct employment at between 22 500 and 33 500 jobs lost (1), a figure which has been confirmed as realistic by other sources too (2). These estimates were based on the hypothesis of a 50% growth rate in the stock of robots in 1980-1985. It has also been suggested that flexible manufacturing technologies are cost-effective in those markets where firms work on medium-size batches, but they need a fairly large spectrum of characteristics in final products. Flexible automation technologies are neither cost-effective for the specialized machining of single unique parts, nor for large scale standardized production. Many assembly tasks are still beyond the capacity of automated systems (3).

2. Impact on Skills and Qualifications

All sources point to a major change in the composition of the workforce in connection with new flexible automation technologies; a drastic reduction in manual workers as a percentage of the total workforce; an increase in workers employed in maintenance, supervision, programming or other control tasks.

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(1) PROSPECTA Srl, "Tecnologia e lavoro, la prospettiva robotica, Quaderni di industria e sindacato, N. 6, 1981.

(2) CANAGNI (1984) op.cit.

(3) BIANCHI P., "Divisione del lavoro e ristrutturazione industriale, Il Mulino, 1984.

In the Robotgate system, for instance, the ratio of maintenance workers to total workforce rises from 17% to 70%, whereas the ratio of direct workers decreases from 70% to 10%.

While this trend is clearly recognizable, the evidence on upgrading or downgrading of skills associated with the diffusion of flexible automation is rather mixed.
Maintenance and control tasks may require an improvement of ability and technical knowledge on the part of workers; on the other hand, automation may be associated with an impoverishment of work content, whenever the loss of manual skills in machining is not compensated for by new skills, and workers are required to perform simpler, manual tasks.

International comparisons have suggested that there is no single relationship between the new automation technologies and patterns of organization in the workshop. The studies conducted in Italy seem to confirm this approach. The possible upgrading of skills in the group of workers assigned to machining modules or cells has been emphasized (2). Other studies have noticed the prevalence in reality of a centralized polar model of organization with downgrading of skills (3).

On the contrary the evidence of better working conditions as far as health and safety are concerned is overwhelming.

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(1) MERLI R. (1984) op.cit.

(2) BIANCHI P. (1984) op.cit.

(3) MERLI R. (1984) op.cit., FERRARIS Pino (1984), "L'automazione flessibile e l'ideologia dell'artigiano tecnologico", paper presented at the conference held in Bologna, 20-21 January 1984.

III. GOVERNMENT POLICY IN THE FIELD OF MANUFACTURING AUTOMATION.

1. Promotion of R & D

Up to now, no general coordination policies have been envisaged specifically aimed at industrial automation, either to speed up the diffusion of new technologies or to cope with problems created by their social impact. All the same, interventions have been or may be pursued with the fairly large array of instruments which have been put in place for innovation policies at large.
A special project on information technologies was started in 1979 scheduled to last for five years.
The subproject on "Industrial Automation" included five major research objectives :

1. Modular Integrated System for Automation and Control (Modiac), a general-purpose computing system and a network especially designed for the automation needs of industrial processes;

2. Computer Aided Design in Mechanical Engineering (Cadme), a specialized CAD/CAM system to design parts in the mechanical industry, and to generate instructions for numerically-controlled machine tools and robots;

3. "Cadfi", a general purpose software program for computation in solid state mechinics and fluid dynamics and

4. "Cadlo" a specialized CAD system to design and test integrated systems for VLSI components.

While the "Industrial Automation" subproject was being completed, a new special project "Mechanical Engineering Technologies", was started in December 1983. Over five years this project will receive a total amount of around 31 billion lire, 50% of which will be used by firms involved in the research agenda. The basic aim of the project is to develop technologies for flexible manufacturing systems, and all the major suppliers of robots and automation systems in the Italian Industry are involved with research contracts.

The project is also planned to develop and support the experimental construction of flexible manufacturing systems in a number of selected firms (1).
It is important to note the "Mechanical Engineering Technologies" project, which will monitor through CENSIS (a major research Institute for Social Studies), the impact of the new technologies on employment and work conditions as part of the basic research programme.

A special Project specifically for robotics has been planned; a proposal was drafted to that end. As the proposal stated, the project should aim at applied research in the specific field of robotics, leaving aside the wider fields of flexible automation (2).

It is difficult to evaluate the contribution of the new Special Fund for Technological Innovation, which was instituted by Law 46 (17 February 1982). The Fund, managed by the Ministry of Industry and Trade, was financed at the outset to 1,850 billion lire; a further 1,800 billion lire were later added.

CIPI, the Committee of Ministers for Industrial Policies, defines the main national priorities which form the guidelines for the evaluation and approval of single projects to be financed. Large firms' projects have to be evaluated within these guidelines: they are eligible for financing only if they pertain to applied research areas within the approved national priorities. CIPI chose five "high priority sectors" for intervention: the car industry and the car components industries; electronics, fine chemicals, iron and steel; aerospace.

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(1) CARAVITA G., "Dall'alleanza tra CNR e industria, automatiche - Made in Italy", Il Sole - 24 Ore, 5.11.1985.

(2) SONALVICO M., "Il progetto finalizzato robotica; SIRI", "Stato attuale e prospettive della robotica in Italia", Proceedings of the Second National Conference, Milan , 26-28 March 1984.

For each priority sector high priority research areas have been specified; of those research areas two are directly linked to robotics and flexible manufacturing: process innovation in the car industry to improve productivity and work conditions, industrial automation and control systems for general and special applications (1).

A rather new approach to innovation policies emerged in Bill N 696 (19 December 1983), since the Bill established the possibility of applying for direct financial support by the State for small and medium sized firms wishing to buy numerically controlled machine-tools (2). The contributions which have thus far been approved amount to 90 billion lire. The aid is a grant-in-aid of up to 25 % of the pre-tax price of the machine-tool to be bought; in Southern regions the percentage reaches 32 of the price. The aid cannot exceed a maximum amount per firm.

IV. SOCIAL GROUPS

A research paper draws the conclusion that from the mid-seventies onwards traditional collective bargaining by trade unions became inadequate to deal with problems of innovation or plant renewal (3). In fact, new bargaining procedures emerged, much more important than collective bargaining along the old rigid lines, to deal with situations where radical changes in the productive layout of the firm were involved, with an impact on employment and working conditions. Those bargaining procedures, following the international literature on bargaining processes, may be defined more often as "productivity coalitions" or as procedures for the "management of decline".

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(1) SCANAGATTA G., Paper presented at the conference "Gli strumenti di sostegno all'innovazione tecnologica nel settore dell'agro-industria" Settefonti, 14.12.1984.

(2) OCSE, Tour d'horizon annuel sur l'évolution des politiques industrielles et la situation dans l'industrie - Italie, Janvier, 1984.

(3) PERULLI P., "Consequenze delle ristrutturazioni sulle relazioni industriali", Economia e Politica Industriale N°43, 1984, pp.105-121.

In the case of productivity coalitions, workers accepted the redesign of the productive layout in the factory even at the cost of some reduction in employment to maintain the overall profitability of the firm and its rate of growth. In cases of "management of decline" workers agree on the planned, scheduled reduction of capacity and employment to avoid bankrupcy or the shut-down of the factory.
In both cases it often appears that trade unions experience difficulties in intervening before crucial decisions are made, even if the information rights are formally respected.
The paper by Perulli only examined case studies in the Italian chemical industry, where excess capacity and losses have been experienced in the last decade by some very large firms; but the same general observation seems to apply to the bargaining procedures over new automation technologies (1). A discrepancy emerged between trade union attitudes or official declarations at the national level and the attitudes of workers involved in the factories where the technological change took place. A similar discrepancy emerged between national collective bargaining which often proved ineffective or not operative on problems of innovation, and some concrete experiences of bargaining and agreements in factories introducing the new automation technologies where "productivity coalitions" prevailed.

(1) Fondazione Olivetti Centro Studi, "Esperienze e modelli di democrazia industrialie per i processi innovativi", 1984.

THE NETHERLANDS *

I. Technical and Economic Aspects of Manufacturing Automation

1. The Spread of Manufacturing Automation

The total number of CAD-systems used in the Netherlands is approximately eighty; the total number of robots in use is seventy (1). It is not easy to trace where these systems are located, mainly because different definitions of CAD/CAM systems are used. From market research carried out by Siemens, the following conclusions can be drawn: 6% of industrial companies, and 15% of advisory bureaus use CAD/CAM-systems. As a drawing-tool CAD/CAM is, in industry, primarily used in the fields of mechanical engineering, electrical engineering and architecture. Consultancy firms use CAD/CAM primarily in the fields of electronics, electrical and mechanical engineering, and architecture. (2)

2. Estimates of Future Diffusion

From the Siemens survey it has become clear that increasing automation depends upon further technological innovation; cheaper and more efficient systems are needed.

Other important problems concerning manufacturing automation are the following :

- Education and vocational training do not match the needs of the companies sufficiently in the field of automation, and thus there is a lack of competent personnel;
- there is a lack of standardization of machines;

(1) See the papers of De Bruïne, De Jong and Le Clair in : "De effectiviteit van CAD/CAM : het begin van een nieuwe industriële revolutie" (Intermediair, Amsterdam, 1983; kongresmap)

(2) These data were given orally. They appear remarkably high, but this may be due to different definitions.

*Summary of a report prepared by C. ROTTLÄNDER-MEYER, and A.J. NISSEN, Instituut voor social beleids-onderzoek, 's-Gravenhage.

- and there is some fear of conflicts with the unions (1).

Nevertheless, the same report shows that fifty percent of those questioned expect that CAD/CAM systems will become relevant for their companies within ten years. It should be noted, however, that this mainly voices the opinion of the larger companies. As the Siemens survey shows, future needs concern the fields of mechanical and electrical engineering, architecture, and a combination of these applications.

3. Industry and Domestic Production

There are no producers of CAD systems in the Netherlands. There is one producer of CNC machines and three producers of industrial robots. CAD/CAM service agencies are still limited in number. It is expected, however, that the rapidly growing market (estimate: 30-40% within four years) will stimulate production. At the moment R&D activities can be found in the fields of engineering databases, expert systems linked with artificial intelligence research, geometric modelling and information analysis.
An inventory of production activities shows a rapid development (2), but it is too soon to draw conclusions.

Recently, a research project was carried out concerning cooperation companies in the field of technological innovation (3). There are more than 120 institutions for cooperative activities (called 'collectivities'), with an estimated employment of 2 200 manyears and a budget of 300 million guilders. Approximately 75% of this budget is spent on R&D, which is the most important activity of these 'collectivities'. Furthermore, they organize seminars and conferences, pay attention to information and advice, and are active in the field of technology transfer.
The R&D expenditure results in the development of production processes

(1) IMECONSULT "Invetarisatie Nederland, vraaggesprekken en enquêteresultaten", Incad-project, 1980/81.

(2) TH Twente ; H. Huisman en J. Miedema, "CAD/CAM-systemen, en inventarisatie" -Vakgroep Produktietechiek, (rapport nr. PT 234, 1982)

(3) Twijnstra Gudde, "Collectiviteiten; een onderzoek naar samenwerkingsverbanden van bedrijven met betrekking tot the technologische ontwikkeling", Deventer 1982.

and attempts to standardize equipment. Much attention is also paid to energy and environmental problems.

4. Trade and trade balance

The Dutch share in the export of high-tech products shows a steady decrease from 1963 until now. In an article on the subject (1), Timman explains the difficulties of drawing-up a survey of the trade balance. Nevertheless, he provides the following information:

in 1982 the value of imported goods (computers, monitors, keyboards, etc) was over 3 000 million guilders; the value of exports was roughly 2,000 million guilders. The Dutch hardware-market itself was, in that year, estimated at 4,500 million guilders.

II. Social Impact

1. Impact on employment

No study is available on the specific employment impact of manufacturing automation.

From a general forecast at sectoral level, it can be seen that the only industrial sector expected to increase employment by 1995 is the electronics sector (2).

2. Impact on the organization of work

There is no overall picture of changes in the organization of work. In a recent report on automation and changes in working methods (3) it is concluded that it is still too early to identify these changes. For instance the change of work, made necessary by the introduction and

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(1) Th. Timman, "De informaticahandelsbalans", Intermediair 20/10; 9 March 1984.

(2) "Rapport werkgelegenheidseffecten micro-electronica" - SER/Raad voor de Arbeitsmarkt, 82/4

(3) Intervisie, "Nieuwe vormen van automatisering; veranderingen op de arbeidsplaats in the industrie", Den Haag, 1984.

use of industrial robots, is in practice multiform. The programming of CNC-machines can be done as well by the operator as by his direct supervisor. The only data known on the subject show that in practice 35% of the machines in use are indeed programmed by the operator.
In short, the report suggests freedom of choice concerning changes in the organization of work.

3. Impact on working conditions, safety and health

A study concluded that the only possible progress for employees in relation to production automation has to be sought in the improvement of health and safety, since employment will decrease in general and the content of tasks and responsibilities will be minimized (1).
Another study points to the danger fo a further centralizing of decision-making and a deterioration of the position in the labour market of elderly people, foreign workers, unskilled workers and women (2).
Only one research project has been published on automation and working conditions (3). The results of this point to the following conclusions:
- It appears that work satisfaction is hardly influenced by the degree of automation. There is some correlation between the content of tasks and satisfaction, but this is marginal. The general environment is much more important, as well as the organization of work.
- The machines are partly used as conventional equipment, which means that no optimal use has been reached yet.
- When asked, people show an ambition to enlarge the content of their tasks in terms of planning, programming and control. In practice, however, it appears that this does not take place.

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(1) De Jong (1983) Op. Cit.

(2) SER/Raad voor de Arbeidsmarkt (1982), Op. Cit.

(3) T.H. Twente; H.F. Mulder en B. Kamp, "Menselijke supervisie van geautomatiseerde systemen" - Vakgroep Produktietechniek (rapport nr : PT-224, 1982)

III. Government Policy in the Field of Manufacturing Automation

1. Promotion of R & D

The main governement activities in the field of manufacturing automation focus on the following aspects:

- the stimulation of applications by providing more information about technique and demonstration projects. Expenditure on these projects totalled 12 million Dutch guilders in 1983.
- Stimulation of development and production. In 1983, 250 million guilders was available for development.
- Strengthening of institutions for R&D and the transfer of knowledge.

In September 1984, the first yearly survey of policy activities was published by the Department of Economic Affairs (1) according to the report. The priorities of R&D promotion which were presented in the note "A Market oriented Policy of Technology". At the beginning of 1984 (R&D based on the needs of industry; co-ordination of research and education; stimulating of the Diffusion of Technological Innovation) have not been changed. However, the government R&D expenditure has not been increased.
The scheme for the stimulation of innovation ("INSTIR"), became operational in October 1984. In total, 1 100 million guilders is available to subsidize the costs of wages for companies in which innovatory R&D activities are carried out. This amount will be spent during the following five years. Moreover, the use of the "Technisch Ontwikkelingskrediet' (credit for technical developments) is stimulated and an inventory is made of existing systems of knowledge transfer, in order to facilitate the transfer towards smaller companies.

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(1) Tweede Kamer der StatenGeneraal, "Beleidsoverzicht Technologie; 1984-1985", nr. 18608, Staatsuitgeverij, Den Haag, 1984.

IV, Social Groups

It is worth noting that in the field of the production of software, hardware and turnkey systems various foundations and associations of producers have been set up. There are the previously mentioned collectivities, of which CIAD (1) is an example. This assocation, amongst other things, provides for a monthly test of CAD-equipment. Other associations are meant to look after the interest of their members, as for example the well-knows COSSO and VIFKA (2).

At this moment, no further information on specific employers'attitudes towards automation is available; the same can be said of the unions, and of political parties.

However, it is known that several political parties, as well as employers and unions, are involved in debates concerning technological developments and social change.

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(1) CIAD : Vereniging voor computertoepassingen in de ingenieurs praktijk (Association for the application of computers in the practice of engineering)

(2) COSSO : Vereniging Computer Service - en Software Bureaux (Association for Computer service - and Software Agencies)

VIFKA : Vereniging van Importeurs en Fabrikanten van Kantoormachines (Association of Importagencies and manufacturers of Office-machines)

UNITED KINGDOM *

I. TECHNICAL AND ECONOMIC ASPECTS OF MANUFACTURING AUTOMATION

1. The Spreading of Manufacturing Automation

Definitional problems make it very hard to gauge the precise extent of the diffusion of automation in manufacturing industry. A recent survey of over 700 firms in UK manufacturing industry examined the use of microelectronics in products and processes (1). The results of the sample firms have been weighted to give estimates of diffusion throughout UK manufacturing industry. They show that in 1983, 76% of UK manufacturing establishments were using automated controls on individual machines or processes, but only 16% were using integrated central control systems, 6% were using automated storage, 21% were using automated test and quality control equipment, 15% were using automated design systems, and 18% were using automated handling systems.

Furthermore, results from the survey establishments show that it is not the same firms which are using each application. So, although 25% of users in the sample were using microelectronics for centralised machine control or integrated process control or both, only 8% were also using it for design; only 7% were also using it for handling and testing and quality control or both, only 8 per cent were also using it for design; only 7% were also using it for handling and testing and quality control; and only 3% for all of these at once. These figures suggest that while individual processes in the factory are being automated, there is, as yet, little evidence of the kind of integration required for full Computer Integrated Manufacture (CIM).

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* Summary of a report prepared by Mr. Tim BRADY, Science Policy Research Unit, S.P.R.U., University of Sussex, England.

(1) NORTHCOTT J. and ROGERS P., Microelectronics in British Industry : The pattern of change, Policy Studies Institute, March 1984.

A recent survey carried out by International Data Corporation (1), suggests that 73% of all British engineering establishments do not have access to a computer. If the construction industry is excluded then 54 per cent of firms have no access to a computer. Only 7% of the firms used computers for graphics/design, 14% for technical/scientific work, and 27% for production control.

When considering individual components of automation one finds that something in excess of 3% of all machine tools in the UK are NC or CNO (2) in 1982. The Department of Trade and Industry indicated that there were 1,000 CAD systems (of all types including micro-based systems) by mid 1983 (3). CADSOURCE Ltd. estimated that in September 1983 there were 1,410 CAD systems in the UK excluding 8-bit microsystems and NC type preparation systems (but including applications in the construction industry) (4)

The latest figures on the introduction of robots from the British Robot Association suggest that here are over 2,500 robots in the UK in a variety of applications, the majority being used in welding and surface coating applications, and loading/unloading applications (for machine tools, injection moulding and press tools).

Diffusion of FMS has so far been slow in the UK although something in excess of twenty systems have already been installed or have received some payment from the DTI's FMS scheme and a further twenty projects have been approved but have not received their first payment yet. Other advanced automation systems have been installed in various establishments although they do not conform to the DTI definition of FMS.

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(1) Quoted in Technology, 11 June 1984.

(2) Source: Metalworking Production's "Fifth Survey of Machine Tools and Production Equipment in Britain", Morgan-Grampian, 1983.

(3) ARNOLD E., CAD in Europe, Sussex European Papers N° 14, 1984

(4) Quoted in CADCAM International, January 1984.

2. Industry and Domestic Production

The UK supplier position is not, on the whole, particularly strong. In 1981, only 18% of the output of the UK machine tool industry was CNC (1). Until recently the only indigenous supplier of numerical controllers was GEC - and they now license French designs. However, GEC is the UK market leader for programmable logic controllers (PLCs) which are increasingly being seen as a viable, cheaper alternative basis on which to build factory automation.

The UK robot industry has some 60 firms supplying or manufacturing robots in the UK (2). Of these, 27 manufacture robots of UK origin with another 6 manufacturing robots of foreign origin. The rest only distribute robots manufactured abroad.

The supply of CAD equipment presents a complex picture because there are so many different configurations of CAD and different end uses.
In 1984 there were over 140 suppliers of turnkey systems consisting of a package of hardware and software that should be complete and ready to use (3). The 140 firms include large computer manufacturers and software houses as well as specialist CAD suppliers and products range from 2-D drafting systems to multi-user supermini systems.
Roughly one half of the firms are supplying micro-based systems.
By 1984 there were very few UK-owned interactive graphics CAD suppliers (other than micro-based systems) - Racal, Ferranti, Marconi, CAE and Pafec.

Suppliers of FMS generally fall into three categories. The first is "machine-tool-up" in which a machine tool company is the main contractor. Firms like KTM, Cincinatti Milacon and TI Machine Tools fall into this category.

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(1) Source : Machine Tool Statistics 1982, Machine Tool Trades Association.
(2) 1984/85 Uk Robots Industry Directory, British Robot Association.
(3) 1984 Directory of CADCAM Suppliers, CADCAM International, November 1984.

The second is the "turnkey consultancy" approach whereby consultants design a system and may commission the various specialist firms - machine tool suppliers, materials handling suppliers, robot suppliers, etc. - to carry out individual parts of the installation while having overall responsibility for the implementation of the project. Firms like Ingersoll Engineers and Fairey Automation fall into this category. A third alternative, not very much in use yet, is to use software houses or computer manufacturers to act as main contractors in a "computer-system-down" approach. IBM and ICL are setting their sights on the factory automation business and are installing sophisticated manufacturing systems in their own factories to help build up expertise in this area.

3. Trade and trade balance

The UK supply industry is generally weak in world markets. Racal Radec exports the majority of its production of CAD equipment but the UK market is dominated by US turnkey suppliers like Computervision, Calma and Applicon. Although 33% of robots installed in the UK in 1984 were built in Britain, only 30% of these were worth more than £20,000, while 92% of European-made robots sold in Britain were over £35,000 each. Of the 679 robots installed in 1984, 225 were British-built, 221 were European, 163 were Japanese and 70 were American.

In 1981 the Uk had 4.7% of the world export market for machine tools. By 1984 this had gone down to 3.5%. The principal export markets were the USA and the "old empire" countries - especially South Africa, Canada and Australia. The major import sources are West Germany, the USA and Japan, the latter especially important for general purpose CNC machines. As yet there is no recorded export of an FMS from this country.

II. SOCIAL IMPACTS

1. Impact on Employment

As yet there are few examples of very advanced manufacturing systems in use in the UK. This makes it hard to assess social impacts.

The PSI research into use of microelectronics in British industry found that overall job losses directly attributable to microelectronics introduction were small in comparison to other causes of job losses. The majority of losses were unskilled shopfloor jobs. However the authors noted that :
"more advanced forms of automation, with microelectronics used in integrated systems for control of groups of machines or processes rather than individual ones separately, sometimes in combination with CAD, automated handling and storage, testing and quality control and use of robotics and other sophisticated equipment...may have significantly greater consequences in terms of job displacement than those mainly used hitherto". (1)

Another study concludes that "the evidence for job displacement due to FMS is not yet strong" and that much depends on the choice of implementation strategy adopted by the user organisation. (2)

A case study examined 30 establishments involving the introduction of some 100 robots. Using this sample as a base, the study estimated a diplacement of some 2,000 jobs in robot user firms and the creation of some 1,400 - 1,700 jobs in the UK robotics infrastructure.

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(1) NORTHCOTT J., ROGERS P. : "Microelectronics in British Industry : The Pattern of Change", Policy Studies Institute, 1984, pp. 76-77.

(2) BESSANT J. and HAYWOOD W. : "The Introduction of Flexible Manufacturing Systems as an Example of Computer Integrated Manufacturing", interim report, Brighton Polytechnic, 1985, (mimeo).

By 1990 the total job losses directly attributable to the introduction of robots would be in the region of 20,000 to 30,000.(1)

2. Impact on Skills

The use of advanced manufacturing technology requires new skills and different approaches to the organisation of work. Bessant suggests that there is a need for :

"flexibility as much as for new skills. As manufacturing industry approaches the process industry type of pattern, so there will be a shift towards small autonomous teams of multi-skilled workers with responsibility for overall monitoring and supervision rather than direct intervention in the plant". (2)

In order to get the best from new manufactururing systems more resources within firms need to be devoted to work organisation. One of the main barriers to the diffusion of AMT is the traditional organisation of work into strict departmentalised categories (3). One of the main benefits of examining the use of FMS or other advanced automation is the way it shakes management perceptions on work organisation "there can be no efficient use of costly and powerful technologies such as FMS" (4).

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(1) FLECK J., "The employment effects of robots" in Proceedings of the 1st International Conference on Human Factors in Manufacturing, 3-5 April 1984, IFS (Publications) Ltd. and North Holland.

(2) BESSANT J., LAMMING R. and SENKER P., "The challenge of computer-integrated manufacturing", Technovation (forthcoming, 1985).

(3) SENKER P., "Some problems in justifying automation" in Proceedings of AUTOMAN 1983, IFS (Publications) Ltd.

(4) BESSANT J. and HAYWOOD W., op.cit.

3. Impact on Working Conditions, Health and Safety.

Much of the debate on working conditions has revolved around whether automation has devalued the work of operators. Different findings emerge from a number of studies on work organisation.
There have been examples of automated machinery deskilling work and leaving the operators with boring routine machine-minded roles (1).

There are, on the other hand, areas where the introduction of automated equipment, in the form of robots, can be considered beneficial.
For example, there are instances when the working environment is hostile to human workers - paint-spraying foundry work, certain welding work, maintenance of nuclear power stations etc. - and the use of robots eliminates the exposure of humans to health and safety risks. There are no specific legislative measures covering health and safety of automated equipment. Rather, the Health and Safety Act 1974 is an umbrella covering all aspects of safety at work. However, there are numerous regulations which are more specific, so automated equipment is subject to many legal requirements. The Government body responsible for the inspection of factories, the Health and Safety Executive, has set up a special liaison committee to work with the robot industry. The HSE is training its inspectors on how to deal with robot installation under the terms of the present Health and Safety legislation. The Machine Tool Trades Association has published a code of practice drawn up in collaboration with robot manufacturers and users but it is in no way legally binding.

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(1) D. BUCHANAN, D. BODDY : "Computerised Equipment Controls in Biscuit Making : United Biscuits", Organizations in the Computer Age, Gower, 1983.

4. Education and Vocational Training.

The successful introduction of advanced manufacturing technology demands a totally new approach if the integration which is such an important factor in achieving full success is to be achieved. We have noted earlier that the traditional organisational set-up, the traditional craft-based shopfloor skills, the narrow departmental outlook of managers, and the narrow focus of engineers have to be changed to achieve computer integrated manufacture.

This change requires a fundamental reassessment of the education and training systems in the UK. Many commentators have compared the vocational training in the UK with that in other western industrialised countries and found it severely lacking. A recent report produced for NEDO and the Manpower Services Commission compares the position in the UK with that in the USA, Japan and West Germany (1). The authors point out that "the main thrust of the debate has been the avoidance of key skill shortage constraints to performance in high-technology product markets".

However, there is general agreement that in the UK there is a general lack of commitment to training throughout the economy. The problem is not restricted to initial training. A recent report from the House of Lords' Select Committee on Science and Technology (1985) notes that the Committee were "concerned at the levels of initial training; but they are gravely disturbed at the inadequacy of continuing training ... While recognising that some British companies have good retraining records, the Committee consider the average company's performance in this field ought to be improved".

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(1) National Economic Development Office, Competence and Competion, NEDO, 1984.

III. GOVERNMENT POLICY IN THE FIELD OF MANUFACTURING AUTOMATION

1. Promotion of R & D

The main thrust of Government policy is to assist research and development in AMT. There are two main arms to this assistance. The first is via the Science and Engineering Research Council (SERC) which supports post-graduate training and research in universities and polytechnics. One of SERC's main priorities is to encourage more collaboration between academic institutes and industry. One programme run by SERC is the robotics initiative, launched in 1980 to develop "second generation" robotic devices. By 1983 over £4 million from SERC funds had been committed to the programme involving 34 major partnerships between industrial and academic concerns. This scheme is now part of ACME (the Application of Computers to Manufacturing Engineering).

The second main arm is via the Department of Trade and Industry (DTI). The DTI has provided funds for R&D into AMT through a variety of different schemes which have recently been bundled together under the general title Support for Innovation (SFI). Several of the schemes under the SFI umbrella are designed to increase the use of advanced technology in UK industry by providing assistance to first-time users in the form of grants to cover all or part of feasibility studies and to cover a percentage of the installation costs of capital equipment and software. The CADCAM (Computer-Aided Design / Computer-Aided Manufacture), CADMAT (Computer-Aided Design, Manufacture and Test), CADTES (Computer-Aided Design and Test Equipment), FMS (Flexible Manufacturing Systems) and Industrial Robotics schemes fall into this category.

The longest running support scheme has been the Microelectronics Applications Project which began in 1978 which is designed to encourage the wider application of microelectronics in products and production processes in manufacturing industry. The Small Engineering Firm Investment Scheme was developed to assist small firms in the purchase technological advanced capital equipment. Finally the Government-assisted Alvey programme of collaborative research into new information technologies includes certain projects examining AMT.

IV. SOCIAL GROUPS

1. Policy of Employers' Organizations.

The employers groups generally would like to encourage the use of AMT to help achieve improved competitiveness. The Engineering Employers Federation (EEF) has asked the Government to provide more financial aid to encourage companies to develop and mnaufacture high technology products. They are particularly interested in changes in fiscal arrangements (tax credits, etc.) and increased research and development grants.

2. Trade Unions' Policies.

Trade Union Congress policy on automation is based on their general policy on technological change announced at the 1979 special conference and described in full in the report "Employment and Technology" (1). This document is still the main plank in TUC policy towards new technology. Within the TUC, the employment and technology group includes representatives of about twenty unions. The group was originally set up following the 1978 TUC Congress and was responsible for the formulation of the "Employment and Technology" report. Since then, the group acts mainly as a forum for policy on technological developments.

3. Collective Agreements and Labour Disputes.

A recent report by PSI found that shopfloor and trade union opposition was rarely an important factor when managements decided on how and when to introduce new technology - "only one factory in 17 sees the opposition from the shop floor or trade unions as a very important problem" (2).

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(1) TUC "Employment and Technology", 1979.

(2) NORTHCOTT J. and ROGERS P. : "Microelectronics in British Industry : The Pattern of Change", Policy Studies Institute, 1984.

Collective agreemnts on new technology have generally been made by the white-collar unions rather than blue-collar unions. Often these agreements concern the introduction of CAD.

There have been a few problems wtih different unions claiming responsibility where the introduction of new technology challenges traditional patterns of work organisation. For example, there has been conflict between the white-collar AUEW/TASS and the blue-collar AUEW/Engineering Section as to who carries out programming of advanced machinery. However, the electricians trade union, the EETPU, wishes its members to be responsible for maintenance of advanced electronic equipment whereas the employers would like to use technicians who belong to other unions.

However, the fact that many trade unions and workers have accepted that the introduction of new technology is almost inevitable has meant that there have been few major disputes.

TERMINOLOGY

CAD : computer-aided design.

The capability of a computer to be used for automated industrial, statistical, biological, etc., design through visual devices.

CAM : computer-aided manufacturing.

Manufacturing of products where the main production processes are pre-programmed and performed automatically.

CAD/CAM : computer-aided design/computer-aided manufacturing.

Systematic combination of computer-aided design and computer-aided manufacture where - in principle - the design model could be tranferred automatically into a respective manufacturing process. CAD and CAM systems are usually connected via a central data base.

CAE : computer-aided engineering.

Automatic computing of problems related to the engineering realization of computer-aided designs.

CAPP : computer-aided process planning.

Automatic computation of planning procedures for carrying out complex processes.

CIM : computer-integrated manufacturing.

The integration of the major areas of manufacturing technology by a centralized, decentralized or distributed processing system. These areas are: design, storage and retrieval of information about the parts being manufactured (group technology, manufacturing resource planning), materials handling, control of CNC devices or single-purpose machinery and robots.

CNC-machine tool : numerical controller.

Machine tool controlled by computer capable of carrying out complex operations in a manufacturing process.

FMS : flexible manufacturing system.

Automated set of programmable machine tools operating in real time, controlled by a hierarchy of computers, linked by a materials-handling system that carries workpieces from one machine to the next and directed by a mainframe computer which is programmed to operate the tools in a specified sequence. Specialized soft- and hardware - CNC devices, robots - enable small quantity production, enhanced productivity and quality and create a more personal working atmosphere. Such systems can also run for hours without intervention.

N.C.-robot : numerical control robot.

Manipulator which can execute the commanded operation in compliance with the numerically loaded working information such as positions, sequence or conditions.

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