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PROGRAMME ON INDUSTRIAL AUTOMATION OF THE CAPITAL GOODS INDUSTRY OF LATIN AMERICA

Report of a Meeting of International Experts,
Vienna, Austria, 27-28 November 1989

Working Papers in Industrial Planning
No.3

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WORKING PAPERS IN INDUSTRIAL PLANNING

The papers presented in this series have been produced by the UNIDO secretariat or by outside experts in the course of the technical co-operation activities carried out by the Industrial Planning Branch. The series contains selected papers that are believed to be of interest to a wider audience. They are often of an exploratory and tentative nature, presenting issues for discussion, and do not necessarily reflect the official views of UNIDO.

Preface

At the recommendation of the Latin American and Caribbean Group (GRULAC), UNIDO is undertaking a Regional Co-operation Programme for the Industrial Recovery of Latin America and the Caribbean. In the framework of this request, a preparatory assistance has been carried out by the Industrial Planning Branch to formulate a regional programme on industrial automation of the capital goods industries of Latin American countries.

The preparatory assistance included an official mission of a consultant on capital goods to seven countries of the region, the preparation of a project concept for discussion with potential counterparts, the elaboration of a draft project document, and the organization of a meeting of international experts on capital goods and industrial automation technologies.

The present report contains the proceedings of the Meeting of International Experts on a Programme on Industrial Automation of the Capital Goods Industry of Latin America, which was held at UNIDO Headquarters in Vienna, Austria, on 27 and 28 November 1989. It is presented in the series of Working Papers in Industrial Planning, issued by the Industrial Planning Branch, since the global topics presented and discussed should be of benefit also to other readers interested in industrial automation issues.

Contents

1. ORGANIZATION OF THE MEETING

1.1 Introduction

The Meeting of International Experts on a Programme for Industrial Automation of the Capital Goods Industry in Latin America was convened at UNIDO Headquarters in Vienna on 27 and 28 November 1989. It was attended by international experts from Latin America (Argentina, Brazil, Colombia, Mexico and Venezuela) and Europe (Federal Republic of Germany, Italy, France and the United Kingdom). UNIDO staff members from the Regional and Country Studies Branch; Area Programme Latin America and Caribbean; the Division of Technologies, New Manufacturing Technologies Unit also participated in the Meeting. The list of participants is attached as annex 1.

At the recommendation of the Latin American and Caribbean Group (GRULAC), UNIDO is undertaking a Regional Co-operation Programme for the Industrial Recovery of Latin America and the Caribbean. In the framework of this request, the UNIDO Industrial Planning Branch has proposed to carry-out a special project for the capital goods industries of the region, oriented to promote the systematic introduction of industrial automation technologies in the production processes. This proposal was made taking into account the experience gained by the Industrial Planning Branch of UNIDO in the implementation of capital goods technical assistance projects in Mexico, Colombia, Venezuela, as well as the outcome of several sectoral analysis of the industry (issued as UNIDO documents), on the situation of the capital goods industry in the Latin American Region. Finally, the Regional Project on Capital Goods, implemented by the UNIDO/ECLAC Joint Division of Industry and Technology, as well as the four expert group meetings organized by UNIDO and ECLAC, have provided the technical justification to recommend this programme.

The proposal can also be seen as the outcome of different programmes, projects and activities developed by UNIDO in the field of industrial automation at regional and inter-regional levels.

1.2 Opening session

Mr. A.A. Vassiliev, Deputy Director General of the Department of Industrial Operations of UNIDO, welcomed the participants who attended the Meeting of International Experts. He expressed his appreciation to the experts for their interest in collaborating with UNIDO in the formulation of a Regional Programme on Industrial Automation of the Capital Goods Industry in Latin America. He briefly described the importance of the programme for the Latin American countries, and the important role industrial automation technologies are playing to change the face of the industry at world level. The statement of Mr. Vassiliev is attached as annex 2 to this report.

1.3 Election of officers

The participants elected Mr. Luis Gustavo Florez, Vice-President of the Colombian Federation of Metal-Working Industries, FEDEMETAL, as Chairman and General Co-ordinator of the Meeting.

1.4 Agenda and programme

The participants adopted the programme of the Meeting as attached in annex 3.

1.5 Documents

The list of documents distributed for the Meeting is attached in annex 4.

1.6 Adoption of the report

The report of the Meeting was adopted by the participants on 28 November 1989.

2. DEVELOPMENTS OF THE MEETING

2.1 Overview of the issues of industrial automation in industrialized countries

2.1.1 Professor J. Bessant, Brighton Polytechnic Centre for Business Research, United Kingdom.

Competitiveness in the future will depend not only on price factors but also on a range of non-price factors, better design, better quality, shorter lead times, better delivery performance, more customization, more frequent product innovation, etc. Meeting these needs, whilst also hoping to make productive use of inputs of capital, energy, labour and materials represents a major challenge to manufacturers.

Advanced manufacturing technology appears to offer a solution to this problem. In particular, it can be applied across a spectrum ranging from simple substitution to innovation ("doing new things in totally new ways"). As we move towards more radical innovation (characterized by integrated systems such as CAD/CAM or flexible manufacturing systems), the benefits in the efficiency of one operation or function contribute towards improvements in overall organizational effectiveness. Examples include shorter lead times, lower inventories, higher quality and better customer service.

Evidence suggests strongly that achieving these benefits is not straight forward and requires careful attention to the implementation process. In particular, such changes place great emphasis on the need for a strategic approach.

With these background points in mind, some issues are raised which should be considered in the development and shaping of any programme designed to suport and promote industrial restructuring through technology. These include:

- The need to see technology as a total system involving not only hardware and software but also the organizational dimensions. The experience of many firms is that it is possible to make extensive improvements through minimal investment in hardware but with substantial organizational changes along the lines of just-in-time manufacture and total quality management. Any support programme should show this aspect.

- The development of a strategic framework is another prerequisite for successful innovation. Once the enterprise has a clear view of its business strategy (what products for what markets) it needs a manufacturing strategy which sets out how these goals will be achieved.

- A key component of such a strategy is a step-by-step approach to innovation. Whilst the long-term goal may be a radical, highly integrated facility, the short-term progress towards it may involve small increments of change. Such an approach allows for organizations learning and accumulating technical and management expertise with which to deal with increasingly complex technology.

- Many firms may need assistance (particularly smaller enterprises) in identifying what sources of assistance (technical, management, etc.) are available and likely to be of use to them. There is a role for what can be named an "innovation consultant" whose task is to assist firms in the innovation process by helping them articulate problems and by establishing the necessary contacts between the firms and the relevant sources of assistance. The key contribution of an innovation consultant is to make what are often passive assistance programmes (which require the firm to take the initiative) operate in more pro-active fashion.

- Evidence from policies used in other countries to promote the adoption and diffusion of advanced technologies stress the requirement for experts information and assistance in all aspects of selection and implementation. Such consultancy support has two main advantages: it transfers skills/knowledge to the firm rather than hardware and it puts the firm in a better position to assess the appropriativeness (or otherwise) of proposed investments.

- Given the emphasis (above) on organizational change and development, such consultancy programmes should extend into the management and organizational change areas and not to be confined to technical support.

- The value of the "demonstration effect" in diffusion of innovations is well-documented. Its relevance to a support programme is that it creates a low cost, low risk opportunity for firms to explore a technology and provides them with some information with which to negotiate with sales people "pushing" particular solutions.

  Two kinds of demostration facilities have been of value in industrialized countries:

  (a) The financial support of early uses of a technology within a sector on condition they make available their facilities as a demostration for other firms in the sector; and

  (b) The setting-up of centres where potential users are encouraged to try different versions of the same technology. Such centres are often equipped by suppliers in anticipation of future sales.

- Financial support for investments, especially in key building blocks (such as CNC tools), and targetted at smaller firms.

- Education and training to provide the necessary human resources. A key role here would be the creation of specialist courses to upgrade technical and (importantly) managerial skills without the need for firms to lose key people over extended periods of time.

- Mobilization of effective co-operation between industry and universities, polytechnics and other key institutions.

2.1.2 Dr. R. Rabellotti, Bocconi University, Milan, Italy

Dr. R. Rabellotti has presented the work undertaken by Professor R. Camagni, Bocconi University Milan, Italy.

The concept of technological trajectory, defined as cumulative and self-generating directions of technical development, has recently been applied to the study of the diffusion of flexible automation processes in the manufacturing industry.

This concept is a very interesting one, as it highlights an element that is often overlooked in the literature: namely, the deep dependence of the trajectory itself from constraints coming from the economic, managerial and institutional sphere. Not only these factors operate as "selectors" in the start-up phase of the new "paradigm", but then also determine the pace, time, form and direction of the aggregate diffusion trajectory in the development and maturity phase, interacting deeply with purely technological factors.

At the micro level, the diffusion of these complicated production systems is a difficult "learning" process, and in particular a "creative" one, which highly limits the possibilities of easy imitation processes.

At the aggregate level, the adoption of flexible automation processes may prove to follow a previously unexpected direction: while small and medium sized firms were supposed to be natural receivers of these technologies on the basis of simple technological considerations (and namely of the flexibility and "covertibility" characteristics of these machines), it appears up to now that mainly big firms, operating in mass productions like automobile and electrical appliances, have adopted them idely, exploiting their "versability" characteristics (i.e. the possibility of working on different pieces in random sequence with the same equipment).

The persistence of scale economies at the factory level, even if in the new form of economies of joint production or economies of "scope"; the risk of losing elasticity in dimensioning the volume of production over time; the necessity of integrating robots in complex networks of computer controlled production systems; the importance of organizational and strategic implications of the new technologies/all these and other reasons may hamper a faster diffusion of these technologies among small and medium scale enterprises.

A second hypothesis that looks worth testing is that the efficiency of the investment in flexible automation processes highly depends on the general adoption philosophy. A simple "substitution" philosophy, mainly pursued through the installation of "standalone" robots and CNCs, may soon reach a limit in the productivity performance. A second stage of "production integration", exploiting synergies among the different components of the production system may push this limit upward. The third stage of "strategic" or "systematic" integration among different functions of the firm may reach the best effort/performance ratio.

On the basis of what we are about to say, it seems to make it absolutely necessary to assess the true effectiveness of this technology's penetration in an advanced region's industry. For this reason we have carried out a study on the Milan area, with the help of Assolombarda, by sending a "light" postal questionnaire to all the enterprises associated (4,052 in number) also asking their reasons for not adopting, or eventual adoption of new technologies in the following years.

From the distribution of answers divided into groups based on their size it also transpired that adoption in enterprises with less than 100 employees is to be considered either as an exception or as a manifestation which is still largely experimental) or linked to simplified technologies (simple mechanical arms of "pick-and-place").

More interesting are the adoptions by medium-sized enterprises generally characterized by the fact that they operated in advanced technological sectors, and therefore with an interesting electronic know-how at their disposal.

Therefore, the adoption of flexible automation technology is still nowdays a phenomenon largely limited to the medium-sized and large enterprises.

These results have allowed us to reach some conclusions which we consider important, and to confirm some first hand perceptions and hypotheses which we had matured beforehand and which are contrary to many beliefs which are quite consolidated in the flexible automation field. In the following paragraphs we will point out the most important elements, which are interesting because they could open new ways of redefining strategic industrial policies in our country.

(a) The flexible automation processes which have a considerable effect on a company's performance are complex systems, which involve a difficult and slow learning process and specification in each one for company courses.

(b) The complexity of these systems not only follows technological type elements but more important organizational type elements.

(c) In addition to the previous statements, it seems extremely difficult to transmit the technological know-how from one enterprise to another and the "imitation" proces is therefore very limited.

(d) With regards to the reasons behind the adoption of flexible automation, the reduction in the cost of labour and the increase in productivity are the most widespread.

(e) The effects of technological advance on the enterprises' performance depends on the level of complexity of the sytems adopted, and the degree of learning of their characteristics on the part of the enterprises structure.

(f) The technologies in question are naturally equal to production and saving labour. However, the major increases in productivity are accompanied by a large expansion in turn-overs more than in a reduction in employees.

If we want to synthesize the results of our research into the diffusion of flexible automation systems in the Lombard and Milanese industries, we could say that we found ourselves faced with extremely difficult, slow and complex processes. The contrary of the sensations that one could feel if we only took note of the quantitative data regarding the diffusion of these advanced systems of production.

In fact, successful adoptions involved a long internal "learning" process, reorganizational processes and strategic reorientation, all elements which make it possible for only the large enterprises, or smaller enterprises operating in important sectors and therefore accustomed to the problems of advanced electronic technology, to continue on the road to flexible automation.

The difficulties which obstruct the rapid diffusion are certainly of a technological nature; in Italy there is still not widespread know-how in terms of worker and technology, and the flexible characteristics of the new processes cannot easily be compared to the flexibility which is persuable in the small enterprises with traditional process and manually controlled machines. However, the greatest difficulties still seem of an organizational type, linked to the integrated and integrating nature of new technologies. In fact, they represent integrated production planning and design systems; they involve new professional figures and new organization structures; they require the ability to programme the production sales flow which is certainly superior to that of most of our small enterprises.

Moreover, with the aim of taking full advantage of these technologies, it is necessary to be flexible and strategically sensitive, to be able to avail oneself of the new differentiating potential of segments of its market and to renew the enterprise and the image of its product as a whole.

Nevertheless, the way to flexible automation seems to be indispensable nowadays to relaunch the manufacturing industry in advanced countries.

2.1.3 Professor W. Massberg, University of Bochum, Institute for Automation Technologies, Federal Republic of Germany

The co-operation between university and industry plays a key role in the introduction and optimization of new industrial automation technologies.

The application of the well-organized university resources as educational potential for industrial management, conforms a very important and effective tool for the optimal introduction of new technologies in the industry.

The research and development potential of university laboratories, if well oriented by an apropiate feedback of the industry, could be the motor for new technological developments as well as for the optimization of the existing ones.

Having this concept of university-industry relation in mind, we can point out the following high priority needs and deficits of the industry:

Needs	Industrial deficits
Diminishing of dependency from imports	Poor infrastructure
Decentralization of industrial working places	Lack of capital
Improvement of employment	Lack of know-how
Processing of raw materials in the country	Qualification of personnel

Needs	Industrial deficits
Installation of small-size industries	Lack of raw materials
International competitiveness of products	Shortness of energy
Improvement of social situation	Legal restrictions
Better supplies to population	Poor plant organization

Using the potential of the university some of these deficits could be solved by the application of:

- Continuous educational programmes
- Technology transfer activities
- Consulting activities
- Adoption of new technologies

As a result of our experience in the field, we could propose the following list of priority-finding steps for co-operation industry-university:

(a) Field studies:

Basically through interviews with:

- Governmental planning institutions
- Managers of production plants
- Lower education institutions

(b) Analysis of university potential:

Including:

- Scientific staff
- Laboratories and equipment
- Relevant curricula
- On-going research and development activities
- Reputation of graduates

(c) Definition of new careers and the lay-out of curricula and research and development activities

The above mentioned three steps conform what we have defined as an objective oriented project planning.

Field studies in small and medium size industries

- Scope of products, order lot size, through-put times, complexity, own or foreign design, market conditions, quality standard of products, competitional situation.

- Plant organization, management structure, organizational bottle necks, logistical systems.

- Human resources, number of workers, qualification profile, qualificational bottlenecks.

- Resources (material, tools, machines), state-of-the-art of plant equipment, plant internal information processing, application of new technologies, computer applications, computer-aided applications, infrastructural bottlenecks.

- Innovation activities (product and/or processes).

- Bottlenecks caused by legal regulations (e.g. import or export restrictions, currency problems).

In all these fields it would be necessary to develop co-operation projects between university and industry.

Execution steps for a regional technology transfer project:

(1) Fact finding activities of participating universities (analysis of actual state-of-the-art of local industries)

(2) Identification of deficits in industrial development

(3) Identification of resources for technology transfer participating universities can offer (know-how, research and development capacity, equipment)

(4) Exchange of information about available resources between all participating institutions (atlas of regional resources)

(5) Co-ordinated development of technology transfer programmes (educational programmes, Research and Development activities, continuous education programmes, post graduate courses, workshops, congresses), development of adopted measures

(6) Acquisition of regionally co-ordinated transfer programmes by the participating universities

(7) Realization of a first technology transfer conference between universities and industry on transfer fields, methods and curricula

(8) Finding of priorities for local transfer measures

(9) Nomination of industrial pilot partners for any participating university. Objective-oriented planning for any project

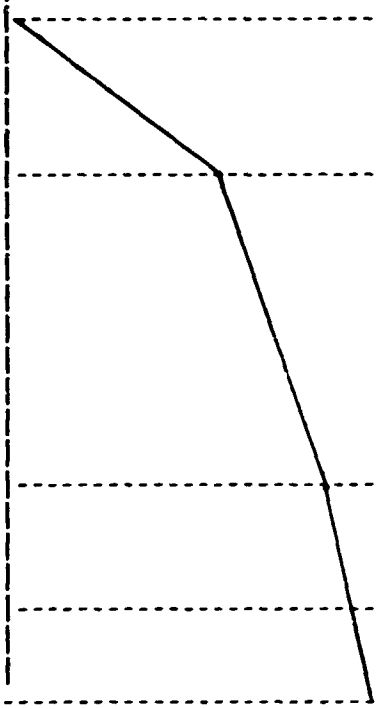
(10) Realization of the pilot projects (eventually with international co-operation)

(11) Exchange of experiences with a second technology transfer conference

(12) Comprehensive evaluation of all subprojects. Execution of a final project conference. Publication of results

Project objectives

- Development of small and medium size industries
- Small capital investment for high improvement of productivity

Gradient of productivity increase	Capital investment	Measure
	LOW	Productivity and flexibility improvement by computer aided organizational measures (CAPP)
	MEDIUM	Intensive qualification measures for managers and collaborators. Subject: product innovation; process innovation; introduction of computerized tools in different plant departments; preparation of CNC-applications
	HIGH	Installation of CNC-machines, machining centres and manufacturing cells/islands
	VERY HIGH	Installation of CAD/CAM and CIM

2.1.4 Professor Y. Bouchut, Lyon II University, Fran

The new features of:

The market;
The customers;
The labour force; and
The energy and materials

produced a new industrial environment.

This means we need:

(a) New responses: Objectives:

- Satisfying customers
- Cutting manufacturing costs
- Better training and qualification profile

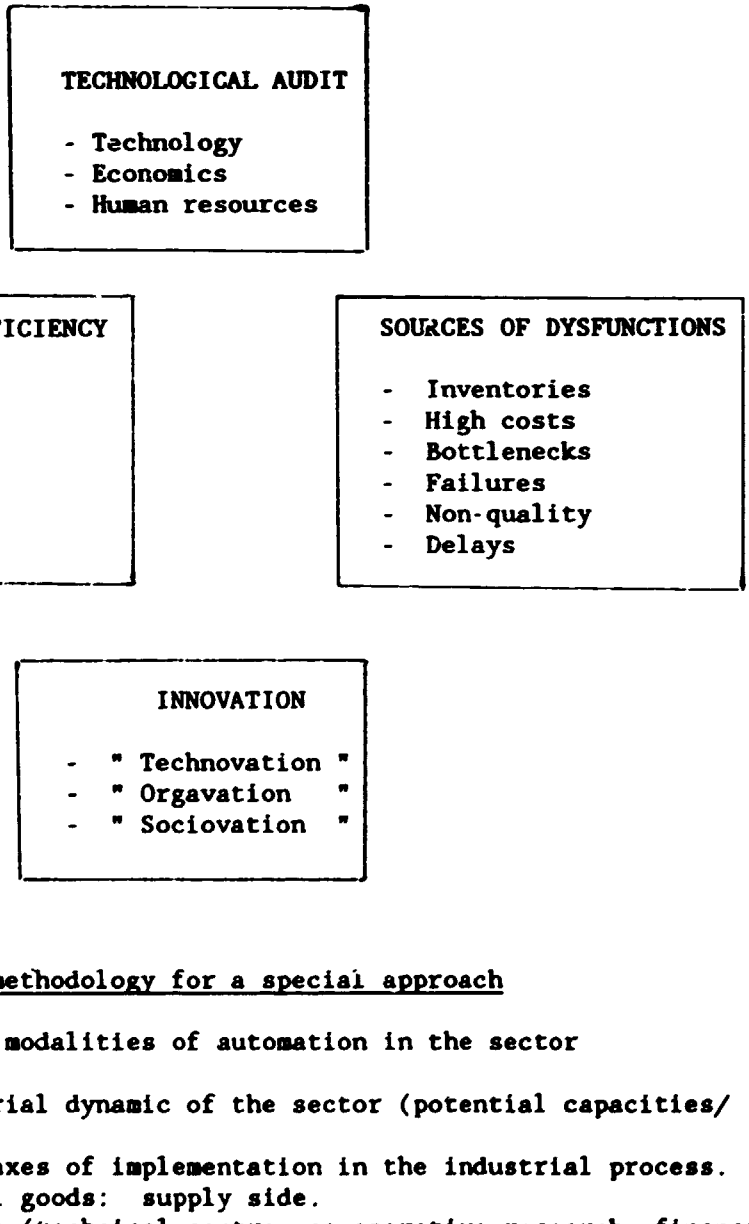
The means:

- New rules for production and management (JIT, MRP, TQC)
- New capital goods (all the CA"X")
- New communication rules (LAN, CIM)

Key words:

- Productivity
- Quality
- Flexibility

(b) New methodology:



Industrial automation: methodology for a special approach

(a) Technological modalities of automation in the sector

- The industrial dynamic of the sector (potential capacities/ deficits).
- Different axes of implementation in the industrial process.
- The capital goods: supply side.
- How to help (technical centre, co-operative research, financial subsidies, technical assistance)?

(b) Economic assessment of automation

- Automation and productivity.
- Labour (direct/indirect) saving.
- Investment decision and procedure of choice.
- Automation and quality (product, production process).
- Automation and efficiency.

(c) The organizational and social prerequisit for automation:

- Automation and employment.
- The organizational barriers.
- Automation, qualification and training.
- Automation and information.

2.2 Overview of the issues of industrial automation in Latin American countries

2.2.1 Professor P. Spinadel, University of Buenos Aires, Argentina

After the middle of this century, the demand for mass-produced manufacturing goods started to decline and many manufacturing industries were obliged to produce customized products. The new market requirements asked for medium to small batch series of products, this means a need for flexibility in the production. The conflict between flexibility and productivity had to be overcome.

With the introduction of the microprocessor, the situation of dependence between the progress in computerized manufacturing and the advances in information technology hardware (storage capacity, data processing time, reliability, cost, etc.) changes considerably and most interest was focused on developments in software and communication aspects.

The logical follow-up of the manufacturing process, will be the use of computer technology tools from the moment of production conception, according to market information, to its final delivery to the customer. In contrast with the traditional automation, in which a chain of inflexible, special purpose equipment was installed to deal with the mass production of relative homogeneus products, the new automation technologies are flexible and applicable to a wide range of machine building operations.

The success of this concept called Computer Integrated Manufacturing (CIM) will depend on the manner the separate technologies will be connected. Until now the development of industrial automation has been done in a considerably fast and therefore very chaotical way. But the automation requires a system idea, beginning at the single production task and reaching the global concept of the plant layout.

The key to a successful implementation of CIM is the understanding of relationships between production objetives, technical components and the organisatory structure of the factory.

The introduction of CIM issues, like most of the new developments, has been done mostly in such a way that none of the expected results has been reached and new problems have arisen.

The fast explosion of the area and also a lot of general information articles presenting CIM as "the panacea", or "the solution to all your problems", or "the factory of the future", has originated a lot of wrong concepts.

We will try to point out some of them:

- We are talking about CIM and not CIAM (Computer Integrated Automated Manufacturing).

- It would be better and more realistic to refer to CHIM (Computer and Human Integrated Manufacturing) and not about CIM.

- CIM is a concept, its application is different in each enterprise.

- The first effect in introducing CIM is always an increase in the production costs for a short time.

Two steps must be taken into account when introducing of CIM technologies:

(1) The first step must be a deep study of the structure of the industry and the enterprises. This study must be made in a top down way, beginning at the managment level and ending at the shop floor.

(2) The second step should be the acquisition of a decision support software at the management and intermediate levels, which will be responsible for the information flow in the plant and for a support for the medium and long-time production planning. In most of the cases, however, the first step has been the introduction of automation elements at the lower level, without consideration on the future developments and the need for a communication with a central system, or in the cases where this communication exist, about the compatibility of the different elements. This always leads into very expensive special developed solutions like protocol adapters, post-prossesors. etc.

Some ideas about the introduction of organizational changes and automation technologies in the Latin American countries

Considerable gains in efficiency could be obtained by the adoption of contemporary methods for factory organization, planning and scheduling and production control, as well as appropriate subcontracting policy.

In the last years, the developed countries have been involved in the correction of mistakes already made in the introduction of automation in a chaotic manner. Actually, many industries in developing countries are still involved in this correction process. This is the reason why we are now at the best moment to try, with a guiding consulting activity, to learn about these errors and not only avoid the increase of the technological gap, but if we make our way intelligently, also to reduce it.

The key will be to (change) optimize the organizational structure of the industry, trying to, on one side, stimulate the introduction of cooperative systems, avoiding hierarchical structures; and on the other side to understand the industry as a whole complex model, where the bottlenecks and possible deadlocks have to be determined.

With this concepts in mind, some important elements must be avoided at the preparation phase, some necessary previous studies and also some of the project steps are listed below:

Avoid:

- Do not simplify the problem to a "machine purchase", this will never be a solution but only a larger problem. If one introduces a computer in a chaotic system, one obtains a "computerized chaos".
- Do not believe that all the increases in productivity are caused by automation, most of them are originated at a change in the organizational structure required for the introduction of a flexible automation.
- Avoid the confrontation between capital and labour, by creating awareness programmes with trade-union leaders, progressive entrepreneurs and the policy-makers group.
- Avoid negative reactions caused by the utilization of wrong terms. Most of the correct expresions like CIM, automation, structure change are not seen in a positive content.
- Avoid short-term programmes that will bring competitiveness based on temporal factors like low loans, tax benefits and so on.
- The programme must be based on technological changes and better working conditions through a better distribution of the resources.

Study:

Analyze the production market in order to select specific areas, trying to:

- Assure a "cascade" effect in the production.
- Introduce advances in industries that could act as pull-up or motor.
- Maximize the direct and indirect benefits in the local society.
- Promote a local technological development through selected imports.

Do:

- Give impulse to the bilateral transfer and communication between industry and university.
- Generate industry clubs that will support local technology transfer centres, implemented as external institutes in the universities.
- Develop training programmes at all levels.
- Use practical demonstration of new technologies (video, PC).
- Encourage inter-disciplinary teams.
- Create a regional information system to allow a better contact between the already existing institutions and projects.

2.2.2 Dr. D. Chudnovsky, Consultant on industrial automation and capital goods, Argentina

The Latin American manufacturing industries and specially the capital goods producing branches have to restructure the inherited physical and technological capacity and move into a more flexible, updated and competitive industry.

In this process of industrial restructuring it is very important to take advantage of the organizational innovations and automation technologies in industry, that are currently available. These technologies, when appropiately incorporated, are powerful tools to increase productivity and enhance competitiveness.

However, to be able to take advantage of these technolcgies it is of upmost importance to introduce them as part of a process of factory reorganization in which the layout is modified, the internal production process is reorganized, total quality control is introduced, workers and technicians participation is sought, inventories are reduced, etc. These organizational changes are key issues in modifying the firm and it is in this process that flexible automation technologies are very useful.

To be able to suggest concrete ways of introducing these organizational changes, it is important to study the current situation and experiences in Latin American countries regarding the adoption of flexible automation technologies.

To be able to modernize capital goods producing firms in Latin America, a programme aimed at training the management of the factories with those new organizational and technological developments is extremely useful. At the same time, it is important to develop a local consultancy capability to be able to assist domestic firms in the difficult task of choosing and introducing in a successful way these technologies.

While given priority to the diffusion of these organizational and technological developments, the possibilities of increasing local production of the hardware and software needed for incoming products should be seriously considered.

In the case of Argentina, a report prepared by myself on diffusion of automation technologies shed some light on the situation in the country ("The diffusion of electronics technology in the capital goods sector: The Argentine case", UNCTAD/TT/66, 1985).

As in the case of industrialized countries, NCMTs constitute the automated machine-building technology that has received the widest diffusion. The technology is in use not only in large firms producing oil equipment, nuclear equipment, ships and heavy electrical equipment but also in medium and some small firms producing agricultural machinery, pumps, valves and auto parts.

The motivations of the user firms in introducing the technology do not seem to concur with what is found in the industrialized countries. Although the initial wave of the adoption of technology through imports took place in 1979-1981, when wages were relatively high and imported capital goods very

cheap on account of the overvalued domestic currency, the fact that NCMTs continued to be installed afterwards in a situation of relatively low wages indicates that capital-labour substitution has not been the main reason for the adoption of the technology, as is found in the industrialized countries. In the case of large users fabricating complex equipment, NCMTs are acquired for technological reasons insofar as the product to be manufactured makes the use of this technology almost imperative. In this connection, it is important to bear in mind that the technology is introduced not in a rational context but in connection with reduced labour costs that have been achieved via shorter machining times, and in this way some capital-labour substitution may take take place, though not with the intensity in the industrialized countries.

In analyzing the diffusion of NCMTs, the local production of these items cannot be overlooked. Proximity to the supplier and the reputation of the indigenous producer in the domestic market with conventional machine tools are factors that have facilitated the purchase of this equipment by medium and small firms. Despite the small scale of production and giver the fact that key component items (e.g. the electronic control unit) are imported, prices of locally made lathes are not vey much higher than imported lathes.

Insofar as the pioneer firm in this field has entered into the manufacture of more advanced lathes and machining centres under licensing agreements and a newcomer has emerged with NC equipment of its own design, it is clear that local production of NCMTs is gaining momentum in the country. Given the critical situation of the balance of payments because of the debt burden, it is likely that imports of NCMTs will be more restricted than in the recent past, making domestic production of this equipment a profitable venture. In view of this fact, the degree of protection to be given to domestic producers, the duration of such protection and the extent of domestic participation (including in respect of electronic components) are key issues on which decisions have to be taken.

Regarding CAD, although some diffusion has already taken place among a small number of large firms, the high cost of the technology has prevented a more siginificant diffusion. The experience of the user firms seems to be rather encouraging with respect to the technical advantages of the technology. However, the economic justification for using CAD/CAM in a country with low wages for drafting and design personnel is rather dubious, unless other benefits, including less quantifiable ones, compensate for this situation.

It is nevertheless likely that CAD/CAM will continue to be diffused in the future, and there is some scope for indigenous production of software. The possibility of using some cheap CAD/CAM systems for programming NCMTs should be explored because this is an area in which the domestic market will certainly become significant.

In the case of robots, despite the very low wages of unskilled labour and the high level of unemployment in the country in recent years, this technology, which basically replaces unskilled labour in repetitive operations, is being introduced though in a very limited manner in the metalworking industry.

In the case of automotive producers, the logic of its introduction is linked to the transnational character of the parent firms to which the Argentine subsidiaries belong and to the commitment of these TNCs to use robot technology not only in the industrialized countries but also in the semi-industrialized countries - even those in which no significant export operations are envisaged.

The other side of the coin is that a leading new technology is being introduced into a country for reasons linked not to labour costs but to consistency of product quality and the improvement of working conditions. This clearly leads to the possibility of indigenous developments in this field. The efforts made by the local metalworking company studies and by the French motor car company, though having a different rationale, are an indication that there is room for the development of a technology policy in this area. Under the present economic conditions, robots should receive less priority than NCMTs and CAD/CAM.

2.2.3 Dr. J.R. Tauille, Deputy Director of the Institute of Industrial Economics, Rio de Janeiro, Brazil

The objective of this presentation was to evaluate the results of the principal investigations conducted in recent years on the socio-economic implications of microelectronics-based automation in Brazil, which originally were issued in Cepal Review No. 36, December 1988 (pages 49-59).

These investigations focused on the quantitative and qualitative impact produced on labour and on patterns of accumulation by the dissemination of microelectronics-automated equipment in Brazil; the link between external restrictions, automation and employment; the relationship between microelectronic automation and competitiveness and lastly, an evaluation of the main socio-economic questions inherent in the dissemination of the microelectronic technical base in Brazil.

Brazil entered the 1980s with an industrial base of large proportions and with a reasonable degree of complementarity in the production system, from consumer goods to sophisticated producer goods used for producing other capital goods. For at least three decades, using essentially electromechanical techniques, Brazilian industrialization was reflected in high rates of economic growth, averaging about 7 per cent per year. Throughout this period, growing numbers of workers were incorporated into the production system, becoming consumers. In spite of this, income distribution grew worse, to the advantage of a population class which became smaller and smaller in number and more and more wealthy.

Thus the constant improvisations necessitated by technical changed implied a fairly versatile labour force that could enable a previously existing quasi-handicraft-agricultural technical base to co-exist with an electromechanical base that was being established. In these terms, highly skilled workers created concrete possibilities for the installation and functioning of a manufacturing base which is already one of the eight largest in the world.

The existing lag between a reasonably developed economy which is beginning to work with the microelectronics base and a labour legislation which goes back to the origins of import substitution in Brazil should be reduced, if not eliminated.

In addition to higher levels of capital productivity resulting from industrialization, this also guarantees even greater returns through the simple relative devaluation of work. In fact the electromechanical technical base that had been established with the industrialiation of Brazil is comparably more productive from the capitalist point of view than the quasi-handicraft base that had existed in the past. Moreover, much of the equipment installed by multinational enterprises had already been depreciated in its countries of origin and was being "revived" for a new accumulation cycle. The rates of profit related to their new utilization were thus potentiated, in view of the fact that in the numerator the fixed constant capital, referring to equipment, had been reduced to almost zero.

Entrepreneurs and production managers who are experimenting with equipment using the new technical base are coming to realize that they must be able to count on a more reliable, and therefore more stable, labour force.

This would seem to mean that there is a way to negotiate new capital-labour relations in Brazil. It is not clear how much progress can be made within this context, mainly because much of the industry is still developing in the traditional way and is being led by entrepreneurs with a conversative mentality and faults rooted in the long period of authoritarian rule which the country underwent recently. What is beyond question is the urgent need to make sure that the technological evaluation of the production apparatous is based on improved and more compatible social relationships.

The second conclusion to be drawn, related to the integration of industrial and technological policies, is an attempt to maintain (and, if possible, to improve) the competitive capacity of Brazilian industry and also to promote a policy of effective technological training in the country, with a view to long-term economic and social development.

The technological jumps produced by external factors to the dynamics of the local economy should be avoided at least until labour legislation is brought up to date, so as to avoid creating distortions even greater than those mentioned. On the other hand, it is to be hoped that there will be a social appreciation of local labour and consequently a gradual increase in real wages. Enterprises will probably try even harder to make their production processes more efficient and more modern. This means that there will be a continued incentive for the dissemination of manufacturing automation technologies since it is essentially through increased productivity that enterprises will be able to maintain their profitability.

This continuous increase in demand can be met in large measure by the local production structure, provided that there is sufficient incentive to make the necessary investments in research and development, in increased production capacity and, over the long term, even in the import of producer goods or particularly strategic production methods for the ordered development of the industry. What must be avoided is the situation in which

the industrial sectors thus encouraged (principally enterprises of foreign origin) enjoy the benefits of an oligopoly as a result of the fact that protection of the market does not fulfil its objectives. In other words, after a period of implantation, production in the leading industrial sectors should be, if not at the advanced level of the international state-of-the art, at least within the range of costs that are compatible with those prevailing on the international scene.

It would thus be possible to avoid excessive and unnecessary acceleration of competitive capacity in Brazilian industry and an effort would be made to ensure the necessary preservation of the capacity to produce and to design the equipment using the new technical base, particularly if account is taken of the long term, when such goods will no longer be the vanguard and will become the standard of technology, and beyond this, when the producer goods of today become the durable consumer goods of tomorrow. What would be happening would be the formation of a professional culture appropriate to a modern, democratic, social-welfare country. The strategy is to preserve in Brazil the forms of work which have the highest value-added among those related to the incorporation of the new technical base, since in this way the country would not only cease to export high-price jobs but also would be creating, at least in this sphere, a better-distributed income structure, which would have a dynamic effect on the internal market. In the final analysis, Brazil will also be preparing and training from now on, a labour force capable of dealing (through production, design, programming or operation) with the future forms of material production.

2.2.4 Dr. E. Romero, CONDIBIECA, Caracas, Venezuela

Electronics in Venezuela: the background situation

The characteristics of the industrial structure resulting from the import substitution model applied in Venezuela appear, at first sight, rather unfavourable of the development of a modern electronics industry.

Until the mid-seventies the electronics industry consisted of a few dozen final assembly plants belonging to foreign affiliates or local firms under license for the production of consumer goods, such as black and white TV and audio equipment, and of some simple instruments with a market in the construction industry, such as fire alarms. It never went far beyond "screw driver assembly", component production was limited to items such as small transformers or some simple capacitors; not even resistors or transistors. Production was strictly for the domestic market. In spite of idle capacity, the industry never exported, nor could it even consider it: the over-valued bolivar determined by oil exports rather than industry made labour costs very high, ruling our assembly-type exports in general.

If those were the conditions of the traditional electronics industry, the situation in the electro-mechanical industries, which worldwide were in the process of becoming microelectronics-based, was even weaker. Only in telecommunications would one find the beginnings of production of some peripheral equipment, under schemes, however, that were quite unusual for the country. In other areas there was practically nothing. Apart from one firm

assembling telex machines, there was no office equipment production of any sort (no typewriters, no cash registers, no calculators and, of course, no computers). Neither was there any machine-tool production. In fact, to this day, the bulk of the capital goods sector in Venezuela could be said to have avoided all "moving parts". It produces mainly structures for its oil and construction industries and ovens, vessels, pipes and valves for the processing industries.1/

This lack of development of the engineering industries is both the result and the cause of a serious absence of skills and experience in precision mechanics. This constitutes a considerable handicap for the manufacture of almost all electronic consumer goods as well as for the most types of computer peripherals.

With such a panorama it would have seemed that there was no hope at all of developing a domestic electronics industry with a reasonable degree of competitiveness. Yet, even at that time, three were some indications of new possibilities: two firms, quite different from each other and quite different from the usual import substitution model, pointed towards a fruitful new direction.

One of them was MCM (today MICROTEL), set up in 1970 by two young electrical engineers. This firm brought to market a PBX of their own design, one of the first fully electronic in the world. The product succeeded in penetrating the domestic market, overcoming the traditional mistrust of local technology. It was later exported in small quantities to various countries and then manufactured under joint-venture arrangements in Ecuador, Argentina and Mexico. To design, export and license technology abroad was almost unheard of in Venezuelan industry at the time.

The other uncommon occurrence was MAPLATEX, a firm set-up in 1974 for the production of telephone sets. It was founded by a local private group with engineering capacity, but they soon had to reach a joint-venture agreement with the National Telephone Company, to become, in fact, a "monopoly-monopsony" in telephone sets. Although at first sight it was a typical import substitution project under Ericsson Licence, MAPLATEX was determined to go beyond final assembly. It did, in fact, end up manufacturing. product: an electromechanical dialing etc. Eventually, all metal and plastic parts were made in-house, including precision screws. Only few parts, about 3 per cent, were either imported or sub-contracted locally. This excessive degree of integration stemmed from two factors: the lack of adequate local suppliers and a zero defects requirement which demanded quality inspection of all parts. It was made possible by a deliberate increase in scale achieved by standardising down to a single-model,

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1/ The availability of oil-derived financial resources privileged and facilitated the import of capital goods to set up protected production of final consumer goods. Until the early 1980's there were no special incentives to manufacture capital goods in the country.

single-colour telephone set for the whole country. This still did not make the industry truly competitive for experts (mainly because of the over-valued bolivar) but with subsidies they did manage to place some of their excess production abroad at cost.

Ten years later, in 1986, next to MICROTEL and MAPLATEX, there were nearly 100 professional electronic firms, mainly in telecommunications and instruments, growing at a rate of 27 per cent a year, with over 100 products of their own design, 14 of which were being exported in small quantities. Among them were around five foreign-based firms and some locals working under license. But the great majority were young local ventures started by electronics engineers and manufacturing product applications of their own design.

Further down, these firms will be discussed in some detail. Here, we mainly want to point out some of the factors that might explain the flourishing of small innovative firms in an environment which has apparently not been very conducive. Besides the main enabling factor, which is, of course, microelectronics technology itself, with its "LEGO-like" applications possiblities, the favourable conditions in Venezuela have been:

(a) The existence of a significant pool of qualified human resources in the engineering design end. There were 10,000 graduates in electrical, electronics, computer and systems engineering in Venezuela in 1985 (that is, one out of every 1,500 inhabitants); many of them with graduate or post-graduate degrees in some of the best universities abroad.

(b) The high exposure of the population to technological advances, from the mid-seventies to the early eighties. The very strong bolivar and the correspondingly high salaries allowed an unusually large proportion of the Venezuelan population to travel abroad to study. Equally the booming conditions brought heavy migration flows from the whole spectrum of classifications. This included technicians and highly qualified professionals from Europe and southern Latin America.

(c) In parallel with the above, the availability of oil derived resources led to a very rapid uptake of information technology by both consumers and managers. So, in general the professional elite is familiar with information technologies and has equipment requiring services.

(d) After 1983, the drastic devaluation of the bolivar against the dollar (three times a 100 per cent since then), has driven down all labour costs, including that of highly qualified personnel, as well as all other local costs.

To these "environmental" conditions, the Government added some incentives and tariff protection, but this generally happened only when firms were already of some significance or when foreign investors wanted to enter the market. One incentive that has played some role for some products is the policy of preferred access to the public sector market, which included the national telecommunications company, the oil industry, electricity, etc.

2.2.5 Dr. E. Garcia, Director of the Centre of Computer Manufacturing Technologies, and Dr. F. Jaimez. Director of the Graduate and Research Division, Technological Institute of Monterrey, Mexico

Centro de Tecnologia Avanzada para la Produccion (CETEC)

The campus of Monterrey created the Advanced Technology Centre for the Production (CETEC), as an answer to the actual situation.

The main objectives of the CETEC include:

- To be a support centre for the postgraduate studies of the Monterrey system.
- To identify the most adecuated technological areas for a new development and to spread it into the industry.
- To prepare the human resources capable to develop and operate these technologies.

The investigation areas of CETEC:

Technological area:

- Robotic and automation
- CAD
- Informatic
- Integrated manufacturing
- Electronic systems
- Telecommunications

Export support area:

- Total quality control
- International markets

Activities of the technological development centres

(a) Centre for Automation and Industrial Process Control

Courses of continuous education in industrial process control. Consulting services and development of research projects in the fields of automation, digital control, instrumentation, robotic and systems.

(b) Centre of Manufacturing Systems

Computer aided research and development of manufacturing engineering activities in the fields of: design, manufacturing process, production engineering, materials engineering, automation, metrology, standardization and control.

(c) Centre of Industrial Development

Research of the innovation, development and administration processes. Exchange of technological information between the enterprises and the research centres in order to promote the technology transfer process.

(d) Centre of Development of Computer Technologies

Development of algorithms, procedures and innovative technologies for their use at industries and service providing institutes.

(e) Centre of Electronics and Telecommunication

Research and development in the fields of interactive television, satelital communication, digital electronics, electro-optica and design and manufacturing of printed circuits.

(f) Centre of Informatic Research

Research and development in the fields of artificial intelligence, distributed systems and software engineering. To use this elements as an impulse for the technological development and as a basis for the higher educational levels.

2.3 Proposal for a Regional Programme on Industrial Automation in Latin America

2.3.1 Dr. L. Pineda-Serna, Industrial Planning Branch, UNIDO

The diffusion of automation technologies will profoundly influence industrial production in general and the capital goods industry in particular. This impact is already significant and will gradually reach further subsectors and industrial processes. Since all countries belong to the same economic environment, this means that industrial automation technologies will influence to an increasing extent the industry in Latin American region, including in those countries that have no plans to automate industrial production for the foreseeable future. In some ways, this process causes a threat to these countries since the industrialized countries, through their ability to develop and apply advanced technologies, will be able to re-establish the competitive advantages in areas where Latin American countries have been able to compete successfully so far and even become experts, such as textiles. But the use of industrial automation technologies also offers new oportunities since it is a substitute for skilled labour and managerial capabilities which might be scarce in some countries. It will be possible through a well conceived industrial automation policy to find adequate response to the international market development.

Consequently, Latin American countries must try to find adequate and feasible responses in good time to the challenges offered by industrial automation. They must have a profound assessment of their own capacities and capabilities. They must define clearly their priorities and formulate dynamic strategies in the light of future trends. Such strategies can also include a review of product lines less likely to be influenced by further automation.

On the basis of the assessment, priorities and strategies that are defined, a technological policy related to an industrial automation strategy must be elaborated. It is essential that a clear-cut distinction be made between the application of new technologies and the production of the corresponding hardware and software. It should be recognized that widespread diffusion might lead to indigenous production later.

The justification for a Regional Programme as proposed by UNIDO can be seen considering the following issues:

(a) A number of new industrial automation technologies (e.g. CNCMTs, CAD systems, process robots) are already commercially available at reduced prices and with an increasing reliability, while other technologies (e.g. FMS) are still in the development stage and are expensive and not very reliable.

(b) Technological progress in this field is very quick, making possible new developments like assembly robots or CAD systems for personal computers that will facilitate further diffusion of the technologies. However, the process of integration of several industrial automation technologies is not without major problems and, therefore, predictions about commercial applications of these systems have to be carefully evaluated.

(c) Despite the technological maturity, reduced prices and increasing reliability of these technologies, the process of diffusion, although very significant in the last ten years or so, is:

- Not as rapid as originally expected;
- Very uneven at country, industry and user firm level; and
- Has been implemented with a varied degree of success.

These features of the diffusion process are mostly explained by differences in country and firm experiences, though the uneven maturity of the technology in question also plays a role.

However, when successfully implemented, industrial automation technologies have proved to be an extremely powerful instrument to increase labour, and in some cases capital productivity. Moreover, they are useful in adapting the manufacturing assets and the product mix of the firms to the changing circumstances of the environment in which business is conducted, as well as in increasing the international competitiveness of the industry and firm in question.

(d) The successful implementation of industrial automation technologies requires not only the incorporation of the relevant technological hardware and software, but also, and fundamentally, requires the development of an "industrial automation culture" through a number of organizational changes at plant level to rationalize the production process and the relationship with suppliers and clients. Moreover, a careful training of the relevant blue collar and white collar personnel to take advantage of the new technologies, adequate maintenance and repair skills and an expected market for the products to be produced with these technologies, allowing a relatively quick amortization of the investment in question, should be carefully planned.

If the introduction of industrial automation technologies is not done as part of a process of restructuring of the production management of the firm, the technology as such will not lead to any significant increase in labour productivity. When introduced as an integral part of a process of serious plant reorganization and industrial restructuring, industrial automation technologies can be a powerful tool to facilitate the reorganization process and increase the production efficiency at task, shop, plant and industry levels.

(e) Despite the reduced prices of industrial automation technologies, the adoption of these technologies is normally an expensive investment (when compared with conventional machines and/or labour costs). Furthermore, these technologies require considerable repair and maintenance skills that are not easily available, especially in developing countries. Therefore, it is more likely that big firms with adequate financial resources will be the early adopters of these technologies. However, small firms with an adequate market for their product (e.g. subcontractors) are also likely adopters.

It is true that one of the great advantages of flexible automation is that it makes the production of small batches in discrete manufacturing as economic as was the production of such batches with conventional machines. It is also true that user firms need to have a substantial aggregate volume of production to be able to amortize the higher investment.

(f) Although industrial automation technologies are adopted for many reasons, such as reduced lead time, quality consistency of the product, greater possiblities of product variety, and better management control of the production process, there is no doubt that cost reduction through labour saving is an important consideration for adopting these technologies. In the case of Latin American countries with low wages for skilled and/or unskilled personnel, it is extremely important to examine the extent to which reasons other than reduction in labour costs per unit of output can have a greater influence in the adoption process of these technologies.

On the other hand, the impact on the skill structure is an important variable to be taken into account. In countries with skilled labour shortages (of machinists, design and draughting technicians), the introduction of, for example, CNCMTS and CAD systems may be used for leap-frogging in the field of machining and especially of designing.

(g) Given the rapid diffusion of some industrial automation technologies and the importance of having a local supply of these technologies to facilitate the after-sales service and hence reduce the repair and maintenance skills, the entry into the production of these technologies is quite important for those countries having a substantial development of the engineering industries if they wish to participate in the most dynamic segments of the industry and remain competitive. However, despite the availability of technology sources and cheap electronic components, the barriers to entry into the production of the most mature and diffused industrial automation technologies are significant, leading to higher production costs and less reliable equipment in the case of indigenously produced equipment and hence hinder the not only well-trained personnel and adequate design, production and marketing skills which are needed, but a careful analysis of the degree of domestic integration of mechanical and electronic hardware and of the software must be made, as well as a determination of the minimum volume of production in competitive products required to be supplied to the domestic and, eventually, to export markets.

It is clear from the above that the impact of industrial automation technologies in the capital goods producing industries of Latin American countries is a very important issue to be carefully considered.

The advances already made by some Latin American countries in manufacturing capital goods products will become more fragile and not sustainable in the long run. At the same time, the entry into the production of more complex capital goods will become more difficult unless these industrial automation technologies are applied. Hence, to remain outside this crucial technological development will only contribute to a further marginalization of the countries from the key manufacturing activities.

The advantages of Latin American countries in the production of capital goods based on low wages for skilled and semi-skilled labour can easily be eroded by the introduction of flexible automation technologies in the industrialized countries.

While it is true that industrial automation technologies do save labour and hence may have a negative impact on the employment of current capital goods production, it is also true that in many cases such production will remain competitive and thus viable in the long run only if these technologies are successfully implemented. On the other hand, and taking into account the skilled labour intensive nature of engineering production, skilled labour released from production of the engineering goods most affected by the technologies in question may eventually be employed to foster the production of other capital goods.

The less rapid diffusion of these technologies than originally expected should not lead to the conclusion that the impact is slowing down. On the contrary, this less rapid diffusion is an opportunity for Latin American countries to remain competitive in the production of capital goods and to benefit as soon as possible from the introduction of these technologies.

Despite the uneven diffusion process of these technologies in the engineering industries of industrialized countries, there is no doubt that their application in the manufacturing process of many capital goods is becoming imperative if the manufacturer is to remain competitive in this segment of the world economy.

The development objective of the UNIDO project would read:

> "To foster development of the capital goods industry in Latin American countries through an adequate and programmed introduction of industrial automation technologies. This requires the formulation of a technology policy to create the necessary domestic capacities in the form of human resources and managerial capabilities through e.g. training, demonstration and other high technology centres as vantage points for an industrial automation policy in the capital goods industry."

To guarantee the achievement of the development objective, the following immediate objectives should be also reached:

(a) To set up in the countries a capacity to provide direct technical assistance and specialized professional services to enterprises which decide to introduce automation technologies.

(b) To provide decision-makers in enterprises at different levels of the public and private sector with the necessary information for a rational automation policy through:

(i) Knowledge of the technological requirements for upgrading the capital goods industry to improve the use of installed capacity and increase productivity; and

(ii) Knowledge of the impact of industrial automation on specific branches of the capital goods industries with particular emphasis on the implications for training of human resources, management skills and know-how requirements.

The programme would be implemented in the following steps:

Step 1

An immediate measure to be taken would be to select priority areas. Tentatively, such priority areas could be:

(a) Country case studies to define the sectors most likely to benefit from automation programmes as well as studies of the impact of such programmes on the national economy and on the traditional financial, educational and social structure.

(b) Explore the possibilities to set up awareness centres for training, promotion and consulting.

(c) Specific projects arising from the awareness programmes to develop human resources, notably managerial capabilities, but also measures to sensitize policy-makers, users and service industries.

(d) Re-orient national capital goods programmes in the countries of the region, to benefit fully from industrial automation technologies.

Step 2

The priority activities should be undertaken according to national capabilities and facilities that are already available in Latin American countries. It is, therefore, necessary to identify those areas which can be extended and expanded into fully fledged regional and subregional projects by means of pooling of country resources as well as through outside technical assistance.

The project proposal of a regional programme (in Spanish) is attached as annex 5.

3. CONCLUSIONS AND RECOMMENDATIONS

3.1 Conclusions

The meeting concluded that the issue of industrial automation technologies is beginning to have a significant impact on the capital goods industries of Latin American countries. Moreover it is one area of technological and organizational changes which helps to improve the competitive position of enterprises through more operational flexibility, and project development.

The Latin American countries must be able to face the challenges of:

- Growing competition in the domestic market due to the policies that several Latin American countries are implementing regarding tariffs and non-tariff restrictions.
- Reduced state purchases and modifications in the public procurement legislation aimed at giving lower preferences to locally made goods.
- Stiff competition in foreign markets and the need to upgrade quality, improve after sales services and reliability of the goods produced to be able to increase exports.
- Increasing the long run competitiveness of production in both domestic and foreign markets on the basis of dynamic comparative advantages instead of policies, based on reduced real wages and devaluated currencies.

The Latin American industries and specially the capital goods producing branches have to restructure the inherited physical and technological capacity and move into a more flexible, updated and competitive industry.

In this process of industrial restructuring it is very important to take advantages of the organizational innovations and automation technologies that are currently available in the industry. When appropiately incorporated, they are powerful tools to increase productivity and enhance competitiveness.

Consequently, Latin American countries must try to find adequate and feasible responses in good time to the challenges offered by the organizational innovations and automation technologies in the industry. They must have a profound assessment of their own capacities and capabilities. They must define clearly their priorities and formulate dynamic strategies in the light of future trends. Such strategies can also include a review of product lines less likely to be influenced by further automation.

To be able to take advantage of these technologies, it is of upmost importance to introduce them as part of a process of factory reorganization in which the layout is modified, the internal production process is reorganized, total quality control is introduced, participation of workers and technicians is sought, inventories are reduced, etc. These organizational changes are key issues in modifying the firm productive performance and it is in this process that automation technologies may be very useful.

From the discussions with the international experts and the review made above, it is possible to reach some preliminary conclusions and suggest some special issues that deserve closer attention.

First: To reach a clear picture of the situation of the organizational innovations and automation technologies in the industry of the Latin American countries, it is required to undertake country case analysis on the state-of-the-art of their diffusion at firm, sectorial and country level. These studies should take into account the implication on development, quality of work, human resources, real wages and other social standards, in order to obtain a clear picture about the objectives and motivations that companies in the private and public sector can have in the introduction of the organizational innovations and automation technologies.

The implementation of automation technologies in the industry requires a strategic framework as a prerequisite for successful industrial innovation. Once there is a clear view of the business strategy, a manufacturing strategy should be formulated on how to achieve the industrial innovation goals. This strategy should include the incorporation of relevant technological and organizational hardware and software. On that basis an organizational environment should be created at enterprise level to optimize the introduction of new technologies. If the introduction of industrial automation technologies is not done as part of a process of restructuring the production management of the firm, the technology as such will not lead to any significant increase in labour productivity.

Second: The Programme on Industrial Automation in the Capital Goods Industry will require the identification of existing needs at country level, especially related to the macro-economic policy adopted, the role of public and private companies, and the dynamic comparative advantages which can arise in the process of modernization. This will require a careful planning and programming of the strategies to be formulated, adopted and implemented in the countries of the region.

Third: The Programme should identify those capabilities already available in industry and trade associations, industrial organizations, universities and research centres, as well as the experiences gained by UNIDO in the implementation of capital goods projects in the Latin American countries, and the programmes that the governments and private institutions have already established on this subject.

Fourth: The formulation of this Programme should closely consider, at the firm level, not only the legal aspects of technology transfer but also the negotiation of technology. Special attention should be given to the preparation of a methodology for the unpackaging of industrial automation technologies, considering the priorities and selectivity that the countries will require in the introduction of these technologies. In view of the different levels of development of the capital goods industry in Latin America, the Programme should give priority to those countries in which the need for introduction of organizational innovations and automation technologies can be seen as a way into entry in the production, and/or upgrading of the technological capabilities already available in the industry.

Fifth: The justification for a programme on organizational innovations and automation technologies in the industry should consider the inter-sectoral linkages of the industry. In order to identify the possible impact on the whole industrial system due to an increase in the capital goods production, the programme should take an integrated approach taking into account the production/consumption systems.

Sixth: Evidence from policies applied in industrialized countries to promote the adoption and diffusion of advanced technologies, stresses the requirement for experts assistance in all fields of selection and implementation of organizational innovations and automation technology in the industry. Such consultancy support has the advantages of transfering skills and knowledge at the firm level and it puts the firm in a better position to assess the appropriateness of the new investment needed for he organizational restructuring or for the acquisition of software or hardware. The Programme should include this issue as being of paramount importance in its execution.

Seventh: Education and training to provide human resources should play a key role in the Programme, through the creation of special courses, seminars, workshops and study tours, to upgrade technical and managerial skills. Mobilization of effective co-operation among universities, research centres and other key institutions, from industrialized countries, as well as countries of the region should be strengthened.

3.2 Recommendations

Based on the conclusions of this International Meeting, the Experts strongly endorsed the need to design a project document based on the UNIDO proposal, and suggested the following recommendations:

First: Given the importance of organizational change in the restructuring and modernization of the manufacturing sector, and the fact that those changes not only are of great relevance to the capital good producing industries, UNIDO should consider the possibility to include other industrial branches in the Programme in addition to capital goods.

Second: To prepare a project document by the end of 1989 entitled "Programme for Improving the Industrial Performance in Latin American Countries" (Programa para Elevar el Desempeño de la Industria en America Latina). The document should be negotiated with potential counterparts in the Latin American countries.

Third: To call for a new meeting to be held tentatively from the 2 to 5 April 1990 at the Headquarters of UNIDO, Vienna. This meeting shall analyze the revised version of the project document.

Fourth: To include for discussion in the agenda of the next expert group meeting, the key role and scope of activities of the potential local counterparts in this Programme.

Fifth: To submit the final document to the potential donor countries.

Annex 1

List of participants

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Annex 2

STATEMENT BY THE DEPUTY DIRECTOR-GENERAL
OF THE DEPARTMENT OF INDUSTRIAL OPERATIONS

On behalf of the Director General of UNIDO, I would like to welcome you and express our sincere gratitude for your presence in this meeting to our headquarters in Vienna. The issues to be discussed are of paramount importance for the Latin American countries in the process of modernization of their industrial sector, and specially of their capital goods production.

The world is going through a technological change, that 20 years ago only science fiction writers were able to foresee. This new technological revolution has a profound impact on the interdependence in the world economy. Developing countries, in particular, will loose their competitiveness if they are not prepared to introduce substantial changes, and to carry-out restructuring programmes with the objective of modernizing selected industrial sectors.

In the capital goods industry we witness how the industrial automation technologies are facilitating the introduction of new production processes and new managerial capabilities. In the case of Latin America, The Department of Industrial Operations of UNIDO has been involved in the last years in projects in the capital goods industry in Mexico, Colombia, Venezuela and in the formulation of industrial restructuring programmes in Venezuela, Mexico,Costa Rica and Peru. The specific aim of these projects has been to promote the development of machinery and equipment production and the modernization of the industrial sector. In these projects the technology content has always played a very central role. However we feel that the countries of the region to a large extent, have not yet realized the scope of the transformation that the capital goods industry is facing, and will continue to face in the years to come.

For this reason our Department has recommended a Regional Programme on Industrial Automation of the Capital Goods Industry in Latin America, within the framework of a concrete request made by the missions of Latin America and the Caribbean, GRULAC, to UNIDO.

The production process of capital goods, especially those made in small batches, will be strongly influenced by the diffusion of industrial automation technologies based on microelectronics and informatics. These technologies not only tend to save labour, but also to provide other substantial benefits to firms applying them. If this diffusion is faster in industrialized than in developing countries, then the existing gap will widen and the competitiveness of machinery producers in developing countries will be reduced. In this case the anticipated share of developing countries in the global capital goods production is likely to be even smaller than their present position would warrant.

In the case of Latin America the actual and potential consequences of the introduction of industrial automation technologies are not too well known. Automation is, in some cases, seen as a threat to further industrialization of the countries of the region and even to their present production of capital goods, due to factor-saving character biases and cost reductions associated with the use of the new technologies. On the other hand, given the skill-saving character of some industrial automation technologies, they probably provide new opportunities for Latin American countries which they should try to exploit. The objective of the present meeting is actually to increase the knowledge on these issues in order to guide country and firm strategies and UNIDO support activities.

The proposed Regional Programme on Industrial Automation of the Capital Goods Industry in Latin American Countries should foster the development and growth of capital goods production in the countries of the region through an adequate and programmed introduction of new information based technologies. This requires the formulation of strategic plans and technology policies to create the necessary domestic capacities in the form of human resources and managerial capabilities through, for example, training and demonstration and other technology centers as vantage points for an industrial automation policy in the capital goods sector.

The regional programme on industrial automation in Latin America should be designed:

- To set up a capacity for giving technical assistance and specialized professional services to enterprises in Latin American countries, which decide to introduce automation technologies.

- To provide decision makers in enterprises and policy makers at different levels of the public and private sector with the necessary information for a national automation policy. This will require:

  First: Knowledge of the technological requirements for upgrading the capital goods production by improving the use of installed capacity and increased productivity,and

  Second: Knowledge of the impact of industrial automation on specific branches of the capital goods production particularly of the implications for management skills, human resources and know-how requirements.

We are convinced that your experience of the subject and of the Latin American countries will be an excellent asset in the discussions in these two days. UNIDO will certainly benefit from your contributions, and more important, for your possible further involvement in the Regional Programme.

I express my appreciation that you have accepted our invitation to attend this meeting. I wish you very successfully deliberations.

Thank you.

AGENDA

MEETING OF INTERNATIONAL EXPERTS ON A PROGRAMME FOR INDUSTRIAL AUTOMATION OF THE CAPITAL GOODS SECTOR IN LATIN AMERICA

Vienna, 27 - 28 November 1989

Monday, 27 November

8:30	REGISTRATION
9:30	Opening Session Mr. A.A. Vassiliev Deputy Director General Department of Industrial Operations Mr. M.H.A. Hamdy, Director Industrial Institutions and Services Division Department of Industrial Operations
10:30	Coffee break
10:45	Introduction to the meeting: Objectives, methodology, presentation of participants Mr. B.O. Karlsson, Head, Industrial Planning Branch Programmes, projects and activities of selected industrialized countries in the introduction and diffusion of industrial automation technologies. Experiences of relevance for developing countries. Discussion leader: Mr. B.O. Karlsson, UNIDO Professor R. Camagni, Bocconi University, Milan Professor W. Massberg, University of Bochum, F.R.G. Professor J. Bessant, Brighton Polytechnic, Centre for Business Research, U.K. Professor Y. Bouchut, University of Lyon, France
12:30	Lunch

15:00 Meeting with delegates of Latin America and Caribbean Missions to UNIDO (GRULAC).

Programmes, projects and activities of selected Latin American countries in the introduction and diffusion of industrial automation technologies.
Discussion leader: Mr. L. Pineda-Serna, UNIDO
Argentina: Dr. Daniel Chudnovsky, Consultant and Ing. Pablo Spinadel, Universidad de Buenos Aires
Brazil: Dr. Jose Ricardo Tauille, Deputy Director, Institute of Industrial Economics, Rio de Janeiro, Brazil.
Colombia: Ing. Jose Demetrio Martinez, National Director UNIDO Capital Goods Project.
Mexico: Dr. Eusebio Garcia, Director, Center of Computer Manufacturing Technologies, Instituto Tecnológico de Monterrey.
Venezuela: Ing. Edgardo Romero, CONDIBIECA

Proposal for a regional programme on industrial automation in Latin America
* by L. Pineda-Serna, Industrial Planning Branch
- The situation of the capital goods industry in the region
- The techno-economic conditions of the industry
- The need for modernization/restructuring of the industrial sector
* Report of field mission on project concept by Ing. Luis Gustavo Florez, Consultant to UNIDO

Operational aspects of a Programme on Industrial Automation of the Capital Goods Industries in Latin America. Financial implications, training and equipment requirements. Profile of the counterparts.

17:00 Closing session

Tuesday, 28 November

9:00 Draft report of the meeting: Issues for inclusion in the Latin American programme on Industrial Automation of the Capital Goods Industries.

10:30 Coffee break

10:45 Round table of discussions: Possible issues for a UNIDO programme on industrial automation in developing countries and other regions. Production vis-a-vis diffusion. The productivity impact. The employment impact. Modernization/restructuring. The technology transfer.

12:30 Closing session

Annex 4

Handouts for the participants

1. Concepto de proyecto: "Programa regional de automatizacion industrial del sector de bienes de capital de America Latina" - Documento de discusion - Revision I, ONUDI, Viena, 2 de noviembre de 1989.

2. CAD/CAM systems for small and medium scale engineering industries in selected ESCAP developing countries. Report of a workshop organized by UNIDO and ESCAP in co-operation with TECHNONET-Asia, Singapore, 9 - 20 May 1988. Working papers in industrial planning No. 1, IO.28, UNIDO, Vienna, 23 March 1989.

3. Production and use of machine tools in selected developing countries. Report of a Seminar, Milan, Italy, 14-22 October 1987, PPD. 81, UNIDO, Vienna, 25 May 1988.

4. Planning and programming the introduction of CAD/CAM systems. A reference guide for developing countries (photocopy), UNIDO, Vienna, 18 May 1989.

5. Basis for a project on planning and programming the introduction of industrial automation technologies in the capital goods production of developing countries, ENG.AUTO/SEM.8/R.56, UNIDO/ECE, Geneva, 13 June 1989.

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CONCEPTO DE PROYECTO

"PROGRAMA REGIONAL DE AUTOMATIZACION INDUSTRIAL
DEL SECTOR DE BIENES DE CAPITAL DE AMERICA LATINA

Documento no oficial
solo para discusión
sujeto a cambios de forma
y fondo

REVISION II

Viena, 21 de noviembre de 1989

CONTENIDO

A. CONTEXTO

A.1 Descripción del sub-sector

La competencia exacerbada por efecto de la crisis económica que golpeó a los países industrializados desde la década pasada, ha difundido en diversos sectores la validez de la opción "automatizarse o desaparecer". Ello se inscribe, en rigor, en un esfuerzo más amplio por aumentar la productividad y la penetración en el cada vez más agresivo mercado internacional y una preparacion frente a los estudios que indican la falta de mano de obra en la decada del 90.

Si bien la automatización de trabajos fabriles no es nueva, el aspecto revolucionario de la nueva tecnologia es la introducción de flexibilidad en los instrumentos de producción, combinada con una mejora importante en el manejo y disponibilidad de la informacion dentro de la empresa.

Estudios realizados en diferentes empresas europeas han demostrado que las mejoras introducidas por medio de cambios parciales de racionalizacion si bien fueron elevadas en un principio, estan alcanzando un valor ascintotico en especial en lo referente a disminuciones en la duracion del periodo de produccion (desde la entrada de la solicitud de fabricacion, hasta la terminacion del producto). Estas razones han llevado al convencimiento de que solo un cambio sustancial en la estructura organizativa de produccion podra traer aparejado nuevas mejoras en la productividad.

Mediante la programación de la maquinaria, ésta puede adaptarse a diversas tareas, modificando sustancialmente la economía de producción en pequenos lotes. Un indicador de la importancia de esta tecnologia es que, en páises como en los Estados Unidos, Francia y Alemania Federal, cerca de dos tercios de los productos manufacturados lo son a través de series cortas las que, con la automatización flexible, pueden ser ahora fabricadas con costos sólo alcanzables antes con producciones en gran escala. Esta situacion facilita el desarollo de nuevas empresas en su primer etapa a nivel local dentro de mercados pequenos, para poder luego pasar a competir en el mercado internacional una vez estabilizada y fortalecida su produccion .

Si bien con diferencias -dependiendo del equipo de que se trate- las técnicas de automatización permiten obtener ventajas del siguiente tipo:

- Disminuir los "tiempos muertos" (en un taller medio las máquinas convencionales están paradas entre el 70% y el 95% del tiempo) y aumentar la utilización del capital invertido.
- Elevar la calidad y asegurar un nivel constante de la misma.
- Mejorar la gestión de compras y reducir los niveles de stocks y del trabajo en proceso.
- Disminuir el consumo de materias primas.
- Aumentar la productividad del trabajo.
- Mejorar la "mezcla" de productos.

- Reducir el espacio físico de planta.

- Articular diseno con producción y reducir el tiempo de desarrollo de nuevos productos.

- Reducir la duracion del periodo de produccion.

La automatización, basada en el empleo de sistema de control número, robótica, control de procesos, etc. ofrece una posibilidad cierta de ahorro en casi toda la gama de los insumos productivos: mano de obra, energía, materias primas y aún capital, a la par que aumenta la calidad y la flexibilidad de la producción. La integración de esos mecanismos en "células" de manufactura flexible y su combinación en plantas automatizadas, son un paso hacia un futuro industrial cada vez más cercano.

Numerosas experiencias en los paises industrializados dan prueba de las ventajas derivadas de la automatización. El control numérico, en un estudio realizado en Alemania Federal, demostró hacer posibles ahorros globales del 3% al 40%. Aún mayores resultados (60%) se encontraron en Suecia, el país con mayor difusión de robots por trabajador del mundo. Los robots, incansables manipuladores, pueden aumentar la productividad del trabajo seis o más veces, ahorrar energia y materiales y producir con mayor calidad. Los sistemas flexibles de manufactura, por último, permiten producir en pequenos lotes, en una mezcla de productos que optimize el aprovechamiento de los recursos existentes como asi tambien los requerimientos del mercado y disminuir los "tiempos muertos" en fábricas, los que representan del 60% al 85% del tiempo en talleres, según el volúmen de producción y su organización interna.

También existen ejemplos sobre estos resultados en el ámbito latinoamericano. La industria siderúrgica brasilena transitó un proceso de automatización (principalmente mediante la incorporación de control de procesos) que desempenó un papel estratégico en su crecimiento y éxito exportador. El aumento en la calidad, pero también el de la producción, la reducción de costos y el ahorro de energía son algunos de los beneficios que dejó la automatización.

La automatización no sólo es en ciertas circunstancias un imperativo del desarrollo industrial para expandir las exportaciones y competir en un contexto crecientemente exigente. También representa un medio para liberar al trabajador de tareas repetitivas, insalubres, de alto riesgo (como en el caso mismo de la producción siderúrgica) o de muy bajo o nulo nivel de aprendisaje. Bajo ciertas condiciones, la automatización reemplaza el trabajo directo, si bien aumenta los requerimientos de vigilancia y mantenimiento. Se consigna que la planta automotriz de Fiat en Italia, por ejemplo, redujo del 70% al 10% del total, el número de operarios en trabajos tradicionales tras la automatización; no obstante, los empleados de mantenimiento aumentaron, en cambio, del 17% al 72%.

Vista de conjunto de las técnicas de automatización industrial

La utilización de computadoras en aplicaciones especificas en las empresas ya es de tradición. Ejemplos de aplicación tradicional son control de finanzas, planificación estratégica, preparación de trabajos, control de almacenaje y, en cuanto a producción, máquinas herramientas de control

numerico por computadoras, etc. Todas estas aplicaciones eran generalmente en base a programas especiales para cada caso, sin mucha interrelación (a excepción de empresas grandes). El desarrollo de la microelectrónica y la introducción de microcomputadoras al mercado causó una reducción considerable del precio de las computadoras en más que un factor 20 en un lapso de aproximadamente 8 anos. Esta disminución del precio cambió fuertemente la rentabilidad de la aplicación de las computadoras y causó, por la inversión relativamente baja, una rápida divulgación de estos sistemas en la industria mediana y pequena en los paises industrializados y en los paises en desarrollo más avanzados.

Paralelamente se vió la necesidad de interrelación de los diferentes sistemas y programas de computación a nivel de empresa aplicadora. De alli se originó un desarrollo rápido de software para facilitar la intercomunicación. En cuanto al área técnica y tecnológica de las empresas se vió la necesidad de combinar programas complementarios. La falta de normas técnicas y la multitud de programas diferentes existentes presentaron problemas de compatibilidad, tanto de hardware como de software de los sistemas, que gradualmente se están reduciendo, mediante trabajos importantes de normalizacion de los protocolos de comunicacion como ser MAP/TOP en USA o CIM/OSA en EUROPA.

El desarrollo del software dió luz a una serie de expresiones nuevas utilizando las dos primeras letras de Computer Aided (CA) y siempre relacionadas a la aplicación específica. El cuadro 1 da una recopilación de las aplicaciones más utilizadas.

La interrelación de estos sistemas de aplicación de computadoras a nivel de empresa y las funciones correspondientes se ve en el gráfico 1. Hay que notar que la aplicación de técnicas de tipo CA está dirigida a apoyar la ejecución de los trabajos correspondientes a cada noción, pero no se hace cargo de los trabajos por completo, y que el sistema de operación es interactivo, es decir, el usuario de las computadoras está en diálogo con ellas teniendo la posibilidad de intervenir, cambiar y proponer soluciones alternativas. Al mismo tiempo, cabe mencionar que el esquema presentado intenta demostrar la interrelación de las técnicas CA y no representa un caso especifico de una empresa. La implementación de las técnicas CA en una empresa deberá realizarse en cada caso gradualmente, a partir de la decisión que debe hacer la gerencia respecto del area inicial de aplicación y basandose en un concepto y/o modelo general de la futura estructura organizativa y de manejo de la informacion de la empresa.

En los paises industrializados la utilización de CAD y CAM en la producción se realiza en áreas en donde estos sistemas contribuyen a un incremento de la flexibilidad de operaciones (para reducir tiempos de entrega y mejor servir a la clientela) y/o un incremento de la productividad que conduce a una reducción de costos de producción. En algunos casos, en especial en el area de autopartes pertenecientes a sistemas de seguridad (por ejemplo sistema de frenos), la automaciones es requerida por el comprador que exige un nivel constante de calidad y un protocolo individual de las caracteristicas y los controles realizados en cada producto como resguardo legal en el caso de un accidente. Todavía son más frecuentes sistemas aislados, pero últimamente avanzan con rapidez sistemas integrados. Los sistemas aislados utilizan bancos de datos distintos confeccionados según requerimientos de la empresa mientras que los sistemas integrados se basan en un banco de datos relacional central en una computadora grande. En cuanto a industrias medianas y pequenas

en paises en desarrollo entra otro factor decisivo para aplicación de sistemas CAD/CAM: hacen posible la manufactura de productos de alta complejidad tecnológica y de alta calidad basándose en software para CAD y CAM importado y luego permiten la construcción propia de nuevos productos utilizando las bases de computación instaladas. Parece muy adecuado para la mayor parte de las empresas en paises en desarrollo, comenzar por centros de maquinación con software especifico para la gama de producción seleccionada y teniendo en cuenta sus caracteristicas de programacion y comunicacion futura en el momento de adquisicion, permitir luego utilizar sistemas CAD para introducir productos nuevos y propios.

Cuadro 1 Aplicaciones más comnues en el grupo "Computer Aided"

Abreviación	Denominación	Explicación
CAE	Computed Aided Engineering	Noción maestra para la aplicación de computadoras en áreas pre-productivas
CAD	Computer Aided Design	Diseno y cálculo de construcción de productos
CAM	Computer Aided Manufacturing	Planificación y ejecución de la producción con apoyo de computadoras
CIM	Computer Inte-grated Manufac-turing	Noción maestra para la aplicación de computadoras en todas las áreas técnicas de una empresa
CAP	Computer Aided Planning	Planificación en el área técnica de una empresa
CAPP	Computer Aided Production Planning	Planificación y manejo de la producción
CAT	Computer Aided Testing	Ejecución de ensayos técnicos con aplica-ción de computadoras (por ejemplo de productos nuevos)
CAQ	Computer Aided Quality Assurance	Control y aseguramiento de la calidad de los productos
CAR	Computer Aided Robotics	Manejo por computadora de robcts en la producción
CAA	Computer Aided Assembly	Ensamblaje apoyado por computadoras
CASE	Computer Aided System Engineering	Estudio de la emprersa como sistema

La introducción de la informática en el proceso de producción industrial se manifiesta en cuatro rubros principales en forma local: máquinas herramientas de control número (MHCN), diseno asistido por computadora (CAD), robots y robots industriales (R.I) y sistemas de comunicacion; y a nivel global en toda la estructura de produccion mediante sistemas de simulacion, planificacion y ayuda o soporte de decision en especial a nivel gerencial medio y alto.

Las MHCN materializan una de las tecnologias más maduras dentro del arsenal de la automatización flexible, no obstante lo cual su precio ha sufrido una caida espectacular en la última década (en el Japón, los precios de los tornos de control numérico cayeron a la mitad y los de centros de mecanizado dos tercios).

Se trata de un mercado global que supera los 4.000 millones de dólares, liderado por Japón (con 45% de la producción mundial) y en el que, no obstante una fuerte concentración, pequenas firmas innovadoras pueden desafiar a los productores establecidos.

El progreso en robótica, genera creciente inquietud en el sector del trabajo. El cambio en las calificaciones y condiciones de trabajo abren interrogantes sin claras respuestas. En rigor hay aún gran incertidumbre respecto del efecto que la automatización tendrá sobre el trabajo. En términos generales, puede afirmarse que a iguales tasas de crecimiento del capital, los sectores más automatizados crearán menores empleos pero con mayores cualificaciones. Dado que la difusión de robots es limitada, sin embargo, se estima que hacia 1990 la desocupación asociada a aquélla en los paises de la OECD seria inferior al 1% de la mano de obra ocupada en la industria.

El efecto neto de la utilización de robots sobre el empleo depende de un conjunto de variables tales como la organización de la planta, las calificaciones disponibles, la tasa de crecimiento del sector, etc. Así en Japón, la implantación de robots, la mayor del mundo, no ha provocado desocupación, lo que ha tenido que ver no sólo con el crecimiento de la economía sino con la organización del trabajo en ese país. Es importante aclarar en esta referencia al Japon que por un lado la definicion japonesa de robots es mucho menos estricta que la normalmente utilizada a nivel internacional que exige tres grados de libertad libremente programables (en algunas estadisticas japonesas se llega a aceptar como robot una maquina con un solo grado de libertad y programable por Hardware. Por otro lado en Japon la mayoria de los robots son utilizados en empresas terminales que actuan como "pull" de la industria y en la mayoria de los casos los productores de partes estan poco o nada automatizados. Un estudio realizado en Estados Unidos indicaba que el 48% de las empresas que se automatizaron denunciaron un aumento en el empleo, debido a incremento en las órdenes de compra, expansión de los negocios, o la necesidad de incorporar personal con nuevos perfiles laborales.

Por otro lado, la automatización en algunos casos representa un medio para liberar al trabajador de tareas repetitivas, insalubres o de alto riesgo.

B. JUSTIFICACION DEL PROYECTO

B.1 Problema a abordar

Se considera que la industria fabricante de bienes de capital es de estratégica importancia para el éxito de la politica industrial de los paises de America Latina, ya que a través de la modernización de este sector es como se puede aumentar de manera más significativa y eficiente la productividad, siendo también de gran importancia para el mantenimiento de la infraestructura industrial.

Cabe observar que las nuevas tecnologías de información también proporcionan las siguientes ventajas:

- Fabricación económica de lotes pequenos
- Disminución de gastos indirectos
- Mayor precisión en los procesos de manufactura
- Flexibilidad en la producción para aprovechar las condiciones cambiantes del mercado.

En este sentido, politicas que busquen avanzar en el desarrollo y asimilación tecnológica serán altamente positivas para el sector y para todos los procesos de modernización industrial que se requiera llevar a cabo.

El presente proyecto comprende la incorporación de nuevas tecnologias de información como instrumentos para la automatización industrial.

La automatización industrial cubre dos aspectos, el de los equipos (hardware) y el de los sistemas de soporte lógico (software).

Los principales productos que pueden ser empleados en la automatización industrial son:

- controles lógicos programables (PLC);
- máquinas-herramienta de control numérico por computadora (CNC);
- robots controlados por computadora (CRC);
- sistemas neumaticos de automacion;
- computadoras:
- microcomputadoras y computadoras personales;
- minicomputadoras, superminicomputadoras (computadoras de procesos);
- unidades centrales de proceso; y
- equipo de ensayo y de control de calidad;
- redes de comunicacion.

En el segmento de sistemas, se pueden identificar al menos los siguientes programas de soporte lógico:

- planificación de la producción, con inclusión de los materiales necesarios y recursos de fabricación (MRP-I y II). Esta es la denominada CAP (Planificación con ayuda de computadora);
- simulacion de procesos complicados o criticos;
- sistemas dinamicos de optimizacion de la produccion como soporte del nivel gerencial.

- diseno y desarrollo de productos (CAD);
- planificación de procesos incluida la programación CNC y CRC (CAPP);
- herramientas mecánicas para el soporte lógico (software) (CASE);
- garantía de calidad y control estadístico de calidad (CAQ);
- prueba y medición (CTA);
- automatización de servicios (CAS);
- células de fabricación flexible y sistemas de fabricación flexible (FMC y FMS).

La gradualidad en la incorporación de la automatización industrial juega un papel importante. El primer punto debe ser un estudio del sistema de produccion que permita un lineamiento global en los suscesivos pasos graduales. En general, pueden identificarse etapas a cubrir, que comienzan con la introducción de dispositivos sencillos de control automático, que pueden ser exclusivamente eléctricos, electromecánicos o más complejos, los controladores programables, Applied Specific Integrated Circuits (ASIC) o equipo e instrumentación existente en planta.

La automatización flexible es comparable, por su impacto, con los cambios que introdujeron en su momento la máquina de vapor y el motor eléctrico. Su proceso de difusión, es menos rápido de lo que frecuentemente se cree. Por lo tanto, sus efectos sobre la productividad, organización de la producción, calidad, empleo, etc. sólo han comenzado a materializarse.

Las ventajas de estas tecnologías, empero, indican que su diseminación será segura. En qué medida los países de América Latina sufrirán aquel proceso? Sera posiible lograr un cambio gradual desde dentro del sector que permita una adaptacion gradual socioeconomica a las nuevas estructuras, o este cambio solo podra ser introducido en forma traumatica y tajante como un paquete completo desde afuera? Que ventajas pueden obtenerse y qué efectos tendrán en el campo organizativo y laboral? Como pueden contribuir, en especial, para aumentar la competitividad de la industria?

Sin bien no existen aun estudios comprensivos que den respuestas satisfactorias a estos interrogantes pueden anticiparse algunas consideraciones.

Primero, la difusión de estas tecnologías estará muy relacionada con las tasas de interés y el costo de la mano de obra. En la situación actual, no sería de esperar que, sobre la base de una ecuación costo/beneficio económico exclusivamente, se produzca una difusión muy rápida.

Segundo, el impacto sobre el trabajo es probable que se dé principalmente por el cambio en la demanda de calificaciones (orientada a la "mecatrónica") más que por una disminución de aquélla. Por otro lado, no puede olvidarse que, no automatizar puede significar la pérdida de competitividad, e indirectamente la de un mayor número de puestos de trabajo.

Tercero, si bien la automatización flexible implica una mejora de productividad en series cortas, el costo de los equipos y su instalación exige, en principio, un volumen agregado de producción de cierta dimensión, para hacerla rentable. Esta circunstancia deber ser analizada en cada caso y podría constituirse en una limitante para la difusión de esa tecnología en pequenas empresas. Asi tambien es importante hacer notar que la automacion comienza a ser rentable, mediante calculos economicos tradicionales que no tienen en cuenta las mejoras introducidas entre otras en los niveles de calidad o disponibilidad del sistema productivo, con una produccion de mas de un turno de trabajo.

Cuarto, la introducción de la automatización, para ser exitosa, deberá ser enmarcada en una organización preparada para recibirla. En particular en países de America Latina exigirá cambios importantes en la gestión empresarial y la redefinición de áreas de trabajo y funciones al interior de las estructuras empresariales.

Quinto, la industria de bienes de capital de los países de América Latina deberá hacer un gran esfuerzo de aumento de productividad y calidad, si pretende entrar en una etapa de crecimiento abierto con énfasis en la exportación. La automatización flexible es un instrumento para ello, aunque no necesariamente el único. En cada caso deberán valorarse sus ventajas relativas. En muchas circunstancias, probablemente, su introducción será opción necesaria para cumplir con las normas internacionales exigidas.

Sexto, desde un punto de vista de la política tecnológica, es deseable la difusión e introducción de la automatización industrial, en la medida que ello contribuya a satisfacer los objetivos de productividad y crecimiento. Para hacerlo, deberían acordarse, como lo han hecho antes países industrializados, incentivos directos incluyendo estímulos al comprador.

Septimo, los países de América Latina deberán definir estrategias de industrialización en torno de la optimizacion organizativa y la automatización industrial. No hacerlo implicaría renunciar a oportunidades en una actividad extremadamente dinámica, intensiva en inteligencia, y agravar la relación asimétrica con los países industrializados; hacerlo en forma inteligente y organizada podria permitir evitar los errores estructurales iniciales cometidos por los paises desarollados y reducir por lo tanto la brecha tecnologica existente. El solo hecho de mejorar la estructura del proceso productivo tanto a nivel intraempresario como a nivel interempresario, con elementos como ser por ejemplo el establecimiento de un sistema de premios y punitorios en las relaciones proveedor/comprador, puede aumentar en valores considerables los niveles de productividad del sistema.

Octavo, el rol del gobierno o del organismo correspondiente es fundamental como ente consultor independiente, para evitar que un deficiente conocimiento del tema pueda llevar a soluciones indeseadas. A modo de ejemplo pueden citarse:

a) El costo de una celda de trabajo robotizada es por lo menos dos veces mayor que el costo del robot mismo, debido a toda la periferia necesaria.

b) Una automatizacion en un punto incorrecto del proceso productivo puede llevar a una estructura tal que sea necesario introducir cambios en toda la empresa para alimentar la seccion automatizada y llevarla a niveles rentables de utilizacion.

c) Todo proceso de automatizacion consiste basicamente de inversiones tempranas y reditos tardios, por lo que la empresa debera estar financieramente preparada para absorber no solo el gasto de la inversion inicial, sino tambien todo los gastos correspondientes al periodo de transicion.

B.2 Expectativas a la terminación del proyecto

El diagnóstico detallado de la situación actual, y el análisis de las perspectivas de subsectores seleccionados integrantes de la industria fabricante de bienes de capital será el punto de partida desde el cual se pueda evaluar el impacto de las propuestas de modernización que permitan configurar un portafolio amplio de empresas susceptibles de ser modernizadas y automatizadas. Asimismo, este diagnóstico y análisis también permitirá sentar el marco de referencia desde el cual se podrá hacer el análisis de la conveniencia de realizar un proceso de automatización industrial en empresas seleccionadas que tenga como objetivo final la modernización/automatización de empresas especificas.

A la terminación de este proyecto, centros satélites y las empresas de consultoría industrial, tendrán una capacidad para evaluar los proyectos de tecnologías modernas de manufactura y promoverán la utilización de estas tecnologías, caso por caso, definiendo propuestas de proyectos de modernización a nivel de empresa, cuyo costo sería cubierto por la misma empresa.

Dado que en la industria se encuentra capacidad ociosa y que con las nuevas políticas cambiarias los costos internos se reducen respecto a los equivalentes importados, las propuestas efectivas de modernización, que resulten de interés para las empresas, requieren de un desarrollo conjunto, entre la empresa usuaria, empresas especializadas o grupos de consultoría y por lo general tambien del conjunto de proveedores, de propuestas adaptadas a la realidad nacional y del grupo usuario. Por consiguiente, la simple compra en el exterior, no resulta una alternativa práctica, sino tenderá a resultar onerosa, poco flexible y de difícil aplicación.

El proyecto tendrá una duración de 36 meses, despues de los cuales el programa a nivel regional deberá tener vida propia y se autofinancira por las instituciones participantes.

B.3 Beneficiarios previstos (mision de campo)

B.4 Estrategia del Proyecto

La estrategia de este proyecto pone énfasis en la modernización de la industria de bienes de capital de los países de América Latina para así incrementar su productividad y competitividad. Sobre esta base, se plantean acciones tales como:

- elaborar un diagnóstico detallado de la situación de subsectores de interés para la industria de bienes de capital y evaluar la conveniencia de su modernización, considerando sus posibilidades de desarrollo a corto y mediano plazo tanto a nivel local como internacional.

- estimular el desarrollo tecnológico en áreas selectivas de la automatización industrial;

- promover la aplicación de técnicas modernas de producción en forma sistemática;

- desarrollar la industria productora de bienes de capital existente mediante la incorporación adecuada y programada de la automatización industrial; y

- promover la instalación de nuevas empresas dedicadas a la producción de equipos y sistemas aplicados en la modernización de la industria.

El punto crítico consiste en crear una capacidad para:

1. Incrementar la eficiencia en la producción de bienes de capital complejos.

2. Desarrollar la oferta de diseno básico y promover la innovación tecnológica.

3. Promover la especialización de ciertas líneas de productos tanto para el mercado doméstico como internacional.

4. Incrementar la exportación de bienes de capital.

La baja productividad del sector de bienes de capital tiende a empeorarse especialmente a nivel de la planta, debido a una organización inadecuada del proceso de producción y a un grado excesivo de integración vertical. Esta situación exige medidas correctivas que promuevan una mayor participación de firmas pequenas y medianas creando incentivos para aumentar la productividad y a través de un mejoramiento de la gestión e ingeniería de productos y procesos de calidad.

C. OBJETIVO DE DESARROLLO

Incrementar el desarrollo, la productividad y competitividad de la industria de bienes de capital de los países de América Latina, por medio de la introducción sistemática de la automatización industrial en la producción de bienes de capital.

D. OBJETIVOS INMEDIATOS Y RESULTADOS

D.1 Objetivos inmediatos

O.I.1. Contribuir a la formulación sistemática de planes de acción, estrategias y políticas que faciliten el desarrollo, expansión y modernización del sector.

O.I.2. Crear en la región las posibilidades de prestar asistencia técnica directa y servicios profesionales especializados de asesoría a las empresas que decidan introducir la automatización industrial.

O.I.3. Facilitar a los ejecutivos de las empresas, las instituciones públicas y privadas vinculadas a la industria de bienes de capital de la región, a través de programas de aseguramiento y gestión total de la calidad, gestión tecnológica, capacitación, equipos (hardware y software) y actividades promocionales. las informaciones necesarias para la introducción sistemática y racional de las tecnologías de la automatización industrial.

O.I.4. Promover y auspiciar la cooperación técnica internacional con países industrializados y entre países de la región (CTPD), a través del aprovechamiento de experiencias, capacidades instaladas, programas y proyectos en ejecución, y centros de excelencia existentes en el sector público y privado relacionados con la automatización industrial del sector de bienes de capital.

O.I.5 Llevar a cabo un programa que permita una mayor transferencia de experiencias y conocimientos hacia países de un menor grado de desarrollo relativo, desde los países con alto nivel de industrialización.

D.2 Resultados

Resultados R.1: Puesta en operación de una red latinoamericana sobre "Núcleos de Innovación Tecnológica en el Sector de Bienes de Capital" para alcanzar la transferencia, asimilación y aplicación de las nuevas tecnologías de automatización industrial.

Resultados R.2: Capacitar en cada país de la región 50 ó 60 profesionales y técnicos para planificar, aplicar y difundir las tecnologías CAD-CAM-CAE en empresas productoras de bienes de capital.

Resultados R.3: Mecanismos operativos para promover e incrementar la cooperación regional en la introducción y aplicación de tecnologías de automatización industrial en el sector de bienes de capital.

Resultado R.4: Publicaciones sobre la situación y el estado de las tecnologías de automatización industrial en las industrias de bienes de capital de la región y tendencias a nivel internacional.

D. Insumos

D.1 Gobierno o institución sede (por definir en cada caso)

- Instalaciones locativas: En cada país, el respectivo gobierno o institución sede de acuerdo con las negociaciones definitivas, deberá proveer la planta física apropiada, necesaria para las oficinas de los expertos, profesionales y personal de apoyo participantes en el programa, así como la instalación de los equipos.

D.2 Programas de bienes de capital y agremiaciones privadas vinculadas al Sector

D.3 Consejos Nacionales de Ciencia y Tecnología y otras instituciones de carácter nacional

Los Consejos Nacionales de Ciencia y Tecnología, participarán mediante la asignación de becas para los cursos y la financiación de subprogramas nacionales.

En forma complementaria se espera que la industria, los gremios y las universidades apoyen financieramente las diferentes actividades.

D.3 ONUDI

- Expertos internacionales: Dentro el programa se proveeran los fondos para la contratación del equivalente a cinco expertos permanentes. 180 m/h.

- Expertos internaciones de corto plazo: 60 m/h

- Equipo y software: Se proveeran los fondos para la adquisición del equipo y software. En cuanto al software se incluye la posibilidad de que se contrate en la región el desarrollo o adaptación de algunos de los paquetes de aplicación.

- Estudios, pasantias, misiones: Se proveeran los fondos para realizar estudios, pasantias y misiones necesarios para el cumplimiento de los objetivos del programa.

- Información: Cada núcleo o centro dispondrá de fondos para la adquisición, procesamiento y difusión de la información técnica.

- Gastos de operación: Se proveeran los fondos para la contratación de personal de apoyo, los costos de comunicaciones y la adquisición de otros equipos y materiales de uso general.