OCCASION

This publication has been made available to the public on the occasion of the 50th anniversary of the United Nations Industrial Development Organisation.

DISCLAIMER

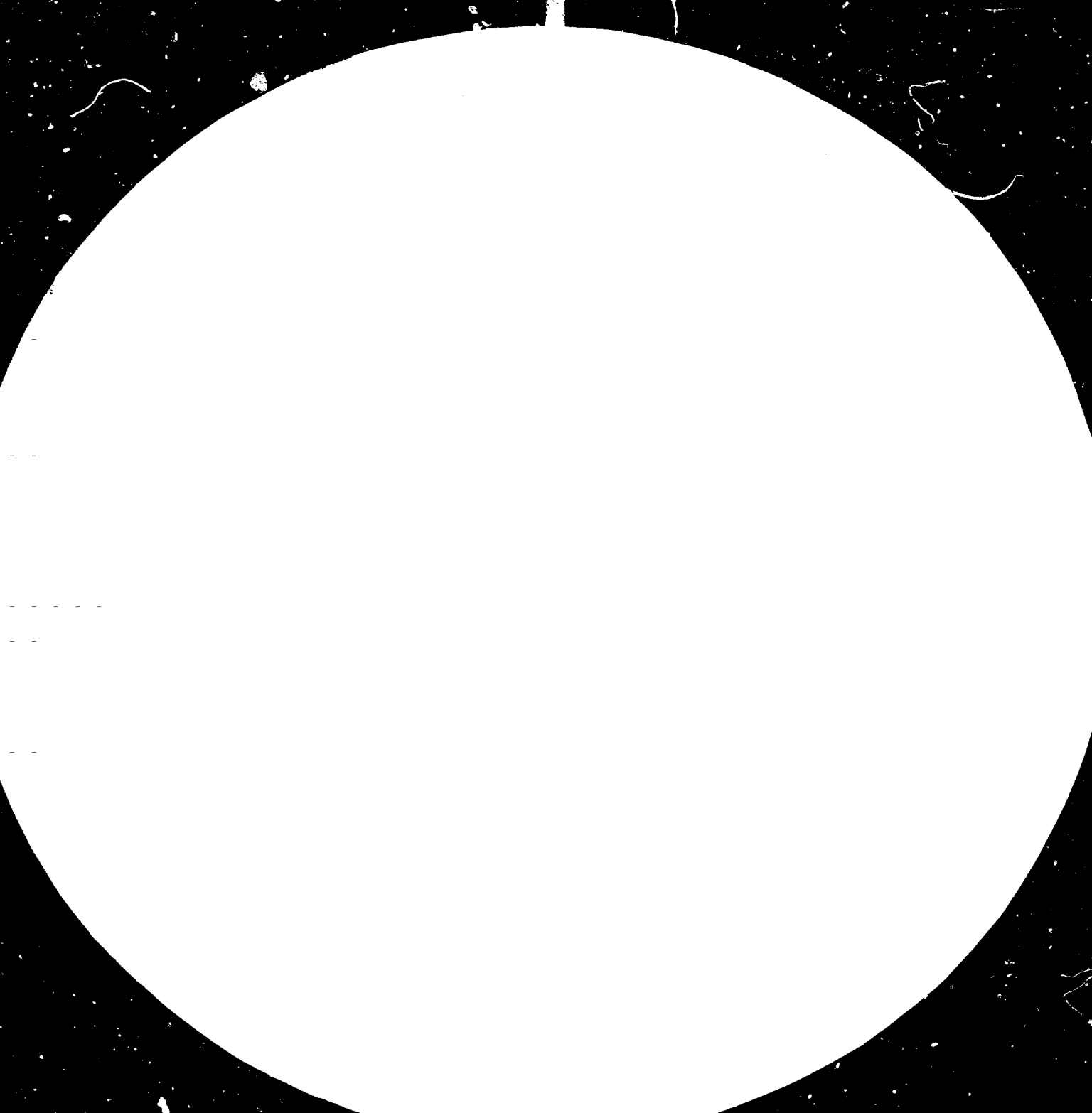
FAIR USE POLICY

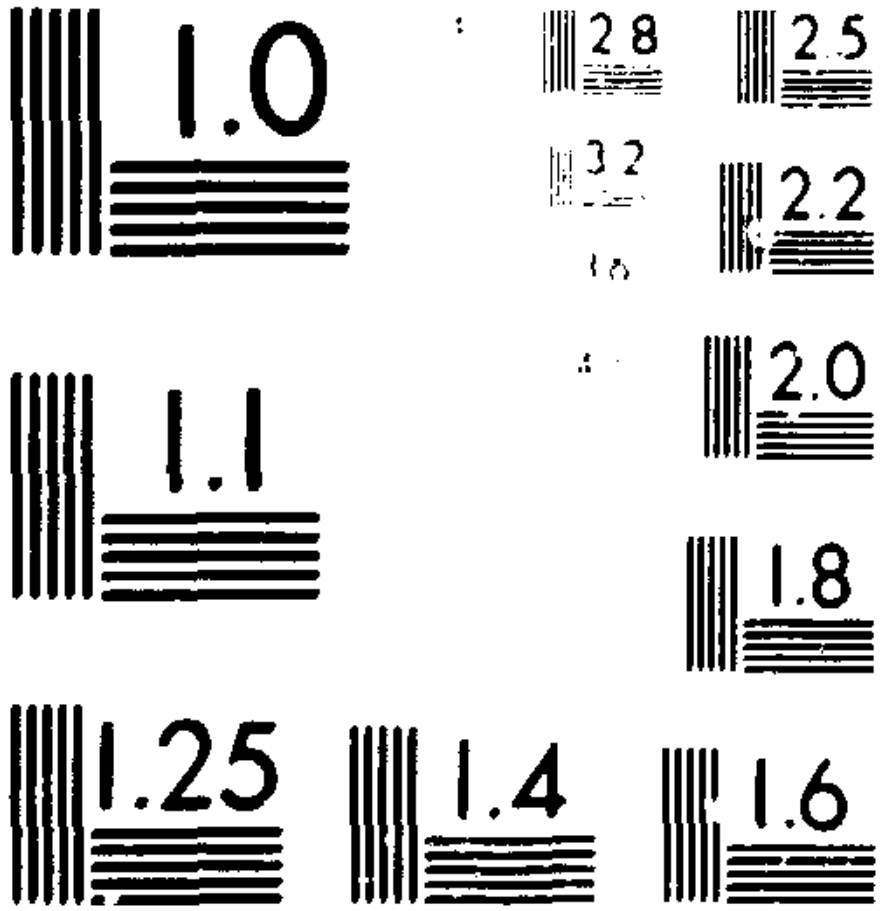
CONTACT

Please contact publications@unido.org for further information concerning UNIDO publications.

For more information about UNIDO, please visit us at www.unido.org

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org




1.0
2.8
2.5
3.2
2.2
2.0
1.1
1.8
1.25
1.4
1.6

11739-E

ID

Distr.
LIMITED

ID/WG.372/12
4 August 1982

ENGLISH
Original: SPANISH

United Nations Industrial Development Organization

UNIDO/ECLA Expert Group Meeting on the Implications of Microelectronics for the ECLA Region

Mexico City, Mexico, 7-11 June 1982

THE DEVELOPMENT OF MICROELECTRONICS IN ARGENTINA *

Country Monograph

by

O. Filipello ** and R. Sagarzazu ***

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

** Executive Secretary, Electronic Components Research Centre (CENICE), Buenos Aires.

*** CENICE.

V.82 29328

It may safely be stated that the most important technological advances of recent years have derived from microelectronics. Without the contributions of this technology it would not have been possible to send men to the moon, explore the solar system or build the strategic weapons systems which dominate today's world political arena. Integrated microcircuits are essential components in systems which range from telecommunications satellites to digital watches, which everyone can now afford. Perhaps less well-appreciated but certainly more significant has been the impact of microelectronics on computer design; the dramatic development of microelectronic technology in recent years has made it possible to reduce the cost per memory unit of a computer by a factor of 25 in the last decade.

This process has had the effect of transforming information into a resource which is unique in that it is not consumed as it is used and, thus, must be manageable in massive quantities. As a consequence, it is inevitable that the developed nations, which are at the forefront of this new revolution, should make available to the developing countries one of the most essential tools for closing the technology gap - namely, information. For example, by enjoying access to data banks via satellite, these countries can immediately acquire information, bypassing the time-consuming and occasionally prohibitive process of storing data in large libraries.

In other words, in a repetition of what has happened in other circumstances throughout history, the same process of growth through which certain countries have become the most powerful in the world is, on this occasion, creating through technology the tools which will enable the lagging nations which know how to use them to catch up with the leaders.

Thanks to miniaturization, electronics today has invaded every area of human activity. Systems which only yesterday were thought of as within the reach of none but the largest firms or the most ambitious scientific programmes are today accessible to small organizations. The obvious advantages which electronics has brought to the production area make it impossible to conceive of a future without electronics, just as following the industrial revolution those producers who did not mechanize their operations failed to survive.

In the face of this reality, countries which fail to undertake the effort to acquire and develop this technology are destined to play at best a secondary role in the future.

Let us now consider what problems this process of incorporating microelectronic technology raises for Argentina.

The speed with which a country can develop a technology depends on the resources which it allocates to this end. As used here, the term resources refers to financial, human and infrastructural resources; of these, the last two cannot be modified to any extent in a short time.

It is easy to imagine an increase by one order of magnitude in the funds currently allocated to projects in the area of microelectronics, but it is not possible to imagine that the country's 50 or 100 specialists in the various areas of this technology could quickly be built up to a pool of 500 or 1,000 trained persons.

The same reasoning applies to the supporting infrastructure available in the country. The transition from a laboratory water-treatment system to a system satisfying a transistor pilot plant's requirements for ultra-high-purity water took more than one year in Argentina because of the domestic industry's lack of experience.

In a country like Argentina, this situation means that a technology such as microelectronics can be introduced only by working simultaneously on all fronts, from applied research to the plant level. This is true because, since the technology which it is intended to introduce and develop does not exist in the country, there are accordingly neither an industry pressing for results, nor universities training manpower in this technology, nor research teams seeking to find solutions to the problems posed by development.

A situation of this kind normally leads to the emergence of two positions usually regarded as diametrically opposed: one position which advocates self-sufficient development and another which calls for the purchase of technology from abroad. The fact is, however, that this alternative is a specious one, for even though the acquisition of technology may imply a momentary technological jump, if the country's resources do not make it possible to maintain this new relative status vis-à-vis the developed countries, it will not be long before it falls back to something

like its original backward status. On the other hand, the totally domestic development of all areas of microelectronics is unthinkable at a time when not even the most advanced nations are following that path. Examples that might be cited include the reciprocal licensing agreements that have been concluded by IBM with the five major Japanese companies in the area of semiconductors, namely NEC, Hitachi, Toshiba, Fujitsu and Mitsubishi.

The real option, therefore, involves a combination of domestic development and the acquisition of technology geared to the country's potential and its policy of national technological development.

In line with this principle, the Argentine Government, with the assistance of the State institutions representing the areas of national defence, science and technology, and the electronics consumer sector - namely, the Armed Forces Technological Research Centre (CITEFA), the Department of Science and Technology (SUBCYT), the National Council for Scientific and Technological Research (CONICET) and the Department of Commerce (SUBSECOM) - established the Electronic Components Research Centre (CENICE), which it has charged with the following responsibilities:

- To enhance the effectiveness of the scientific and technical sectors in the electronic components area;
- To advise Government bodies in negotiations involving these technologies;
- To meet special requirements for electronic devices on the part of the armed forces, service organizations and/or producers of professional electronic systems;
- To transfer to the domestic production sector technologies developed in Argentina or foreign technologies that have been further developed and adapted to Argentine conditions;
- To guarantee the quality of the electronic components supplied to the armed forces and Government organizations.

These points are discussed in annex 1; annex 2, which describes the Centre's main areas of activity, indicates the work which has been accomplished to date.

Let us consider the speed with which microelectronics has evolved in the technologically advanced countries. In 1964, Gordon Moore, the Director for Development at the Fairchild Corporation in the United States, pointed out that since the production of planar transistors in late 1959 every year had witnessed a doubling in the number of elements per integrated circuit, and he went on to predict that this trend would continue. So far at least, there have been no significant deviations from this general trend as complexity has increased, from the simple transistor to today's integrated circuits accommodating more than 200,000 transistors in a single microchip. In other words, "Moore's law" has held over a period of 20 years, for increments of five orders of magnitude.

The number of components which can be integrated on a single chip is the best gauge available for evaluating technological capacity in the microelectronics area. In the discussion that follows, we shall use this parameter as a way of quantifying the development of microelectronics in our country.

Let us now turn to the situation in Argentina. There have been a number of attempts at developing microelectronics since the 1960s but it was not until 1974 that work on planar silicon transistors was begun in the CITEFA Microelectronics Group. The continuity of this Group's work and its inclusion in CENICE (founded in 1977) make it possible to study the dynamics of Argentina's technological growth in this area over the past five years. On the basis of the data obtained from this analysis, of the factors set forth above and of worldwide trends, the possible future development of this technology can be predicted.

The first prototype of a marketable transistor was obtained in 1978 and in 1980 transistors were being produced in a pilot plant. Having acquired the complete manufacturing technology for transistors, Argentina was in a situation comparable to that of the United States in 1960, that is to say we were 20 years behind. Since then, an integrated circuit with 30 active components has been designed. It is currently being developed into a prototype and will begin to be produced in a pilot plant at the end of 1982.

If we take into account Argentina's limitations, arising out of the circumstances mentioned above and reflected by the experience of the past few years of work, and if we suppose that a law similar to the one put

forward by Moore is at work, we can define the maximum possible rate of development of microelectronics in this country.

In the figure, this maximum is juxteposed with Moore's law. It can be seen that if this situation materialized, the growth would be much faster than that in the main manufacturing countries. This is easily understood, in view of the fact that our lag gives us the chance to have information and equipment which were obviously not available to the pioneers. Therefore, it must be assumed that, as the technological gap narrows, the growth rate will decline as well.

If the resources available do not permit the country to overtake the leading nations, the reasonable approach is to establish a gap at which the country can develop at the same rate as the leaders. If the decision was to maintain the present technological gap, the growth rate would be that indicated as the minimum in the figure below. A programme envisaging a lower growth rate than this would of course be completely inadvisable.

It is interesting to observe the development of Brazil in this area, since it is encountering problems with its technological development programmes which are quite similar to our own. In 1968, the Microelectronics Laboratory was set up at the University of São Paolo and has since been operating continuously with the following objectives:

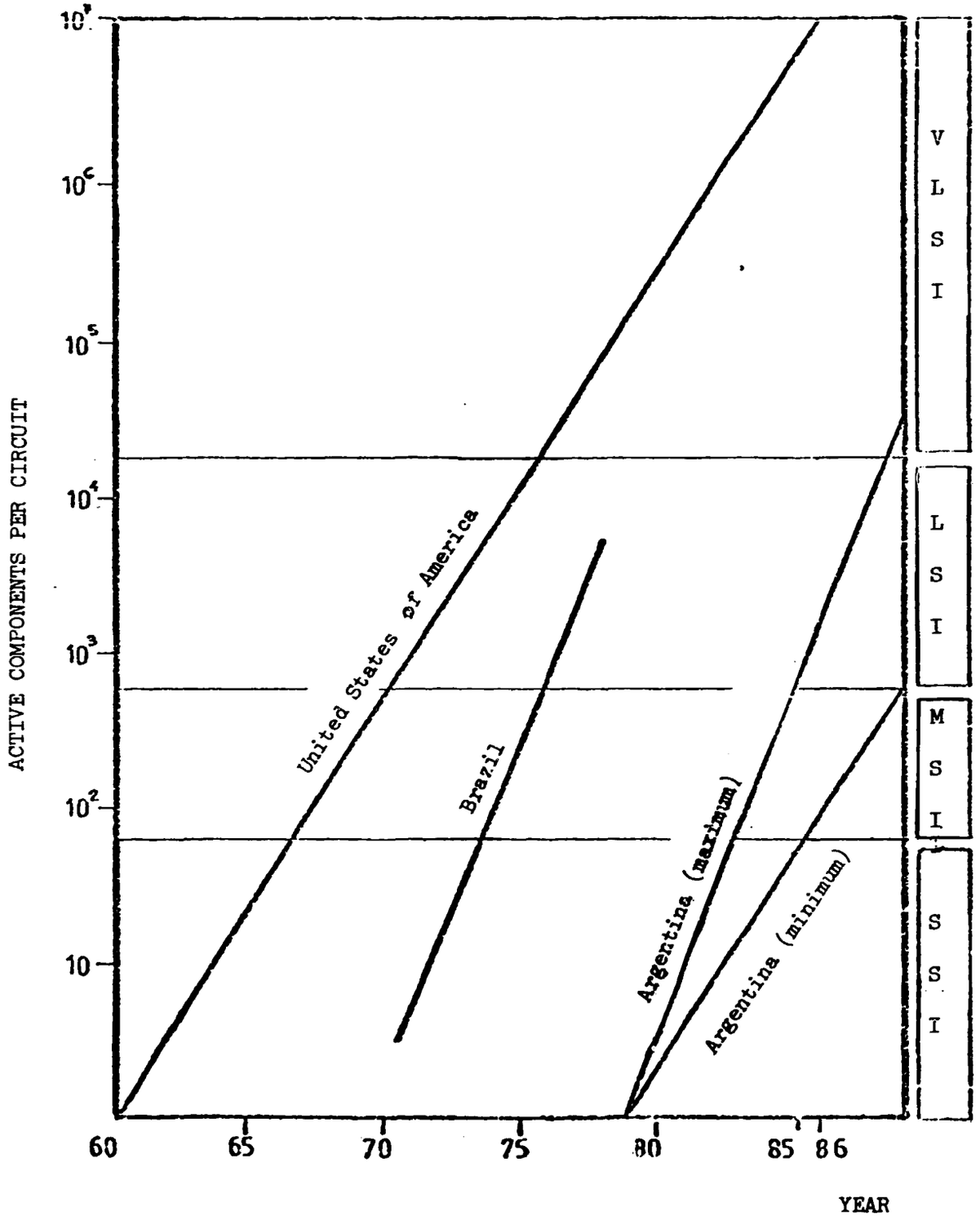
Training of personnel;

Research and development;

Support to Brazilian industry.

Information making it possible to determine the progress achieved in Brazil has been drawn from a recent publication of the University of São Paolo. The increase in the level of integration there has taken a course similar to the one posited by Moore's law and is shown on a line parallel to the one shown as the maximum for Argentina. This suggests that the growth model put forward is correct and should be taken into account when determining development policy in this area of technology.

In Argentina's case, continued growth in line with the maximum-rate hypothesis will require investments of about $US 4 million a year for research and development in microelectronics.



Legend:

SSI: Small-scale integration

MSI: Medium-scale integration

LSI: Large-scale integration

VLSI: Very large-scale integration

ANNEX 1

1. How to enhance the effectiveness of the scientific and technical sectors in the microelectronics area:

   - By setting up a centre of excellence to carry out research and development in this area and to make possible the training and tapping of manpower resources;
   - By assimilating all kinds of inputs from basic research findings to industrial processes, by virtue of the centre's high standard and wide area of interest, which ranges from the physical principles of devices to pilot plants;
   - By developing its own creative capacity so that it can develop innovations in the field of microelectronics;
   - By facilitating manpower training by means of post-graduate courses, special technical training and the installation of specialized laboratories.

2. How to advise Government bodies in negotiations involving microelectronics technologies:

   - By having experts who are able to characterize the technologies to be acquired;
   - By evaluating the feasibility of local manufacture;
   - By evaluating alternative technologies;
   - By recommending the inclusion of clauses allowing for access by Argentine experts to technological information which would facilitate the process of refining technologies which are of interest to our country.

3. How to meet special requirements for microelectronic devices on the part of the armed forces, service organizations and/or producers of professional electronic systems:

   - By manufacturing in pilot plants those devices which for some reason (e.g. strategy, time reduced demand, etc.) are not available on the market, as is currently being done with hybrid circuits.

4. How to transfer to the domestic production sector technologies developed in Argentina or foreign technologies that have been further developed and adapted to Argentine conditions:

   - Through technological development up to the pilot-plant level;

   - By adapting technologies which can be obtained from multinational corporations through negotiations, using the purchasing power of the State.

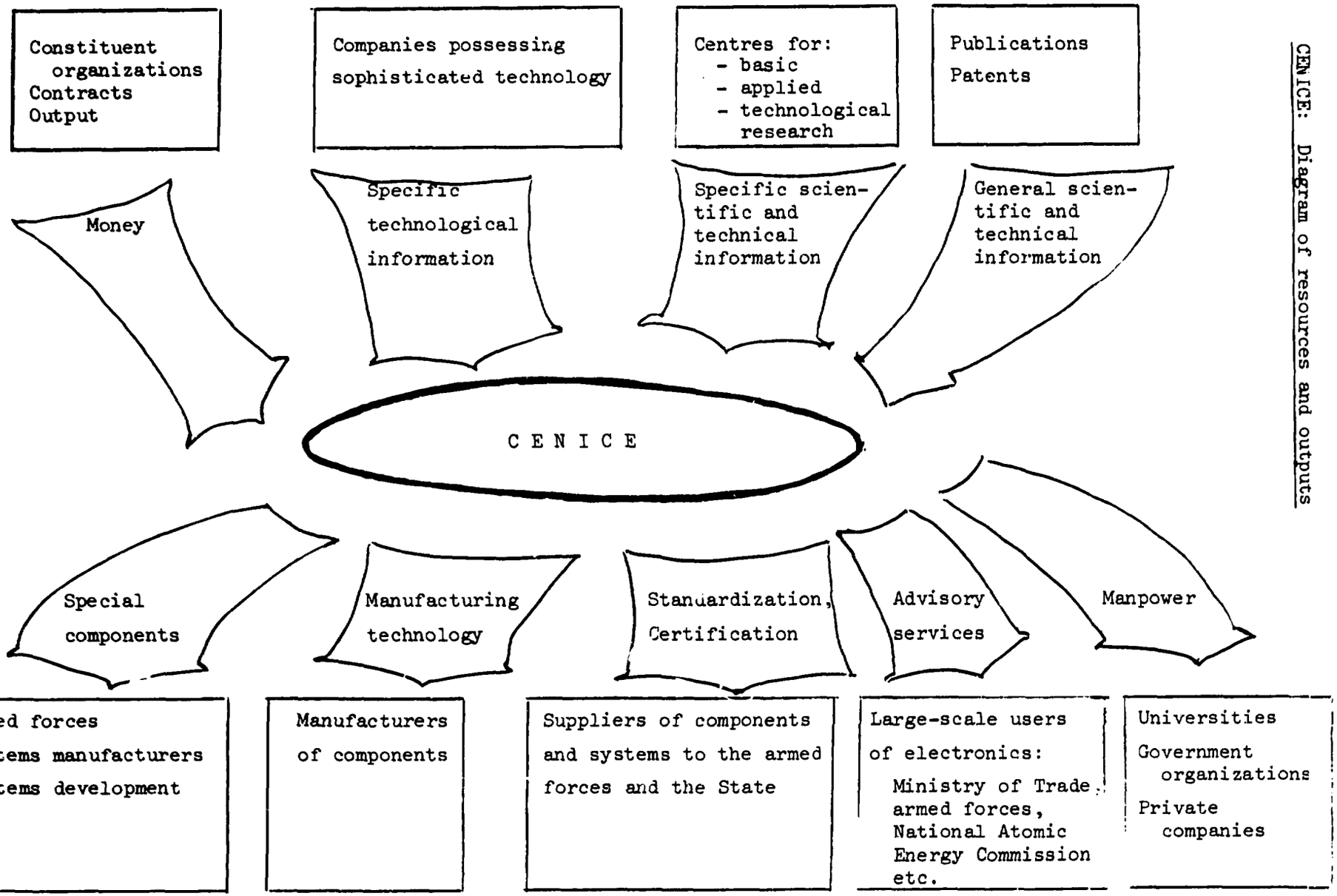
5. How to facilitate the development of electronic systems in Argentina:

   - Through custom design of microcircuits, to be used in the manufacture of systems wherever their complexity, miniaturization or the need for secrecy require it.

6. How to guarantee the quality of components supplied to the armed forces and Government bodies:

   - By issuing standards and certifying components in accordance with them.

CENICE: Diagram of resources and outputs



ANNEX 2

17 February 1982

CENICE

Electronic Components Research Centre

1. Objectives of the Group:

- To facilitate the development of electronic systems in the country;
- To transfer to the domestic production sector technologies developed in Argentina or foreign technologies that have been further developed and adapted to Argentine conditions;
- To meet special requirements for microelectronic devices on the part of the armed forces, servic organizations and/or producers of professional electronic systems;
- To advise Government bodies in negotiations involving this type of technology;
- To guarantee the quality of components supplied to firms, the armed forces and Government bodies;
- To enhance the effectiveness of the contribution of science and technology in the field of microelectronics.

2. Development and future prospects of the Group:

Development

Over the past ten years CENICE has developed from a small laboratory without experience in the field of microelectronics into an organization which is able immediately to fill orders for special devices of medium or low complexity, with a high level of quality and reliability and acceptable for military purposes. There are able and experienced trained persons on its staff who can take part in negotiations on microelectronics technology. It can carry out the military-standards approval procedure in respect of components from any source. This has been achieved despite the fact that at some times in the past the Centre has not received the support it needed.

Future prospects

In future CENICE will be able to manufacture devices of increasing complexity to meet the requirements of the armed forces and of the professional sector. It will make new transfers of technology to industry to the extent required by the latter and have an advanced design centre for integrated circuits at its disposal, which will enable it to develop equipment and systems successfully within Argentina by providing the design for the special integrated circuits even when these are not manufactured domestically. This will make the technological standard of our electronics industry comparable to that of the more advanced countries and ensure secrecy for new developments whenever necessary.

We will also have an efficient advisory capability, making possible international negotiations involving these technologies.

3. Projects under way:

- Development of technology for manufacturing high-reliability hybrid circuits for military uses;
- Manufacture to order of hybrid circuits for the development of electronic systems for the armed forces and to meet the requirements of industry, especially in the fields of communications and nuclear energy;
- Research into new manufacturing processes for hybrid circuits: multiple layers, conductor crossovers, functional adjustment;
- Establishment of an assembly and encapsulation plant for high-reliability hybrid and integrated circuits;
- Manufacture of bipolar silicon transistors for use in the professional and military electronics industries;
- Development of manufacturing technology for bipolar integrated circuits;
- Development of new manufacturing processes for special semiconductor devices;
- Design of non-conventional hybrid and integrated circuits, as required;
- Development of a quality and reliability control system for electronic components;

- Operation of a training course for engineers in the design of integrated circuits in collaboration with the University of Buenos Aires;
- Project for the construction of a pilot plant for complementary metal oxide semiconductor (CMOS) technology.

4. Resources available to the Centre:

- Pilot plant for hybrid circuits

  Area: 193 m^2

  Value of equipment: $US 400,000

  Staff: Professionals: 4

  Technicians: 3

  Auxiliary: 5

- Pilot plant for bipolar technology

  Area: 148 m^2

  Value of equipment: $US 410,000

  Staff: Professionals: 3

  Technicians: 4

  Auxiliary: 3

- Development laboratory

  Area: 160 m^2

  Value of equipment: $US 300,000

  Staff: Professionals: 4

  Technicians: 1

  Auxiliary: 1

- Quality control

  Area: 60 m^2 *

  Value of equipment: $US 250,000

  Staff: Professionals: 2

  Technicians: 1

---

* Under construction.

- Technical infrastructure

  Area: 101 m^2 *

  Value of equipment: $US 217,000

  Staff: Professionals: 1

  Technicians: 10

  Auxiliary: 1

- Assembly and encapsulation

  Area: 45 m^2 *

  Value of equipment: $US 270,000

- Economic control

  Area: 75 m^2 (including store)

  Value of equipment: $US 17,000

  Staff: 5

Summary:

Total area available: 822 m^2 **

Total value of equipment: $US 1,869,000

Total staff including management offices and technical and administrative secretariat:

Scientific	18
Permanent	1
CLO	11
Other	21
TOTAL	51

* Under construction.

** 206 m^2 of which are under construction.

5. Sources of finance:

The sources of finance for this project are:

DIGID

CITEFA

SUBCYT

CONICET

SUBSECOM

6. Funds received:

The following funds have been received in the last two years:

1980

Argentine pesos: 2,445,000,000

United States dollars: 1,319,481

1981

Argentine pesos: 5,626,480,000

United States dollars: 1,590,000

7. Scientific achievements and practical applications:

- Commissioning of the Centre's pilot plants and laboratories and of the necessary complex infrastructure (ultra-pure water, ultra-pure gases, etc.);
- Transfer to private industry of technology for the manufacture of thick-film hybrid circuits;
- Manufacture of special devices to meet the requirements of the armed forces;
- Manufacture of devices for the professional market (telecommunications) approved by the leading companies in the field such as Siemens, Thomson and GTE;
- Manufacture of transistor series which meet the specifications for those currently used by Fabricaciones Militares;
- Acquisition of high-frequency transistors from the firm Texas Instruments with a view to manufacturing them in the future;

- Development of a design capability which will make it possible to manufacture, to order, integrated circuits of high reliability and complexity;
- Study and development of the manufacturing processes for hybrid and integrated circuits contained in 192 technical reports, three input specifications, eight maintenance specifications, 34 control standards, 35 process standards and one product specification.

8. Connections with other organizations:

In the domestic public sector:

DIGID;

Fabricaciones Militares;

SUBSECOM;

SUBCYT;

CONICET;

CNEA (National Atomic Energy Commission);

INTI (National Institute for Industrial Technology);

University of Buenos Aires;

National University of Rosario;

National University of the Coast.

Local companies:

LACI (Laboratorios Argentinos de Circuitos Impresos S.A.);

Siemens;

GTF

Thomson;

ITALTEL;

Texas Instruments;

ELCOMAT.

Foreign universities and technology centres:

Massachusetts Institute of Technology (United States);

University of Berkeley (United States);

University of Delaware (United States);

LETI - Electronics and Data Technology Laboratory (France);

Institute for Solid-State Technology (Germany);

Telebrás - Research and Development Centre (Brazil).

9. Publications, patents, etc.:

"Desarrollo de transistores planares de silicio" (Development of planar silicon transistors) by C. Cortés, A. Boselli, O. Pilipello, M. Maciel, J. Albisu and J. Bragagnolo.

- Presented as a paper at the sixty-first Scientific Meeting of the Argentine Physics Association (AFA) in Buenos Aires on 16 and 17 June 1975. Published as paper A 2 in the review of the Argentine Physics Association, vol. 1, No. 4, section 2, page 371 (1976).

"Desarrollo de baterías solares de CdS-Cu_2S" (Development of solar CdS-Cu_2S batteries' by J. Bragagnolo, J. Albisu, A. Boselli, C. Cortés and J. Molina.

- Presented as a paper at the sixty-first Scientific Meeting of the Argentine Physics Association in Buenos Aires, Argentina, on 16 and 17 June 1975;

- Published as paper A 10 in the review of the Association, vol. 1, No. 4, section 2, page 377 (1976);

- Presented as paper E 20 at the first Latin American Conference on Solar Energy, held in Buenos Aires, Argentina, 21-25 July 1975;

- Presented as paper 311 at the fifth Latin American Symposium on Solid State Physics, held in Lima, Peru, 14-25 February 1977.

"Obtención y caracterización de películas de CdS serigrafiadas" (Production and characterization of serigraphed CdS films) by J. Albisu, C.M. Cortés and S.J. Liberman.

- Presented at the second Working Meeting on Solar Energy, held in Salta, Argentina, 21-24 July 1976;

- Published in the Proceedings of the Meeting published by the Argentine Solar Energy Association.

"La situación energética Nacional" (The national energy situation) by J. Albisu and J.A. Bragagnolo.

This study was used as a working document at the first Co-ordination Meeting for the National Plan for Solar Energy Utilization, held in Vaquerías, Córdoba, Argentina, in 1975.

"Effects of Contact Resistance and Dopant Concentration in Metal - Semiconductor Thermoelectric Coolers" by Carlos M. Cortés and Robert G. Hunsperger, IEEE Transactions on Electron Devices, vol. ED-27, No. 3, page 521 (March 1980).

"El Desarrollo de la Microelectrónica en la Argentina" (The development of microelectronics in Argentina) by O. Filipello and R. Sagarzazu.

- Presented at the Scientific Conference on Electronics in La Falda, Córdoba, Argentina, in October 1979;

- Presented at the Symposium on Microelectronics Technology, Technical University of Munich, Federal Republic of Germany;

- Presented at the fourth Latin American Symposium on Small and Medium-Sized Businesses, held by INTI in Buenos Aires, Argentina, in September 1980 and published in its Contributions, vol. II;

- Presented at the Conference on the Impact of Science and Technology on Development, held by the Uniersity of Comahue, Bariloche, Argentina, in 1980.

The following patents are pending:

A new method for producing improved photoresistive cells (C. Cortés and J. Albisu), patent pending with the National Industrial Property Register, file No. 278083.

Echo Canceller for an 80 Kb/s Baseband Modem (O. Agazzi, David A. Hodges and David Messerschmitt).