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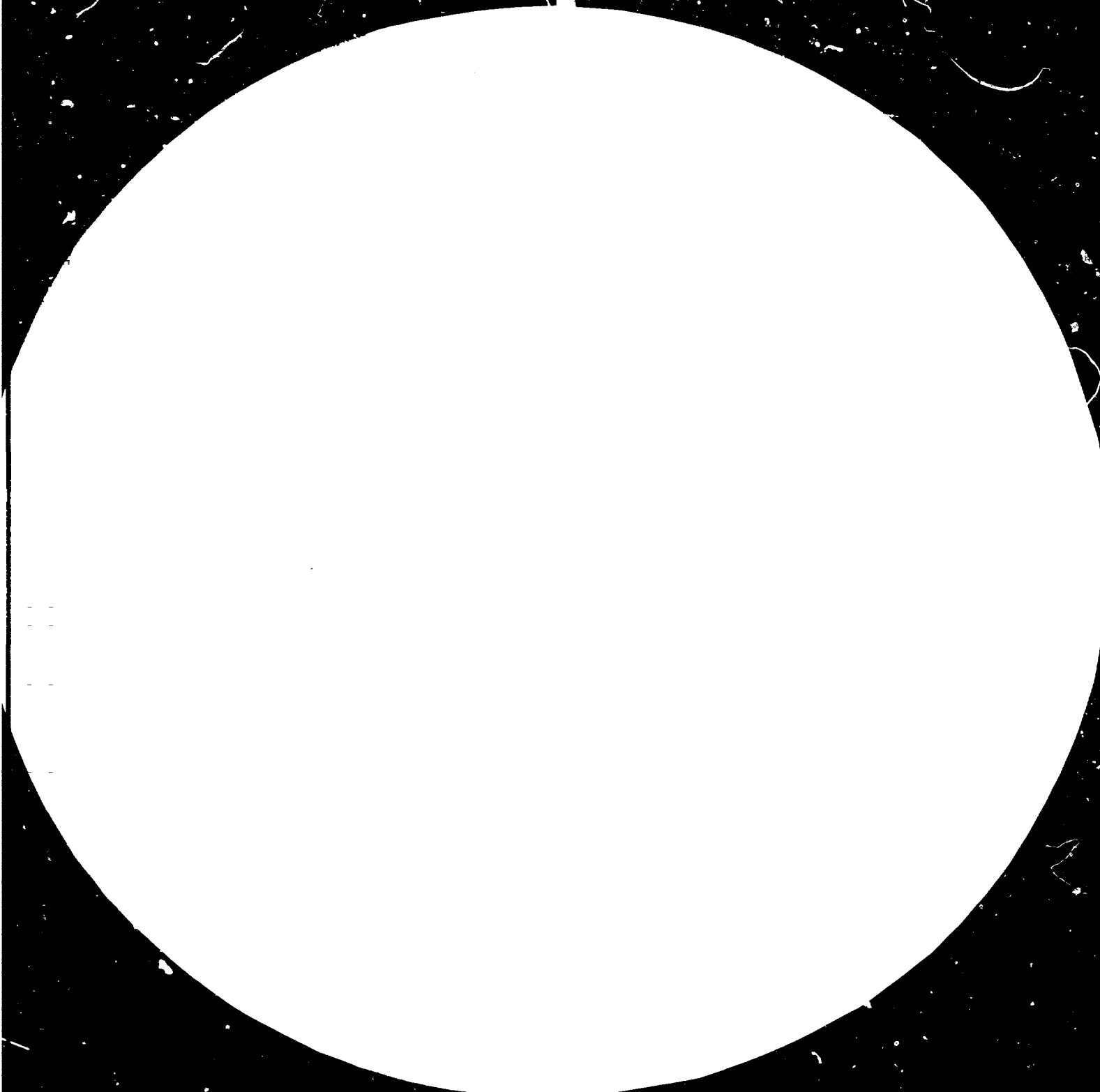

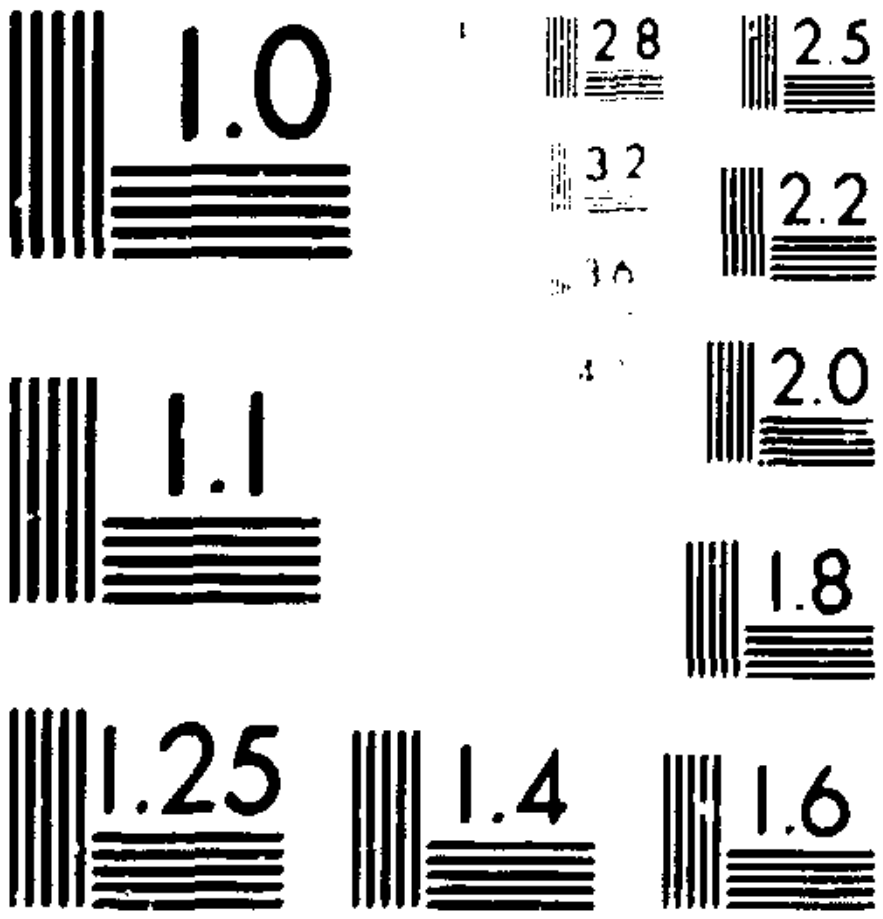

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ELEMENTS FOR THE FORMULATION OF A REGIONAL PROGRAMME OF ACTION IN THE AREA OF MICROELECTRONICS *

Country Paper

by

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* The views expressed in this paper are those of the authors and do not necessarily reflect the views of the Secretariat of UNIDO. This document has been translated from an unedited original.

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I. INTRODUCTION

Like many other countries in the world, the Andean countries have gradually been introducing microelectronics into various areas of activity, such as communications (including telephony), health (diagnostic and treatment apparatus), trade (cash registers), services (calculators), entertainment, management (computer centres), and in university curricula and laboratories.

Despite these beginnings, the Andean subregion must take additional action if it is to be able, within a brief period, to gain a full mastery of this important branch of technology and put to work, for their knowledge-generating potential, the techniques and processes which, over the medium and long term, may well have a decisive impact on the subregion's structures for the production of goods and services.

The purpose of the general considerations presented in this paper is to suggest a few ideas on the elements that might be included in a microelectronics programme of action from the point of view of the common objectives of the Andean nations within the framework of the Cartagena Agreement.

This Agreement represents one of the most important and novel integrationist experiments between any group of developing countries in that it provides the basis for a genuine economic union among the participating countries. In pursuit of this union, the Agreement involves, among other things, an undertaking on the part of the member countries to co-ordinate their national development plans and harmonize their economic and social policies, and stipulates that this harmonization must be accompanied by the formation of an expanded market enabling the member countries to benefit, effectively and fairly, from the new economic subregion thus created.

This harmonization process is being brought about through the application of various instruments approved in the form of decisions which are taken by the Commission of the Agreement and which affect a variety of development objectives, some of them in the areas of industry and technology.

Of particular importance among the first category are decisions No. 146, "Restructuring of the Sectoral Development Programme for the Metalworking and Engineering Industry and Venezuela's Inclusion in the Programme", No. 120, "Sectoral Development Programme for the Automotive Industry", No. 91, "Sectoral Programme for the Petrochemical Industry", and No. 160, which contains elements for further progress towards the ultimate approval of the Andean Iron and Steel Programme.

On the other hand, the Andean subregional policy and strategy for technological development may be found in the following decisions: No. 84, "Bases for a Subregional Technology Policy", No. 24, "Common Rules for the Treatment of Foreign Capital and Concerning Trade Marks, Patents, Licences and Royalties", and No. 85, "Rules on the Application of Industrial Property Norms", which has been supplemented by decision No. 154 creating the Andean System of Technological Information.

The legal provisions and instruments enacted under the subregional policy and strategy of technological development are intended mainly to regulate the import of technology from abroad and contribute to the strengthening of the subregion's ability to assimilate and generate technological know-how through different means, including manpower training and the formation of production teams and their incorporation in national and subregional development plans as viable alternatives in the face of foreign supply, and the generation of demand on national capacities to produce capital and consumer goods and to provide technological services. The subregional policy and strategy of technological development is seen as one of the mainstays of the subregion's efforts at industrial programming.

II. OBJECTIVES OF SCIENTIFIC AND TECHNOLOGICAL DEVELOPMENT IN THE ANDEAN SUBREGION

During the past years, the Andean Group of countries has carried out, under the decisions of the Commission of the Cartagena Agreement already mentioned, a number of projects and programmes of technological development.

Generally speaking, the results that have been achieved through the application of these policy instruments show that:

- A methodology has been produced for the specific involvement of the technology factor in the programmes and planning for socio-economic development;
- The programming of scientific and technological activities - on the basis of intensive advance preparation, the setting of specific targets and requirements, detailed and advance scheduling, and adequate financial backing - has produced positive results;
- A process has been initiated for removing the obstacles to technological development by strengthening each country's individual efforts and easing the way to concerted action; co-operative links have been

established at different levels of scientific and technological activity; and the scientific and technical infrastructure of the several countries has been more closely geared to the economic and social realities of the subregion within a scheme of specialization and training;

- Successful efforts have been made to develop a mentality which is concerned not only with the problem of monitoring and regulating imported technology, but also with actively promoting the creation and introduction of original technology in the subregional countries themselves;

- It has been possible to bring about conditions for the gradual integration of technology into the life of the subregional countries through the participation of the production sector, the research organizations, the universities, and responsible government agencies.

In the light of the experience of the Andean nations in carrying out joint programmes and the positive results that have so far been achieved, and considering the development outlook over the next two decades, an outlook which is likely to be greatly affected by difficult economic conditions, these countries' objectives in the area of science and technology include the following goals:

- Strengthening and mobilizing national and subregional science and technology systems with a view to the autonomy of these systems and the encouragement of balanced and sustained development;

- Advancing knowledge in areas of priority interest and permitting the use of this knowledge for the production of goods and services and the cultural development of Andean society;

- Improving the decision-making process, with particular attention directed to the careful design of standard and realistic models, the analysis of problem areas, and a major effort in the formulative phase of projects to correct existing structural imbalances;

- Accompanying universal scientific and technological progress by research and information activities at and through appropriately established centres and networks;

- Developing fresh forms of international co-operation, seeking to redistribute the world-wide effort in science and technology and to improve the access of the Andean countries to the know-how they need to meet their development requirements;

- Consolidating the links between science and technology in the production of goods and services, on the one hand, and the educational and cultural sector, on the other.

Among the ways in which these objectives can be attained, the following may be mentioned: the arousal of a deep-rooted awareness of the contribution of science and technology to the development process; the training of an adequate pool of research specialists and managerial personnel in this area; the establishment of an adequate physical infrastructure; the creation of an effective and responsive financing system; the formulation of a workable scheme for interaction between the scientific and technological community and the other sectors of the economy; the proper management of external technical co-operation; and finally the carrying out of joint activities with other countries.

Accordingly, the focus of the activities of the Andean community will be on:

- The basic and advanced training of the subregion's human resources in all areas of science and technology, from research and development to the industrial application of know-how (assimilated, adapted, or original), including services, the end effect being the creation of a strong and efficient management capability;

- The strengthening of the physical infrastructure needed to support the R and D activities of the subregion (laboratories, pilot plants, semi-industrial facilities, etc.), or where necessary the establishment of a new infrastructure;

- The strengthening and utilization of the technological capacity already present in the subregion for the production of capital goods and the provision of technical services, including the establishment of multinational enterprises operating in the technology sector;

- The more effective application of the instruments contained in decision No. 84, in such areas as: technology imports, the assimilation and adaptation of technology, the tapping of the know-how existing in the subregion, the adaptation and creation of technology, the application of technology in production, technological information, and technology management;

- The formulation of new policy instruments in the science and technology area;

- The ongoing identification of national priorities and the gearing of policies, plans and projects to meet these priorities; the development of methods and criteria to bring science and technology activities into line with the goals of national development planning and to permit the participation of the scientific and technological community in the setting of these goals;

- The study and determination of institutional forms to support the development effort at various levels, and the working out of planning techniques for the timely consideration of the science and technology factor in setting development targets, solving specific problems, and evaluating projects;

- The establishment of appropriate funding procedures.

III. THE OBJECTIVES OF INDUSTRIAL DEVELOPMENT IN THE ANDEAN SUBREGION AND THE SUBREGIONAL ELECTRONICS INDUSTRY

One of the unique features of the subregional integration process under the Cartagena Agreement is Joint Industrial Programming. The essential purpose of this programming is to avoid the imbalances that tend to be inherent in other processes of this kind which emphasize commercial mechanisms and the free play of market forces.

The following are among the principal objectives of Joint Industrial Programming:

- Greater expansion, specialization and diversification of industrial production;

- The maximum use of the resources available within the subregion;

- The improvement of productivity and the effective use of the factors of production;

- The exploitation of economies of scale;

- The equitable distribution of profits.

To achieve these objectives, the programming approach operates with four important instruments:

1. The Sectoral Industrial Development Programmes (PSDIs), currently in the metalworking and engineering, petrochemical, automotive and iron and steel sectors;

2. The market reservations for Bolivia and Ecuador;

3. The Industrial Rationalization Programmes, intended for existing industries producing goods not covered by the PSDIs;

4. The Integrated Development Programmes, whose objectives are to contribute jointly to the implementation of projects which are part of the integration process and which refer to products covered under the PSDIs or produced under other mechanisms or under the Liberalization Programme, the Agricultural Development Programme, the Industrial Rationalization Programme, the Physical Integration Programme, or the Technological Development Programme.

It may be noted at this point that the subregional integration process began some years after the emergence of microelectronics on a major scale, at a time when this science was already yielding significant benefits in the areas of information management and automatic control in the most advanced countries and even in those Andean nations where there was a sufficient technical capability, specifically with regard to current and potential microelectronic applications.

Accordingly, the formulation of the PSDIs reflected these new technical advances, and the Board of the Cartagena Agreement, conscious of its guiding role in the integration process, submitted to the member countries a proposal calling for the implementation of a Sectoral Development Programme for the Electronics and Telecommunications Industry which took proper account of the rapid evolution of the microelectronics sector. With particular reference to telecommunications and, more specifically, to telephony, special attention was given, in this connection, to the question of switching systems, where the trend has been away from electromechanical and towards fully electronic systems through the intermediate phase of hybrid designs, the ultimate goal being the digitalization of these systems.

The objectives of the programme proposed by the Board constitute an appropriate framework within which to consider, as we shall below, the elements of a programme of action in the microelectronics area. These objectives are:

- To attain the kind of technological competence that will make it possible to establish an efficient electronics industry;
- To bring about conditions conducive to the more effective acquisition, utilization and adaptation of technology so as to enable the subregion to develop its own technology and enjoy greater independence in its decision-making;
- To contribute to the technological development of the member countries in other branches of industry which employ electronic items;
- To promote the development of design engineering in the subregion;
- To establish guidelines for the managerial, technical and shop levels and stimulate production in the most labour-intensive areas;
- To promote the kind of demand for components that will justify their manufacture in the subregion and their export to third countries;
- To contribute to the development of such socially significant sectors as public health, education, and communications;
- To contribute to the narrowing of the current gap in economic development between certain member countries, with particular reference to Bolivia and Ecuador.

It is important to note, in this connection, that microelectronics is also involved in the programme for non-allocated products, where it is left to the discretion of the member countries to gear their decisions to their own technological capabilities.

IV. ELEMENTS FOR THE FORMULATION OF A REGIONAL PROGRAMME OF ACTION IN THE MICROELECTRONICS AREA

The technological advances of the last 30 years, particularly those in the so-called new technologies, have found the developing countries unforewarned and unprepared to absorb and incorporate them, fully and quickly, in the production of goods and services. The principal reason for this unpreparedness has been the lack of basic know-how in these countries and the failure of their public and private sectors to provide innovative development.

The pace of these advances, especially the evolution of electronics, has been unprecedented in modern times. Based as it is on research, the electronics sector has maintained its innovative vitality and even increased

it in comparison with other sectors. The principal features of this evolution have been new developments in component manufacture and design coupled with the lowering of costs. Microelectronics in particular has evolved at an accelerating rate and is even now finding applications in very nearly all spheres of human activities, among them the storage and management of information, process control, communications and education, to name only a few. In addition to the changes which it is bringing about in these areas, microelectronics is leading to significant increases in productivity and is thus causing substantial changes in the nature of the work associated with a wide range of occupations. In some cases, occupations are disappearing, as for example in the routine handling of information, while in others new occupations are being created, either in the electronics industry itself or in the industries that use electronic systems. Over the longer term, it is also quite possible that change will affect the structure and location of industry as well.

For all these reasons, the timeliness and wisdom with which the countries of the region respond to the challenges posed by the new technological advances will be a decisive factor in their development over the next few decades.

In this context, and as is evident from an analysis of the possible applications of microelectronics (which need not be described anew at this point), one can appreciate the need for the developing countries to establish innovative electronic industries of their own for the purpose of satisfying the requirements inherent in the industrialization process and, more generally, in economic and social life. The effort here must focus on an analysis of the ways in which this objective can be attained, considering that this kind of development requires adjustments, often very costly ones, which represent the price that must be paid for the benefits to be realized through technological innovation in terms of higher real income. In these circumstances, the role of Governments will be, on the one hand, to contribute to removing the obstacles to innovation and growth and, on the other, to easing the adjustments required of that part of the work-force which is negatively affected.

On the part of the Andean countries, the proposal that has been put forward for the establishment of a Sectoral Development Programme for the Electronics and Telecommunications Industry represents a response to this challenge, and it will be the responsibility of their Governments to act quickly on this proposal.

In general terms, the proposed strategy calls for the joint development of an electronics industry to act in support of the production sector, including the social sector, rather than the establishment of an industry per se for local consumption or export (at least in the initial phase). Regarding this last point, it has been observed that the approach based on an electronics industry producing for export and incorporating a high level of foreign technology and invested capital leads to a fundamentally unbalanced and dependent industrial and technological structure which is difficult to modify as it develops.

With respect to microelectronics, the development of this sector is also regarded as part of the over-all development of the electronics branch and, at least at first, will not require any special strategy, although it is quite clear that there are certain elements that are more proper to microelectronics than to electronics in general, including, for example, the flexibility of the equipment and systems which are possible using microelectronic techniques and the ever more numerous possibilities for major increases in capacity and improvements in production and information processes through the use of relatively inexpensive equipment.

A strategy of this kind is also in line with the fact that, confronted as they are with numerous problems of increasing complexity, countries today need to make difficult choices; accordingly, there would not appear to be individual solutions, but only specific applications.

With a view to formulating an appropriate regional programme of action, it is well to bear in mind a number of relevant considerations, remembering that the implementation of the programme will depend on the local and regional capacity to absorb all that is involved and realize the objectives set at the time the programme was devised.

1. The countries of the region must give very careful consideration to the "painful" lessons learned from their industrialization experiences. What these experiences show is that, if there is no clear direction, the arbitrary importing of the products of a new technology from more advanced countries does not necessarily contribute to the attainment of development objectives. There is no substitute for careful planning, national initiative, and the aggressive but prudent implementation of appropriate measures.

This process involves objectives with many implications (and a wide range of alternative approaches) all the way from the policy-making to the operational level. Accordingly, it is essential that there be effective planning, by both the public and private sectors, covering every aspect of the technology problem - consumption, production, investment, labour, and acquisition. To this end, the national authorities must continuously monitor the country's domestic requirements for microelectronic products - that is, they must determine for the immediate future the types and quantities of products the country needs to support its development programmes in every socio-economic area.

Similarly, a programme of action must include an analysis of the effectiveness of the policy-making machinery in terms of its ability to ensure a correct approach to the importation of microelectronic equipment and components and to prescribe guidelines for the establishment of the proper technical and institutional structures. This machinery must also be capable of planning the acquisition and use of electronic systems, the establishment of a domestic industrial capacity in this area, including the related technical services, and the formation of a trained work-force in the various production sectors.

On the other hand, in order that the development of the sector be properly planned, the programme must include studies aimed at the design of a strategy for the use and self-reliant production of electronic systems. Among other things, these studies must contain an analysis of the following factors: the size of the required investment burden, the role of both public and private enterprise, employment, education, and the setting up of new businesses. Particular attention must be given to the manufacture of articles for use in rural communities, e.g. medical equipment, telephone systems, systems for the production and transmission of television programmes, and the like, and to the possibilities for the creation of new industries through local innovation and the adaptation of technology along with the development of technical and managerial skills in the work-force.

Finally, and still on the subject of planning, major support must be given to the establishment of regional and subregional associations in specific sectors, e.g. the information sciences, and of machinery to provide a link between the non-governmental sectors of the countries of the region with the resources, both human and physical, of the developed nations. This will require the participation of the industrial communities of the individual countries in the design and implementation of policies and strategies.

2. Regarding technological innovation in the electronics area, at least as far as the Andean Group is concerned, no quantitative gauge exists with which to measure the impact of such innovation on the production of goods and services. Nevertheless, the repercussions of automation, information management, etc., already observed in the most advanced countries, are beginning to make themselves felt in the subregion as well in the case of four classes of industry: consumer durables, intermediate products, capital goods, and "social technologies".

There is a substantial difference, however, regarding the problem of employment. The acquisition of new knowledge and the transfer of skills required for adaptation to technological change is far easier in the scientifically and technologically advanced countries than in those which are not so advanced, which is the case, on the whole, of the countries of the Andean subregion.

3. There is another consideration, related to this last point, which concerns the fact that social change may be seen as an explicit purpose of science and technology, which therefore have definite implications for the social values and aspirations of society as a whole, this being particularly true of changes in employment relationships. Thus, the attainment of a better quality of life is part of the quest for a better and higher living standard. In general, the evolution of the world economy shows that the higher the standard of living, the smaller the proportion of the work-force that must be employed in the production of goods and services to satisfy the requirements of the public. It is important, in this connection, to analyse the degree to which the growth of the service sector will compensate for the reduction in the manufacturing work-force, and in what way technical advances will alter the nature of work and recreation by giving rise to activities and occupations very different from traditional production tasks.

In this context, the analysis and solution of the problems of technical change and employment deserve particular attention on the part of the countries of the region.

4. Another area where analysis is required is concerned with the causes underlying dynamic innovation and the factors which affect it in various sectors of industry. This requires a knowledge of the variables which have a bearing on innovation, costs, demand, competence, and science and technology. An analysis of this kind is not now normally performed by the countries of

the region, although recognition is given to the importance of such factors as energy, environmental safeguards, safety and health, changes in the composition of demand, pressures of international competition (especially from the developed and industrializing countries), and the dynamics of the process of scientific and technological development itself; in addition, there are a vast number of new areas of research and development and other related aspects connected with services and the development of new techniques, equipment, and models.

Innovation and its increasingly rapid spread throughout the economy is not only the result of supply-related factors, such as quality improvements and lowered costs in information processing systems, but also represents a response by enterprise to the economic changes of recent years. This is particularly evident in the manufacturing sector, where demand is erratic and competition keen. Thus, the business community needs to increase its productivity at the same time as introducing greater flexibility in its production activities; this it can do through the use of electronic systems.

Within this context, consideration must also be given to the imperative need for new technological know-how, which can only be acquired through the full participation and collaboration of all the countries which either possess or require this information. In the specific case of microelectronics, as in the case of technology in general, an important role in this respect belongs to the countries owning this information, as it is they which must remove the obstacles and other limitations which arise out of industrial secrecy, so as to enable the developing countries to gain access to both their know-how and their scientific facilities, in addition to benefiting from their financial assistance. It should be specifically borne in mind that the policy of today's producers of this kind of equipment is aimed not merely at promoting sales but also at securing service and maintenance business. Accordingly, an important feature of a national policy in this area must be an effort to influence this aspect, and this must be reflected in any regional plan of action.

5. It is also important to consider the quickening pace of change towards capital-intensive technologies in industrial branches which, like electronics, have traditionally made intensive use of labour. In the industrialized countries, for example, there is expected to be no increase in the number of persons employed in the electronics industry over the next few years, despite the fact that production in this sector is to increase rapidly. Predictions of this kind are based on technological changes in circuit design and manufacturing and in the design and assembly of many electronic products,

including even those which traditionally have been regarded as mechanical or electromechanical. Even in the heavily labour-intensive information sector of these countries the outlook is for a considerable shift to capital-intensive operations.

Despite these facts, there are, of course, a number of activities which will employ larger numbers of workers, although here too it should be noted that this will require new skills and knowledge, something that in the countries of this region will create a major problem in terms of the retraining and adaptation of the work-force. Accordingly, specially designed policies will be needed to deal with these problems.

6. Another important area of consideration relates to the need to inject fresh vigour into the system itself in order that it may generate technical progress, i.e. the sustained growth of research and development needed to ensure that the basic research structure remains flexible, creative, and reasonably comprehensive in scope. The kind of measures that will yield long-term results in this area will not only make it possible to adapt new technologies as a response to social needs, but will also lead to greater competitiveness on the part of domestic manufacturing industries.

Thus, as one of its important tasks the programme of action must seek to strengthen the high-level research centres that already exist in order that they may play an effective role as instruments for the development and dissemination of new applications. Properly strengthened, these centres will be able to act as focal points for education and specialization and for the spread of informal and non-university-related education, all of which is essential to the development of the electronics sector.

7. Depending on the strategy adopted, thought should also be given to the question of which fields or areas of activity can best be targeted for a microelectronics programme of action with the assurance of achieving a meaningful impact on the objectives intended. Such areas might include, to name a few, telecommunications, education, health, the automotive industry, and the energy sector. Obviously, this requires the existence of a sectoral development strategy in which needs are clearly identified. In this context, the existence in the region of economic integration programmes, aimed, among other things, at overcoming the obstacles to development in each of the individual countries, represents a major asset to be taken into account when formulating a programme of action, the fact being that, in most cases, these programmes already incorporate a development strategy for a variety of production and service sectors.

8. The rapid evolution of microelectronics, including frequent changes in underlying design concepts and applications, has resulted in a situation in which the training of the human resources required for the operation of efficient systems has, in many countries, not kept pace with advances in the state of the art. The general experience has been - for example, in the information sciences - that far more time and money is required for the training of programming specialists than for the acquisition and installation of the equipment, and that normally the equipment expands at a far faster rate than the pool of trained professionals, there being very few countries which have succeeded in solving the manpower crisis which the technological advances in this area have brought with them. Furthermore, the achievement of high productivity performance with these systems requires far more time than has generally been available, considering that in many countries the use, say, of computers dates back no further than the 1970s.

Additionally, consideration must be given to the role of education in moulding new attitudes towards technical change. Particularly evident here is the need to study the opportunities for flexible university training to enable graduates to move from one area of research to another and to participate in a system of permanent and constantly developing education. One factor which most of the countries of the region have failed to take into account is the integration of the knowledge arising out of social innovation and the social technologies with traditional scientific and technical education.

In the specific case of microelectronics, the educational problem involves a number of special considerations whose effect will be to facilitate the tasks proposed as part of a programme of action. For example, it is important to point out that the adoption of new methods and techniques does not always require the prior acquisition of skills in earlier technical areas, in addition to which the trend in microelectronics and its applications is more in the direction of human than physical resources - i.e. it is a sector in which a great deal can be achieved through education and training. In this sense, the inclusion of an educational component as part of the programme can exert a major and positive effect on the attainment of the objectives intended. Conversely, the application of microelectronics can in turn contribute enormously to the development of new educational methods and learning techniques, through such devices as audio-visual aids and computerized instruction, thus leading the way to a dynamic educational technology "industry".

Through developments of this kind it will be possible to close the educational cycle by promoting the skills and creativity society needs if it is to move ahead in all areas in this new technological age.

9. Another important area which should be examined and within which progress is possible under the kind of co-operative scheme afforded by a regional programme of action is the area of technology forecasting. The forecasting methods which have been developed, among them the exploratory forecasting technique, not only make it possible to predict future technological capabilities, but also provide a tool for monitoring technical change. In the case of the Andean countries, the establishment of the Andean System of Technological Information will be able, once the necessary forecasting techniques have been fully developed, to provide a considerable flow of information.

Furthermore, the development of standard and dynamic forecasting methods, properly used together with exploratory forecasting, will enable the countries to approach the task of identifying their priorities, including the application of microelectronics in the appropriate economic sectors, more effectively and thoroughly. This is of particular importance since, given the complex goals facing a multicomponent economic system, the constant changes in attendant circumstances, and the limited financial resources available, there is an increasingly evident need for the prediction of future developments on the basis of scientifically sound forecasting methods rather than subjective opinion.

10. Although there are a number of studies on the development of new technologies, and in particular microelectronics, and on their possible in new applications in the developing countries, it is important to that the introduction of an advanced technology in a developing environment for an application different from that or those for which it was originally designed is no easy task; the transfer, control and input/output function of a technological system are all inherent in its design, and for that reason the question must be raised as to whether a given society, with its individual characteristics, can genuinely and effectively benefit from a new system.

Accordingly, a strategy for the acquisition of technology and for the promotion of a greater flow of information within the terms already indicated, coupled with an aggressive technological and industrial policy of strengthening and developing a design engineering and consultancy capability (especially for software), are important elements in any programme of action.

In addition, it must be understood that for a developing country to gain the benefits which may derive from technical change, much will depend on its approach to and solution of a series of independent variables, including: the ability of the political system to recognize and comprehend the benefits available from a unified approach to the problems posed by technical change; the ability of the political and social structure to identify and define the dangers which change may bring; the social and political skills needed to gain the acceptance and support of the social groups affected by the change both for the Government's development objectives and for the methods of achieving them; the existing political skills in identifying and analysing realistic development objectives and the solutions to the problems created by change; and the social and political skills in understanding and following through on successful plans in pursuit of development objectives.

Thus, a programme of action must also focus its attention on the arousal of the sense of awareness required of social groups and decision-makers in the countries of the region in order that the advantages and disadvantages connected with the development and introduction of new technologies, especially in the production area, may be clearly understood.

11. A large number of projects involving the transfer or acquisition of technology by developing countries have failed to produce their intended qualitative and quantitative objectives. These failures may be due to a variety of causes, which it is not our purpose to analyse here. It may, however, be noted that projects of this kind must adhere to a particular methodology, which, in general terms, involves three elements: the integration of the project in a given environment, the technical adjustment of the project, and the necessary applied training.

As indicated above, the experience of the Andean countries in this area has been extremely positive, as seen in the execution of the Andean Technological Development Programmes. Mention should be made, however, of the need to include in the programme of action activities in each of the three elements mentioned in the paragraph above, with particular emphasis on enterprises, whether public or private, which manufacture or use electronic systems or components.

As far as the environment in which the project is carried out is concerned, it is important that, from the very outset, the enterprise should have a sufficient understanding of the transferred process so as to be able to identify what environmental factor or factors may affect its operation. In this way, the analysis can be limited to genuinely relevant factors.

Regarding the technical adjustments that may be necessary, the internal operation of the enterprise must be examined so as to ascertain whether all the relevant know-how is being appropriately transferred and adapted to the new conditions. Although it is theoretically possible to discriminate between effects due to technical, staff-related and organizational causes, in practical terms objective analysis is complicated by two considerations: the human factor, since the technology must be used by recently trained personnel, and the effectiveness of the equipment, in terms of its intrinsic technical value, the preferability of one kind of machine over another, the question of ease of operation and maintenance, etc.

With regard to training, the firm's operational problems must be solved through appropriate on-the-job instruction, which may involve training at all levels of the staff.