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UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION

**SOME RECENT TRENDS IN MICROELECTRONICS AND
UNIDO TECHNICAL CO-OPERATION PROGRAMME**

Presented at the

**Expert Group Meeting on the Design, Development, Manufacture and
Application of Microelectronic Components**

4 - 8 March 1991, Kuala Lumpur, Malaysia

by

Dr. Mohamed Arif Nun

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION (UNIDO)

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1. *Introduction*

This expert group meeting is organised by the United Nations Industrial Development Organization (UNIDO) in co-operation with the Malaysian Institute of Microelectronic Systems (MIMOS). Its main objectives are to provide a forum for exchange of information and experience between the participants and to identify possible areas of regional and interregional co-operation.

2. *World trends in microelectronics*

For the fiscal year ending March 31 (Electronic Business Asia, February 1991), the leading 50 Japanese companies registered a combined sale of US\$ 220.1 billion while the top 50 American companies recorded a total sale of US\$ 227.1 billion for the calendar year 1989. For Europe, the 1989 total electronics revenue for the top 50 publically held companies was US\$ 144.2 billion (Electronic Business Asia, January 1991).

In terms of growth, the top 20 Japanese electronics companies grew by 13 per cent while that of the top 20 American electronics makers is 6 per cent.

It is prophesied that the 1990s will be dominated by large, extremely high-speed, high-data-rate electronic systems on the one hand and amazingly compact, functionally sophisticated, mobile and light-weight electronic systems on the other.

The latter will exert a larger influence by far on the market and on people's lives. Laptop and palm-size computers are expected to grow five-fold to 11 million units by 1994.

One of the major developments of the 1990's in the field of solid-state microelectronics was the commercialising of chips containing more than 1 million transistors. Probably in 1991, microprocessor chips with well over 2 million transistors will be launched. As far as processor speeds are concerned, in 1990 25 MHz has been taken for granted. The next generation of 1991 chips can be expected to reach 50 to 60 MHz. For example, a 64-bit microprocessor with 100 MIPS working at 50 MHz and based on 0.8 um technology was announced recently (Electronic World News, Feb. 18, 1991). In addition, a new cache-base PC AT chip set was announced, which can handle the entire range of 80486 CPUs, from the current 25-MHz DX up to 50 MHz super 486 processors. Also being delivered are new fast GaAs gate arrays of more than 100,000 gates per chip and BiCMOS PLDs having propagation delays of at least 7.5 ns.

Reduced-instruction-set computer (RISC) microprocessors are offered by many semiconductor houses in megatransistor chips.

Digital signal processor (DSP) chips are adding enormous functionality to desktop computers and workstations. Many foresee that a DSP chip will eventually have equal status with the microprocessor in these units. DSPs are particularly effective in floating-point operations, high-speed modems, voice recognition, transcoders, robot control, hard-disk control, as well as multimedia, digital audio electronics, full-motion-video compression and decompression, animation, color printing and facsimile, as well as data telecommunication.

The market for these types of I.C.s and for high-end 16- and 32-bit microcontrollers and microprocessors, which are used for "embedded control", is expanding rapidly (Electronic Business Asia, June 1991). It is not very well known that the vast majority of microprocessors (MPUs) sold worldwide reside "behind-the-scenes" in diverse products, from microwave ovens and washing machines to automobiles to guided missiles. Microprocessor manufacturers are realising that there are more applications for embedded microcontrollers than there are for general-purpose chips.

The market for these microcontrollers is expected to grow from US\$ 2.9 billion in 1988 to \$ 6.8 billion by 1995 (Electronic Business Asia, June 1990). Most of the growth is expected to come from the high-end 16- and 32-bit products whose share of the market for embedded controllers is expected to grow from 10.9 per cent in 1989 to 40.3 per cent by 1995. The 58 per cent compounded annual growth predicted will be driven mainly by high volume markets in office automation such as laser printers,

as well as telecommunications and automotive electronics.

This market for embedded processors is driven very largely by the "explosion" in applications for image processing (Electronics, June 1990). This field could be the next gold mine for chip manufacturers. Imaging is rapidly migrating from the traditional scientific and medical applications into the office environment for all sort of functions like page printing, digital copying, plain-paper and digital facsimile, and document scanning and conversion - all these using the PC or workstation as platforms. The full potential of image processing is yet to come, in the form of desktop publishing (market of US\$ 3.8 billion in 1989 and heading for 10 billion in 1993) and in the form of the still "infant" multimedia PC market which will be a 2.4 billion industry by 1994 in business and professional markets alone.

Thus, going into the mainstream will be desktop machines designed and fabricated around the 32-bit processors that can now handle imaging, once the domain of super computers. This will open vast new markets for makers of embedded processors, digital signal processors, dedicated RISC chips, data-conversion and video ICs. These microelectronic components will go into PC and workstation-based fax, scanning, processing, printing and multimedia systems.

In general, memory chips, too, are growing bigger and faster. Dynamic RAMs, for example, are being shipped in volume in 4M-bit sizes; 16MB-bit DRAMs are being sampled; 64MB-bit devices have been demonstrated; 256M-bit and even 1G-bit devices are in development. Their access times, meanwhile, are falling steadily; where about 80 nanoseconds is standard now, about 60 ns will be the norm a year from now with standard CMOS technology, and 35 ns may be reached with bipolar-CMOS (biCMOS).

An exciting event which is radically transforming the computer storage arena is the coming of new nonvolatile memory chip technologies and architectures collectively known as flash memories. These flash memories combine features of two different nonvolatile technologies to deliver the easy reprogrammability of electrically-erasable PROMs and the high bit densities of ultra-violet EPROMs (Electronic World News, January 14 1991).

These non-volatile I.C. memories are becoming more and popular and are growing at a faster pace than that of the entire semiconductor market. Flash memories are attaining speeds better than 100 ns. Sales of flash memories are expected to grow from US\$ 37 million in 1990 to \$ 134 million in 1991 and \$1 billion in 1994 (Electronics, November 1990). These flash memories are posing very strong challenges to the traditional dynamic RAMs, conventional uv EPROMs and EEPROMs and even to disk storages.

For all nonvolatile memory types, the market is expected to increase from US\$ 3.15 billion in 1990 to US\$ 4.3 billion in 1992.

In February this year (Electronic World News, February 18, 1991), KTI Semiconductor Ltd., a joint-venture between Kobe Steel and Texas Instruments Inc., announced the setting up of a US\$ 350 million wafer fabrication plant to produce 9,000 8 inch wafers per month. Production will mainly be submicron CMOS logic devices and ASICs.

The tremendous progress in technology in microelectronics is matched by a rapid increase in the cost of setting up of the wafer fabrication plants. The following comparison illustrates this.

| | <u>4 Megabit Chips</u> | <u>64 Megabit Chips</u> |
|-------------------------|--------------------------------------|------------------------------|
| Chip capacity: | 4 million bits | 64 million bits |
| Narrowest circuit line: | 0.8 microns | 0.25 microns |
| Fabrication plant cost: | US\$ 350 million | US\$ 750 million |
| First samples: | 1988 | 1994 |
| Technology leaders: | IBM, Toshiba, Hitachi, NEC & Fujitsu | - same - |
| Peak-year sales: | \$ 10.5 billion | 1994 2000 US\$ 25 billion |

(Business Week, December 10, 1990)

For developing countries and even for smaller commercial organisations, it is heartening to note that there is a new development in the concept and development of wafer fabrication facilities (Electronics, April 1989); this is the coming of new fabrication lines called "minifabs", which can be set up for less than US\$ 5 million and designed for economical small lot production (from 10 devices to 1000 devices) and fast turn-around-time (from 24 hours to about a week). At present, there are about 200 such ASIC-oriented "minifab" out of a total of about 600 fab facilities worldwide.

Beyond the laptop and notebook computers, a new machine will hit the market by the end of this year (Fortune February 1991) that could well be as revolutionary as the original P.C. It is so new that the industry has not even agreed on the name for it. Besides notepads, these machines have been called tablets, stylus computers, pen-based computers, pen PCs and electronic slates. The stylus of these machines combines the best attributes of both a mouse and a keyboard and are capable of recognising hand-written characters. The leader in this field is yet another Silicon Valley start-up, Go Corp. who has created a radically new operating system, called Pen Point. Go is already collaborating with IBM and others to devise a standard notepad design. Microsoft Corp., the software giant, has already got into the picture by developing Pen Windows, a version of DOS that can be controlled with a stylus.

The industry is predicting that 250,000 of these note pads will be sold in 1992 and two million a year, worth US\$ 3 billion, by 1995.

In the semiconductor industry, there has been a tremendous progress in process technology. By the early 80's CMOS 3 μm technology has become the industry standard, and later in the decade, most vendors are producing products based on CMOS 1.5 to 1.0 μm process. Nearly all semiconductor producers are now developing their capability for submicron process technology, phased into three stages: 0.8 μm , 0.5 μm and 0.3 μm . Clean rooms of Class 1 and class 10 (for 0.3 μm particle size) are the norm.

Currently, an exciting challenge has arrived in the form of a new technology, BiCMOS - bipolar complementary metal oxide semiconductor, developed in 1985 by Hitachi, Toshiba and Motorola (Asian Electronics Engineer, January 1991).

BiCMOS technology integrates bipolar and CMOS on a single chip and offers the advantage of high speed and high-current drivers. Among the other advantages of this technology are:

TTL and ECL compatibility, low power consumption, high package density and provides better noise insulation of CMOS components. According to recent statistics, BiCMOS products in 1988 accounted for 0.1 per cent of the entire semiconductor market but is expected to rapidly increase to 6 per cent by the year 2000. In 1989, sales of BiCMOS components was US \$200 million and it is forecasted to grow to US \$ 3.55 billion.

BiCMOS has a wide application of products such as gate arrays, analog devices, SRAM, standard logic devices, manalog/digital converter for high-definition television (HDTV) and digital communications systems.

BiCMOS technology occupies a market niche between the very high speed but power-hungry bipolar ECL and very high density but medium-speed CMOS. However, whatever the technology, its success in industry is still dependent on cost. BiCMOS's device cost can be broken down into (a) manufacturing complexity, (b) parameter control and (c) the number of mask steps (between three to five)

In the field of development of processes, lithographic techniques made major advances. These advances are necessary since for the next generation of chips, the 64-megabit chips, circuits's line size will be less than 0.35 micron. At the same time, the demands on clean room design are staggering - five particles per cubic metre, each of 0.1 micron.

Commercial electron-beam lithography machines were introduced which can write up to five 8-inch wafers per hour with feature sizes smaller than 4 um. X-ray lithography is in a state of ferment, a number of new equipment including large synchrotron-based systems and smaller laser-pumped sources are being developed.

Meanwhile, there seems to be surprising life left in photolithography. Many prophets believe that photolithography will even be able to form the superfine (0.3 um and less) patterns needed in 256M-bit memories.

In practice, optical lithography equipment are still able to cope with industry's demand by incorporating modification and enhancements like using tiny-wavelength "deep UV" light. Another type of equipment generates deep UV light with a laser and a lens system to focus this light.

Industry experts believe, however, that the next generation of chips, the 256-megabit RAMs and then the 1-gigabit chips will require radically different technology like X-ray lithography.

Advances are also being made in the less "glamorous" field of printed circuit board (PCB) fabrication. Processes are being developed, using photoimageable resist as the key element, to take lines down to 3 mils by the end of 1991.

Another star in the I.C. market is the programmable logic devices (PLDs). Early last year demand outstrip worldwide supply. Worldwide PLD sales have grown almost 50 per cent, from US\$ 475 million in 1987 to US\$ 710 million in 1989 (Electronic Business Asia, October 1990). The sale of PLDs is expected to be more than double to US\$ 1.7 billion in 1994. It is estimated that CMOS PLDs will account for 57 per cent of this market.

The demand for PLDs is driven by their widespread use in PCs and other computer peripherals such as disk drives, modems, printers and enhanced graphics displays. These PLDs are also finding their way into telecommunications equipment like digital switches and PBX systems, as well as industrial controls, test and medical equipment and even fax machines and consumer products.

These PLDs are members of the Application Specific Integrated Circuit (ASIC) family, other family types being the gate arrays, standard cells and full-custom I.C.s. ASIC sales are forecasted to grow at 10 per cent annually from US\$ 7.3 billion in 1990 to US\$ 12.6 billion in 1995 (Electronic World News, February 4 1991). By next year, the market for semicustom I.C.s for Asia-Pacific is expected to be US\$ 830 million.

This growth is amply matched by rapidly increasing productivity in the design and fabrication of VLSI and specifically, ASICs chips. With the advent of advanced workstation technology and the availability of powerful design tools like the silicon compilers, the interface between silicon system design and actual silicon processing is becoming more transparent.

In summary, application areas for electronic systems and circuits are expanding at a rapid rate leading to an ever increasing demand for microelectronic devices of ever increasing functionality and performance. Processing technologies are keeping pace and the intense competition worldwide will see a continuing decrease in the price of microelectronic components.

At the same time, the Asia-Pacific region will become a significant player in both the design, production and the consumption of microelectronic components.

KEYWORD SUMMARY OF TECHNOLOGY TRENDS

PCs and workstations

Laptops and notebooks dominate the market place
Reduced instruction set computers (RISC) proliferate and
break US\$ 5,000 barrier
Superfloppy drives reach 20 MB formatted capacity

Software

OOP (object-oriented programming) and
CASE (computer-aided software engineering)

Test and measurement

Artificial intelligence in testers
Smart testers

Industrial electronics

More applications for fuzzy logic
Computer-integrated manufacturing advances
RISC-based computer numerical control (CNC)

Consumer electronics

Digital high definition TV (HDTV)
Fuzzy logic for varied products

Medical electronics

Computer-aided surgery with robotics
Fast magnetic resonance imaging (MRI)
New applications for ultrasound imaging

3. What is UNIDO?

United Nations Industrial Development Organization (UNIDO) was established by the United Nations General Assembly in 1966 to promote and accelerate industrialisation in the developing countries. Since then, with the increasing awareness of the importance of industry, as a dynamic instrument of growth, in every developing nation's attempts to achieve a better quality of life for its people, UNIDO's role is becoming ever more crucial.

Partly in recognition of this, UNIDO became a specialized agency of the United Nations in 1986 with an independent budget under the control of its Member States. It has a staff of over 1,400 at its headquarters in Vienna, Austria and 2,100 project personnel based in the developing countries.

UNIDO activities can be grouped under:

- Technical co-operation
- Investment promotion
- Industrial studies and information
- Consultations
- Training
- Development and transfer of technology

UNIDO has a mandate to assist and co-operate with non-governmental organizations as well as the public, co-operatives and private sectors of industry. In 1989 requests from governments resulted in about 1,900 technical co-operation projects under implementation with a total expenditure over that year of nearly US\$ 134 million.

Technical assistance activities are financed mainly by the United Nations Development Programme (UNDP), for which UNIDO acts as an executing agency. These funds are allocated to each country and region and normally programmed over a period of five years.

UNIDO operates three main types of technical assistance funds in addition to UNDP funds:

- Self-financing trust funds sources from developing country enterprises themselves.
- The Industrial Development Fund (IDF), and
- Third-party trust funds for contributions from Governments and non-governmental organizations.

A typical technical co-operation project consists mainly of three components: project personnel, fellowships and training, and equipment.

A request from a Government generally results in a project-proposal according to a prescribed format which all parties agree upon. After formal approval of budget, the project can then be executed. UNIDO has specialized departments to carry out supporting activities such as the recruitment of project personnel, requests for bids, purchase of equipment, and organization of the training, study tours and fellowships.

UNIDO is responsible for preparing industrial studies, conducting research in the industrial sector, encouraging the development and transfer of technology, providing technical assistance to developing countries, maintaining an industrial statistics and carrying out empirical studies for the industrialization process.

UNIDO activities can be further described as follows.

Firstly, in the area of technical co-operation UNIDO provides experts to assist and advise many developing nations in management, marketing and financial operations. The industrialized nations have the resources mentioned above which enable them to assist the developing countries in their industrialization process.

In the process, UNIDO will seek to identify the needs and resources and to promote international co-operatives efforts. Furthermore, it provides advice and support to Governments wishing to accelerate the industrialization process through better planning and the introduction of incentives to the industry.

In order to promote integrated economic development, UNIDO assists developing countries by implementing technical co-operation projects which use a local processing and domestic raw materials. through the development of local technology and adaptation of foreign technology. UNIDO also provides experts, equipment and fellowships to developing countries on projects designed in consultation with the developing countries concerned.

The projects embrace four main elements: experts to assist and advise, services of consulting firms for work in establishment of industrial undertakings, fellowships, single or in groups in order to develop local expertise and assistance in the equipment for testing, development and pilot plant facilities.

In order for developing countries to accelerate their industrialization, one of the most important factors to be emphasized is the development of the indigenous and endogenous technological capability. Therefore UNIDO plays a crucial role in promoting technology development, working to strengthen the technological systems in developing countries and in assisting in the transfer of appropriate technologies to developing countries.

To doing so, UNIDO has made an effort to sensitize developing countries to technology, to promote research and development and its commercialisation, and to formulate suitable technology policies and programmes in the developing countries.

Another vital function of UNIDO is the provision of a clearing-house for industrial information covering all aspects of industrialization. It is therefore a source of a wealth of information on industrialization and the economic, social and political climate in the developing countries. UNIDO provides industrial statistics, sources of technological information, patent technology and many others. Information is important to make project operations effective, especially with the insufficient availability of this resource in most of the developing countries. An example of UNIDO's information-related activities is UNIDO's Investment Promotion Information System (INPRIS) which matches entrepreneurs with potential investors.

One of the important factors for successful industrialization is to have a well-trained, highly skilled and motivated work force. In order to ensure the developing countries to have this, UNIDO assists them to identify and quantify their need for people with various levels of skills, their training requirements and to draw up suitable policies, and organize specialized programmes, through group training, fellowships and study tours. Under field training operations, UNIDO offers assistance in the design and development of indigenous training capabilities. It will contribute to the improvement of the industrial training infrastructure which will lead to an increase in the supply of skilled personnel.

UNIDO's role as a catalyst for investment promotion is carried out through its Industrial Investment Division (IID). It consists of Investment Promotion Services which assist potential investors from developing countries to identify potentially interested suppliers, prepare industrial investment project proposals, to exchange information on business opportunities, to promote contacts between business people and to provide information on the facilities, resources, and locations of the developing countries.

The programme has received a positive response from the developing world. Between 1980 and 1986, UNIDO's Industrial Investment Programme concluded, in the developing countries, the promotion of 484 industrial investment projects covering more than \$4.0 billion worth of investment to developing countries. During 1986, it has successfully promoted 64 projects with a total value of \$265 million.

Another important promotional activity of UNIDO is the System of Consultations which brings together representatives of Governments, industry and labour unions to exchange information on the prospects of a particular sector. The system seeks measures to deal with industrialization problems in a given sector from policy, economic, financial, social and technical points of view. Such consultations then will seek to arrive at recommendations and conclusions for action which could be taken to establish new productive training, industrial manpower, industrial financing and etc. in the developing countries.

4. Unit for electronic equipment and computer applications

The Unit for Electronic Equipment and Computer Applications focuses knowledge, expertise and applications on advanced technologies related to electronics and computers.

The Unit is involved in all phases of technical co-operation projects, i.e.:

- Project identification
- Techno-economic cost-benefit analysis
- Project design
- Project document formulation
- Project execution

Electronics industry and computer applications in industry cover a vast area. Activities of the Unit can therefore cover only a limited number. These are:

- Electronic components and equipment
- Medical equipment
- Environmental monitoring and control equipment
- Telecommunications equipment
- Industrial process control and automation equipment and system
- Precision mechanical components

Projects can aim at:

- Product design, prototyping, reverse engineering
- Pilot production
- Production rationalization and automation
- Repair and maintenance of products and plants
- Environmental monitoring and control

To achieve these aims, projects involve one or more of the following activities:

- Institution building (e.g. technical, research and development, training centres and institutes etc.)
- Strengthening of existing capacities
- Creating pilot plants
- Convening workshops and expert group meetings
- Providing direct technical support to solve
- an immediate problem

Depending upon their coverage, technical co-operation projects can cost between less than US\$ 10,000 and several million dollars.

The electronics industry and computer application areas in industry cover a wide area. Thus, the activities of the Unit can cover only a limited number of areas which include the following:

Within the area of electronic component and equipment, the activities concentrates on active microelectronic circuit components (semiconductor devices such as intergrated circuits, transistors etc)

Medical equipment, including microcomputers, opto-electronic components and equipment and X-ray equipment.

Environmental monitoring and control equipment which emphasise on electronic test and measurement equipment and controllers.

Telecommunications, equipment which mainly focus on rural telecommunication, environmental testing and tropicalisation of telecommunications equipment, spare parts for subscriber use (telephone sets, party line equipment, private branch exchanges) and low-cost micro earth stations for satellite communications.

Industrial process control and automation equipment and systems emphasises on design and development of computers and microprocessor-based industrial automation and low-cost appropriate automation, industrial robotics and image processing for industrial automation.

Precision mechanical components which focus on dies and mould for precision plastic and metal parts and reverse engineering of dies and moulds.

5. *UNIDO's activities in microelectronics*

By the late 70's and early early 80's, UNIDO has begun to appreciate the potential implications of technological advances on developing countries. Following the 3rd General Conference of UNIDO in 1980, it was acknowledged that developing countries should adopt industrial and technological strategies and look for means to tap the potential of new technologies without being affected by their limitations.

In June 1981, a meeting of experts was organised on the implications of technological advances in microelectronics for developing countries. Among its recommendations were, the formulation of a national microelectronics strategy and at the international level, a continuous monitoring of observed trends and their impact on various sectors. Following the June 1981 meeting, a mission of experts visited four developing countries in different regions to promote selective applications of microelectronics and software development. Its mission was to review national situations in those countries and recommend appropriate approaches to microelectronics application.

The International forum on Technological Advances and Development, organised by UNIDO in Tbilisi, USSR, in 1983 as well as Experts Meetings in Moscow, USSR in 1982 and Dubrovnik, Yugoslavia in June 1983, which respectively preceded and succeeded it, examined the subject of technological advances and development with regard to specific technologies of which microelectronics was an important one.

Following this, an overview of the microelectronics industry in a series of country case studies was to be initiated to provide concrete information and meaningful approaches for regional and international action.

In the 4th General Conference of UNIDO in Vienna, 1984, the importance of strengthening scientific and technological capabilities for industrialisation in developing countries was endorsed. UNIDO was urged to assist developing countries in building their technological capabilities in different fields of technology. Microelectronics was identified as a suitable candidate technology as it can be beneficially employed in health care for the rural poor, educational and information purposes in decentralised locations. Thus the concept of promoting specific projects for international co-operation was aimed at the betterment of life among the poorer countries.

The UNIDO programme on technological advances was designed in particular, to increase awareness through early identification and assessment and to promote action at national, regional and international level on:

- a) the potential and limitations of various advanced technologies for the developing countries
- b) the industrial and technological capabilities that the developing countries need in order to use advanced technologies where appropriate and feasible.

In an effort to co-ordinate activities of various professional groups and organisations in the field of information technology, a Consultative Group on Information Technology (COGIT) was established. COGIT was to meet periodically to review ongoing activities, exchange experience and formulate joint programmes. The concept of software as an industry and the actions that developing countries could take to promote that industry was given serious thought.

In a Conference on Informatics and Industrial Development, it was highlighted that information development, extending beyond data-base systems, networks, industrial management tools and processes, had led to substantial consequences to current industrial development strategies.

Regional level discussions are held by UNIDO with various countries in an effort to assist countries in the field of microelectronics in accordance with the specific needs of a country.

For instance, at the request of the government of Venezuela, UNIDO provided assistance to look into their existing facilities with the view of upgrading it to become a nodal point for a proposed network.

Also with the help of UNIDO, a Latin American Regional Microelectronic Network (REMLAC) was established in 1985. A regional project for strengthening microelectronics infrastructure and capabilities in REMLAC Member countries was established.

The objectives of the project were:

1. Strengthening capabilities in countries at earlier stages of microelectronics development
2. Examining national and regional application possibilities in selected industrial sectors
3. Strengthening capabilities in the acquisition of hardware and software
4. Monitoring technology and market trends in microelectronics for policy formulation and decision-making
5. Strengthening design capabilities
6. Establishing silicon foundaries
7. Strengthening semiconductor manufacturing capabilities in the region.

A symposium on Microelectronics for Productivity held at New Delhi in April 1983, co-sponsored by UNIDO, requested UNIDO to take the lead in the promotion of the establishment of an Asian Centre for Electronics.

National level studies in selected Asian countries have been undertaken to ascertain the needs for regional co-operation. Various projects such as these have been constantly on UNIDO's agenda to assist various countries in the regions of Latin America, Africa and Asia.

UNIDO plays an important role in consultation efforts in the field of electronics. It holds a system of continuing consultations between developed and developing countries.

In November 1989 the First Consultation on the Electronics industry was held in Valleta, Malta. After a review of its past activities, UNIDO decided to carry out global studies on the electronics hardware and software industries.

This was done in order:

1. To appraise the technological, economic, market trends and their implications for the industrial development of developing countries;
2. To determine the implications of the strategies of main actors and industrial policies of developed and developing countries;

3. To identify entry barriers for newcomers and propose appropriate strategies for coherent development.

Issues that were raised during the Consultation meeting were, strategies for integrated development, governments in monitoring technological advances and the provision of training and assistance as required by the member countries.

In a more recent activity and in Malaysia, UNIDO through the Special Industrial Services (SIS) had assisted the Malaysian Institute of Microelectronic Systems (MIMOS) in the conceptualisation of a semiconductor fabrication centre. A UNIDO consultant had assisted MIMOS in deciding on the viability of the project. With UNIDO's assistance, a whole new concept on the waferfab was formulated. It is hoped that the assistance from UNIDO would be a viable component for MIMOS's Semiconductor Technology Centre which is to provide training in wafer fabrication, R&D into device and process fabrication and also to provide a capability for fast prototyping of VLSI circuits.

A trend which is expected to continue with UNIDO would be its active involvement in actual implementation of industrial and technological plans for developing countries. It could further intensify its role in creating awareness in this dynamic field of microelectronics especially among nations which still lag behind in this field due to infrastructural constraints. The publication of the quarterly bulletin, the Microelectronics Monitor is by itself a wealth on information on the latest events, innovations and inventions in the field of microelectronics. However, due to selective distribution, beneficiaries of this bulletin are limited. UNIDO ought to function as a data-base of information to be disseminated to member countries which could then utilise such information for the development of their technological projects.

In acknowledging the intensity and pervasiveness of the microelectronic industry, UNIDO gives its due recognition to microelectronics as the strategic technology for continued development in both industrialised and developing countries. UNIDO as the facilitator for regional and international co-operations should seriously consider the idea of being a focal point for electronic networking. This would immensely benefit all member countries in opening a gateway for communication and co-operation at the international level.

A network of such a scale could be utilised as a platform from which experts, professionals, governments, and all users around the world could intergrate their resources in facilitating future development endeavours of mankind. In conclusion, the future direction of UNIDO would be reflected by the collective direction of its various member countries. Their aspirations in the field of microelectronics would determine the position of UNIDO in its role as a central agency to co-ordinate industrialisation efforts in developing countries.

In summary the UNIDO programme in this field has, among others, the following components:

a) Collection, compilation and dissemination of information:

- Databases

• Industrial and Technological Information Bank (INTIB) which includes:

- Industrial Development Abstracts (IDA)
- On-Line Information Key (LINK), directories of R&D centres
- Technological Information Exchange System (TIES)
- Energy Information System (EIS)
- Investment Promotion Information System (INPRIS) which contains project, investor, bank, institution, sponsor and country investment profile files
- Technology Supply Database contains information on technology offers, requests and joint venture opportunities

• UNIDO statistical database

- UNIDO rosters of industrial expert consultants (14,000 records) and consulting companies
 - Publications: UNIDO News Letter, Microelectronics Monitor, INTIB Net, directories, information packages
 - Network of national and regional focal points
- b) Identification of needs, promoting the formulation of policies and programmes through:
- Studies: country and regional studies, Global Development Report, expert reports
 - Workshops, seminars
 - Advisory services
- c) Promoting the design, development and manufacture of components, hardware and software
- Technical co-operation projects and programmes
 - Investment promotion activities

Some examples of UNIDO technical co-operation projects in electronics and microelectronics are described below.

Problem: The electronics industry contributes to environmental pollution in the form of dangerous waste solvents and gases.

Project: A study will identify the pollutants and polluting processes of the electronics industry and lead to a guide-book of pollution monitoring control in this sector. An associated expert group meeting will increase awareness in the electronics industries of developing countries of industrial pollutants and their control.

Problem: The development of instrumentation techniques in a country, one of main pillars of the overall technical and technological development, depends on efficient use of national instrumentation resources. A frequent problem is the absence of adequate repair and maintenance services, with the result that many instruments are out of order.

Project: Creation of an instrumentation services centre (ISC) with a modular structure that permits the establishment of some or all of the following modules at a time: (i) national register of instruments; (ii) maintenance and repair services, including after sales services; (iii) instrument rental service; (iv) consultancy services (v) measurement techniques service-designing specific measurement set-ups and making expert staff and instruments available; (vi) development of new special purpose instruments; and (vii) training.

Problem: Electronic equipment producers as well as microelectronic component manufacturers from developing countries suffer from reliability problems due to low production yields and/or later failure of components sub-assemblies and assemblies.

Project: Establishment of a centre for failure analysis of microelectronic components. The facility is expected to provide testing services (including the analysis of test results) in particular to small and medium-scale manufacturers who cannot afford a similar service within their plants. The centre acts as a focal point for the failure analysis studies and co-operates with component manufacturers, equipment designers and producers, research laboratories. UNIDO provides expert services, technical staff training, and all necessary equipment.

Problem: Local development and production of electronic equipment can be promoted through a national capacity to design, prototype and manufacture of application-specific VLSI circuits (ASICs). Such capability may also create export possibilities.

Project: Establishment of a centre for the design and prototyping of very large scale integrated (VLSI) circuits. This Centre is expected to act as a focal point for the VLSI design and to co-operate with research laboratories, microelectronic component manufacturers and educational establishments. UNIDO will assist creation of the Centre through provision of high-level expert services, training of staff, and installing and operating of a computer systems, peripheral equipment and related computer-aided engineering (CAE) software tools.

Problem: Local electronic equipment manufacturers are unable to compete in export and import substitution markets due to low quality of electronic products, caused mainly by poor packaging (casing) and related thermal, electromagnetic and other problems.

Project: Establishment of a centre for Electronic Packaging Technology and Ergonomic Design. The centre acts as a focal point in the country and co-operates with research laboratories, electronic equipment and system manufacturers, end-users and educational institutions. UNIDO provides expert services and equipment, trains its staff both abroad and on-the-job.

6. Characteristics of the electronics industry

The electronics industry is a complex sector of the economy and covers a wide range of products and manufacturing activities. Figure 1 gives, in a schematic form, the downstream and upstream linkages of a fully developed electronics industry. Figure 2, on the other hand, shows the bi-lateral relations between electronics industry and other involved parties in both the national and international economy.

These two diagrams show that an integrated and successful electronics industry is more than just one in which the sub-sectors; component, consumer and industrial, are balanced in the right proportions. Concentration should not only be on balancing these sub-sectors, but also on the overall integration of the electronics industry in the economy.

One success factor of electronics industry is its capability to commercialize innovative product design ideas within the shortest possible time period. In this connection and among others, availability of venture capital to small but dynamic companies has proven to be very effective.

Different industrial activities within the electronics sector have varying levels of capital investment requirements and diverging degrees of added manufacturing values. Figure 3 displays industrial activities and products of electronics industry as grouped according to their added manufacturing values as plotted in the graph. This classification, when used together with other pertinent technical, technological and market data, can help policy makers and/or investors in selecting the niche products and activities.

As Figure 3 also shows contours of industrial structures in developed and developing countries, it provides an excellent framework for countries to position themselves with regard to the extent of diversification and value added.

One success factor of electronics industry is its capability to commercialize innovative product design ideas within the shortest possible time period. In this connection and among others, availability of venture capital to small but dynamic companies has proven to be very effective.

7. UNIDO's observation in developing countries and co-operation opportunities

The First Consultation on the Electronics Industry characterized the electronics industry as being predominantly market-driven rather than technology-driven, contrary to the generally held view (UNIDO, 1989).

This finding shows that a country's industrial success of its electronics industry is very much dependent on its competitiveness in the world market. Most developing countries are not competitive enough when building up their electronics industry due to various reasons.

Figure 4 shows that this lack of competitiveness is attributed to three main reasons, which are: insufficient incentives, lack of technological capability, and insufficient engineering manpower leading to a vicious cycle.

This is further aggravated by inefficient production capacity utilization, as well as low product quality and limited product features. Furthermore, small and medium-scale electronic industries suffer from high production cost and low quality of products.

In general, although detailed information in each case is not available, non-exhaustive set of shortcomings of developing countries related to the development of their electronics industries can be identified as follows:

- a) Unclear national vision which led to undirected socio-economic development of the country.
- b) The absence of an intergrated national industrial technology strategy resulting in a lack of effective linkages between different sub-sectors of the industry, lack of promotion of the electronics industry through fiscal measures and incentives, little linkages between electronics production in export processing zones and the rest of the industrial sector, lack of intergration of the sector within the national economies due to inadequacies in policy instruments in national R&D capabilities and lack in awareness of the economic impact of the electronics industry

- c) Inadequacies in accessing markets due to lack of indigenous skills especially in international marketing, lack of service companies in calibration, marketing and after sales service networks, lack of mechanisms to accelerate commercialisation of innovative ideas. This involves overcoming multiple constraints with regard to political controls, specific skills needed, infrastructure, communication across national frontiers and geographical factors.
- d) Inability to gain access to technology as a result of technological and trade protection by the developed countries. Problems are encountered in keeping abreast of technological change as well as in actual technology transfer and aquisition and in identifying the industrial sectors in which electronics will have the greatest impact. Even if access is gained, mastering of the technology would still be a problem due to lack of manpower.
- e) Insufficient human resources due to the mismatch between the industrial needs and the available educational systems, and lack of further trainings among the industrial workers.
- f) Lack of facilities and skills to carry out design and development work.

In designing, formulating and executing the projects mentioned in Section 5, appropriate technologies are selected from a wide range of available options. These include conventional technologies and modern ones such as CAD/CAM (computer-aided design and manufacturing).

However, the problem identified in accordance to this area is that there is a lack of efficient industrial design capability. Although computer-aided design (CAD) is not a substitution for an experienced designer, it can improve quality and productivity in the design process.

One of the shortcomings in the electronics industry is the lack of product design technologies to increase the output of manufacturing industries in developing countries.

"Reverse" engineering is a fast way to product design and implementation and refers to the combination of activities to analyse and document the design of an existing product.

Automation is a key element in new investments in which it can reduce product costs and shortened delivery times.

At this point, it is envisaged that market research and technology trend tracking will assume a greater role in UNIDO's activities to complement its technical assistance programmes.

Solution proposals to the above mentioned issues also help to identify the possible areas of technical co-operation at national, regional and international level.

8. Conclusions

By the year 2000, the electronics industry worldwide will be worth about US\$ 2000 billion with the semiconductor industry contributing about US\$ 200 billion. An ever increasing spectrum of products will be in demand in the computer, telecommunication fields. Global competition will push down the prices of microelectronic components while increasing the functionality and performance of products. Products will possess embedded intelligence resulting from advances in expert systems, neural networks and fuzzy logic.

To remain competitive, developing countries will be under greater pressure to achieve greater success in their industrialisation process which will have to have microelectronics technology as the driving force. It is hoped that the developed and industrialised countries will be able to contribute in some ways towards the development of the technological capability of developing nations, in spite of trends towards economic regional groupings and trade barriers.

The role of UNIDO will certainly become more important and more challenging. UNIDO will be the catalyst and platform for the networking of experts to promote the diffusion of microelectronics technology into the industrialisation process of developing countries.

Figure 1 Interlinkages of electronics industry

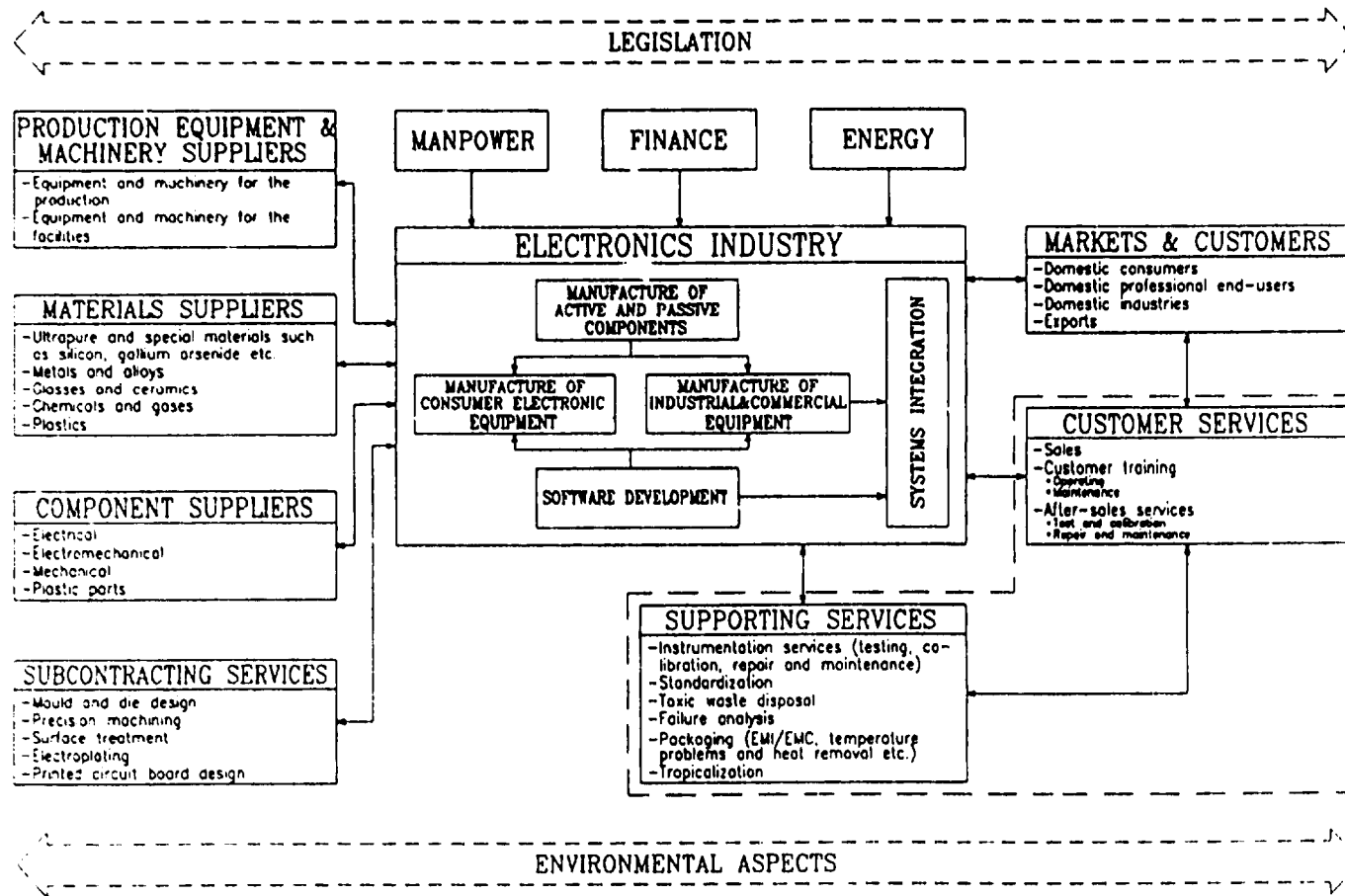


Figure 2. Relations of electronics industry with other involved parties

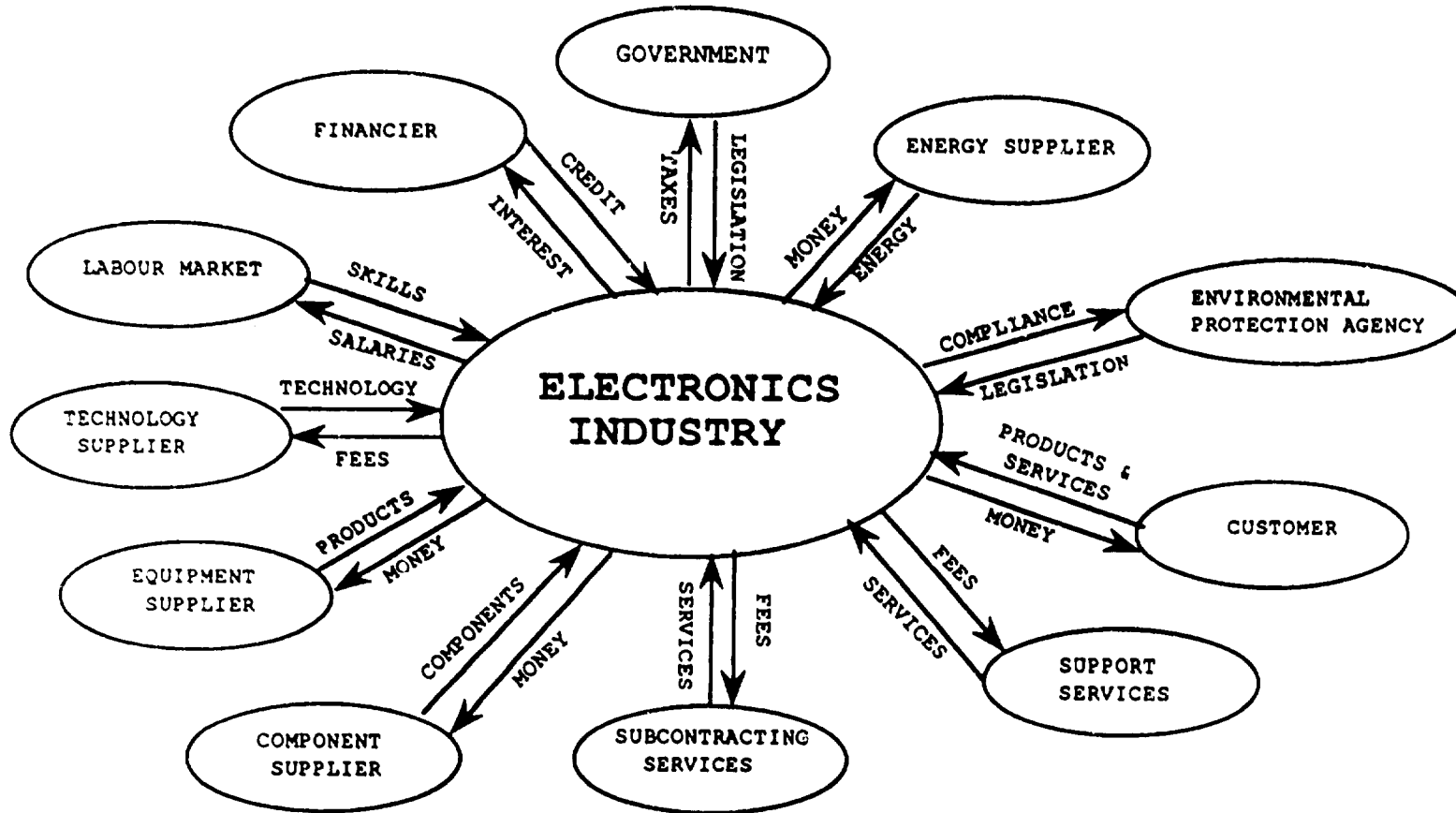
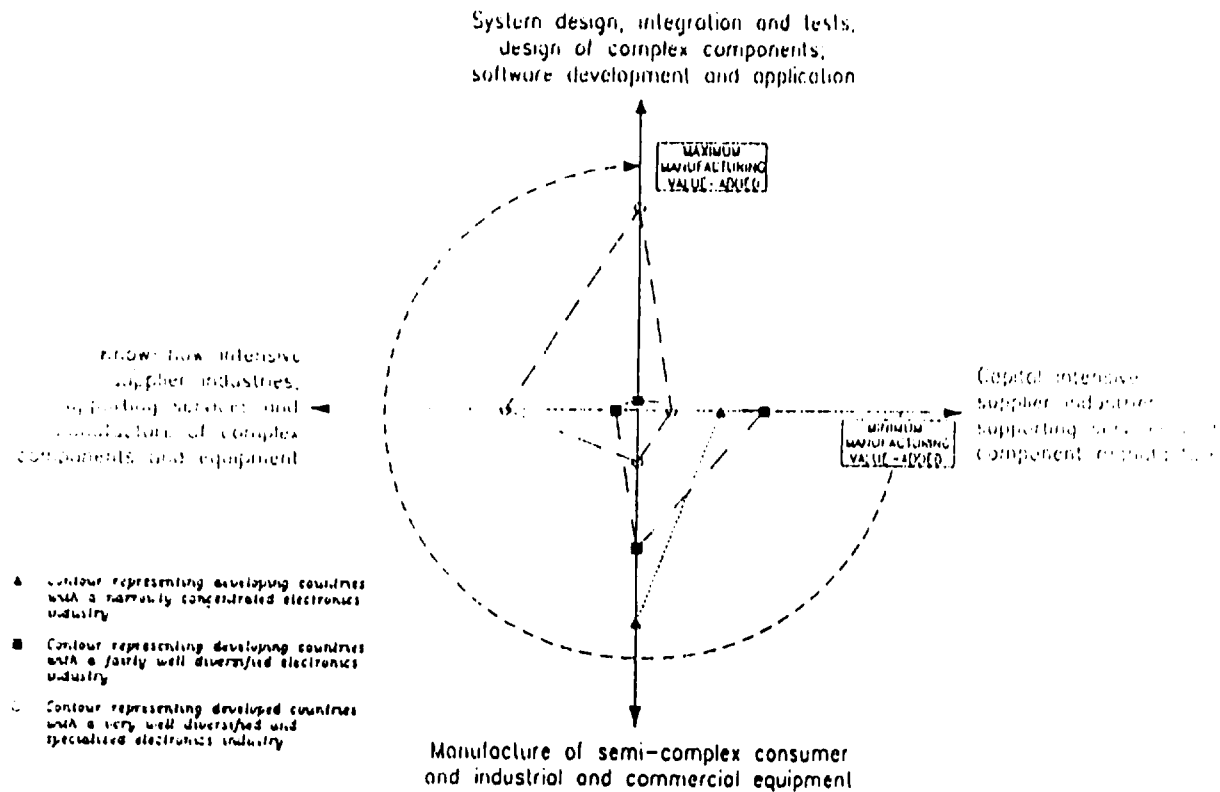


Figure 3. Industrial activities in the electronics sector grouped according to their added manufacturing values

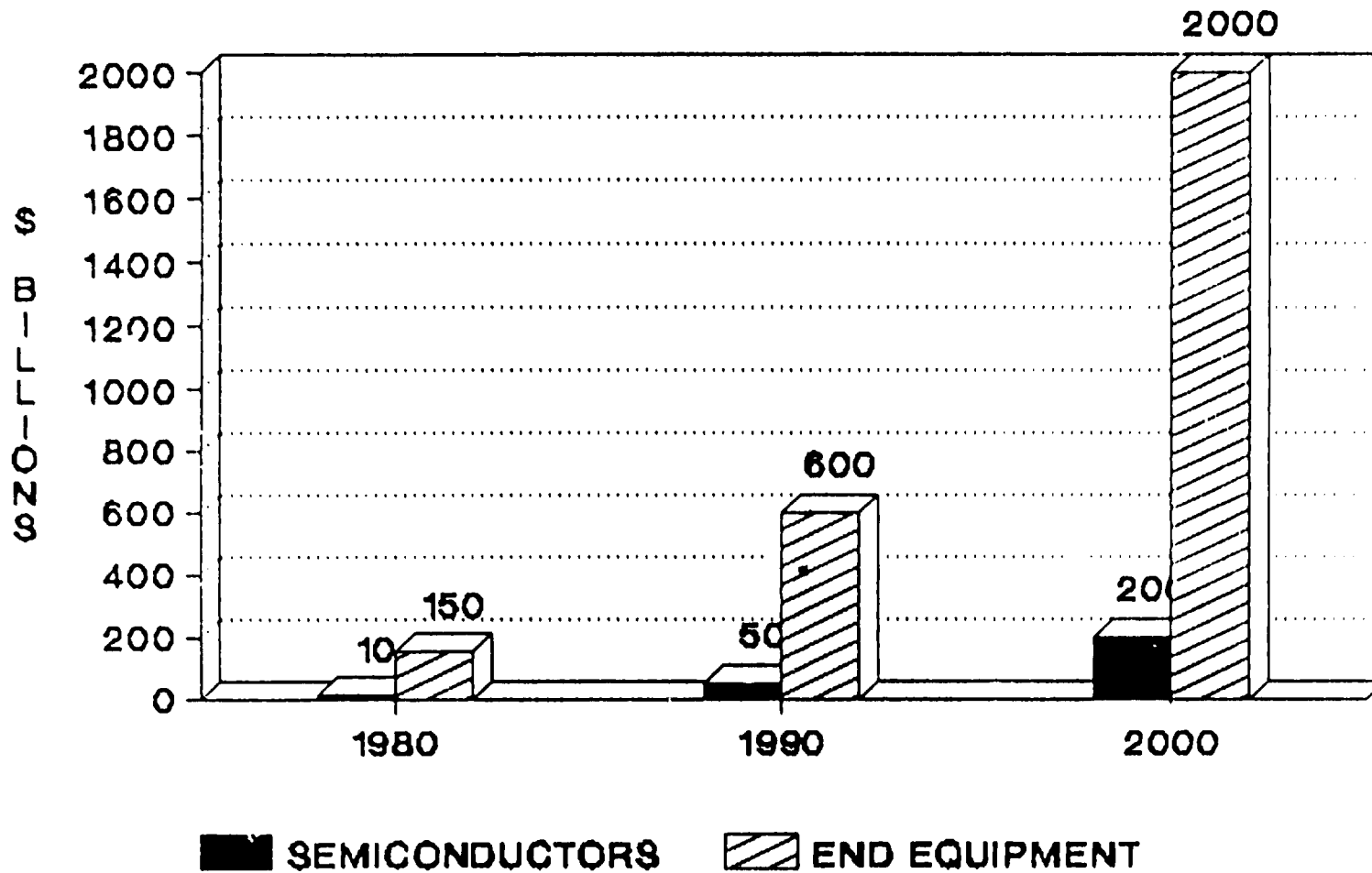


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2. UNIDO, 1989. "Handbook for UNIDO Field Staff", Vienna, Austria.
3. UNIDO, 1990, "Annual Report of UNIDO 1989", Vienna, Austria.
4. UNIDO, various years, "Microelectronics Monitor", Vienna, Austria.
5. "The UNIDO Programme of technological advances: Microelectronics".
6. UNIDO, July 1990, Document, "Unit for Electronic Equipment and Computer Applications, Engineering Industries Branch", Vienna, Austria.

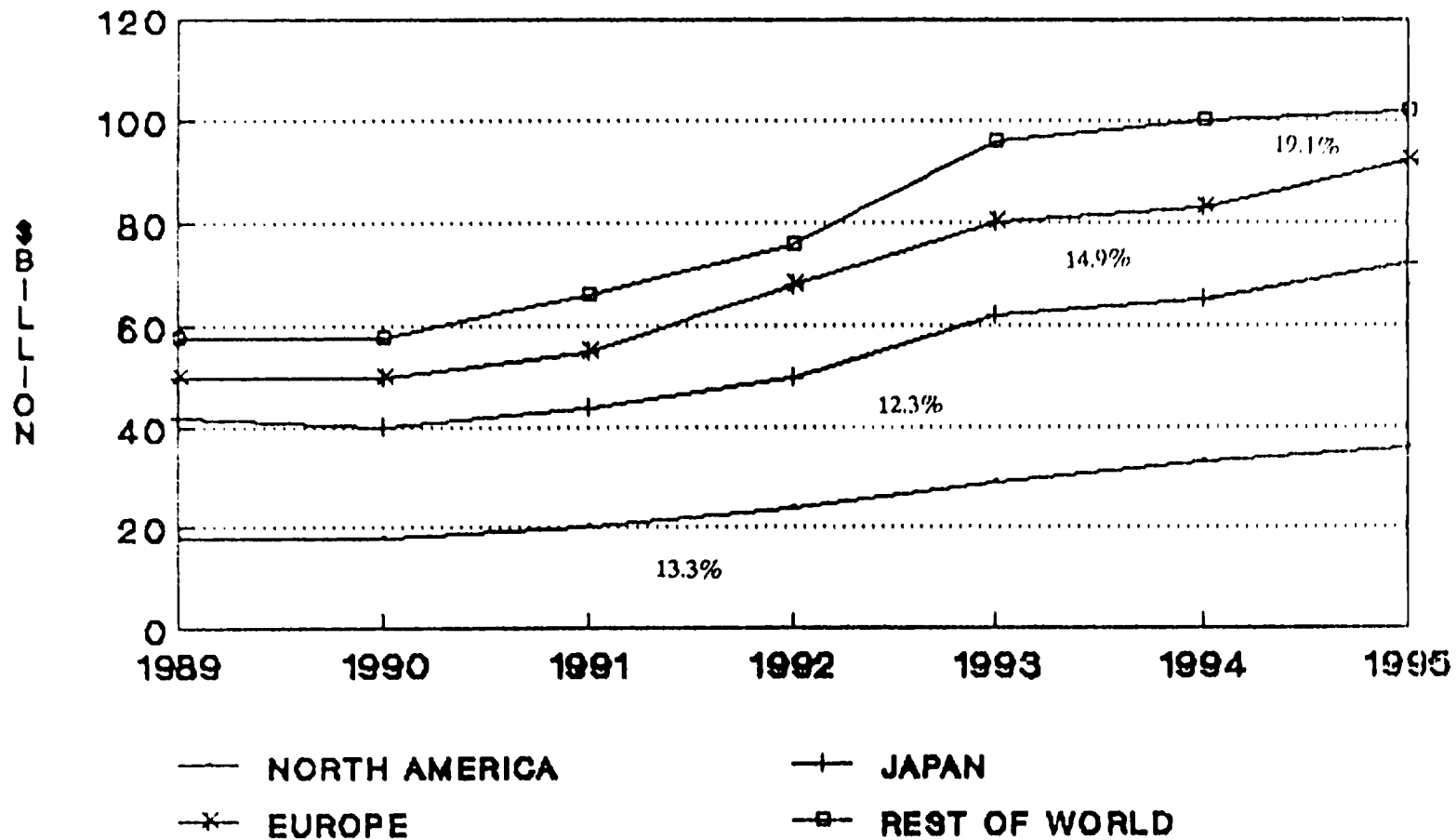
DR. MOHAMED ARIF NUN
MALAYSIA
(Transparency)

BY 2000, THE WORLD'S LARGEST INDUSTRY



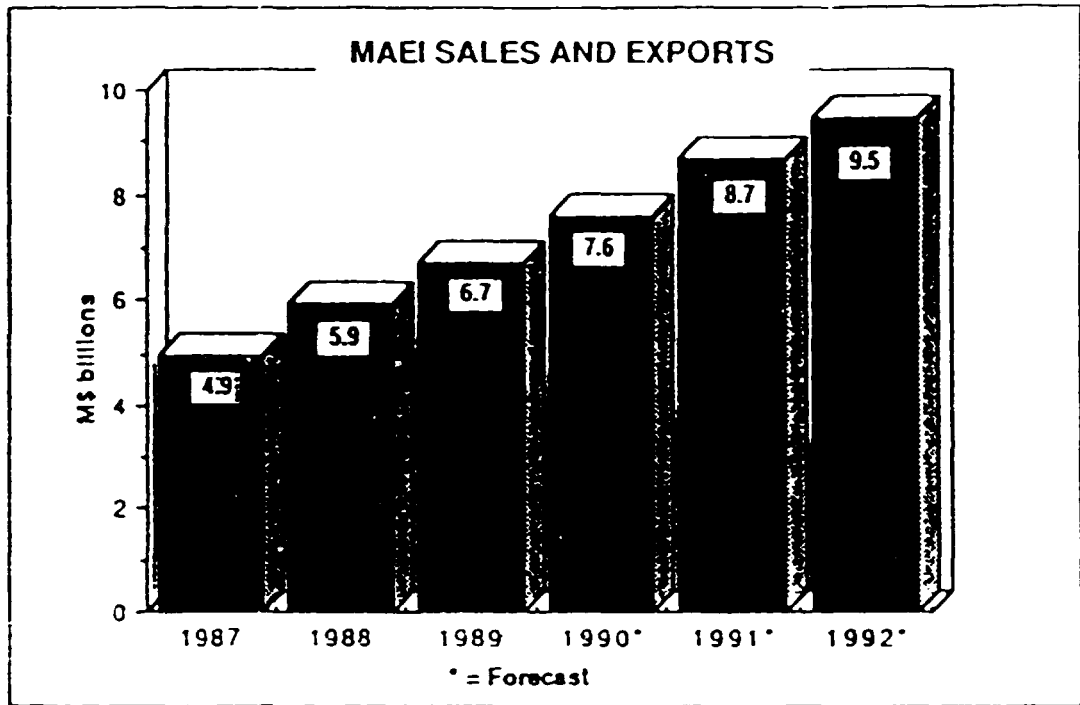
SOURCE: TEXAS INSTRUMENTS INC.,
ELECTRONIC, JANUARY 1991.

SEMICONDUCTOR CONSUMPTION WORLDWIDE



SOURCE: DATAQUEST INC./ELECTRONICS.JAN 91
 -CAGR,1990-1995

GRAPH 2



Sales and exports

The MAEI companies export almost 100 per cent of their products either directly or through sale to other companies within the country's free trade zones.

For the country as a whole, export sales of electronic components, led mainly by semiconductor devices, were significantly higher in 1989 following the increase in regional demand from major foreign manufacturers who had relocated their operations to South East Asian countries.

This was augmented by a transfer of major marketing functions from the United States to Malaysia to increase the quality of customer-oriented service in the region.

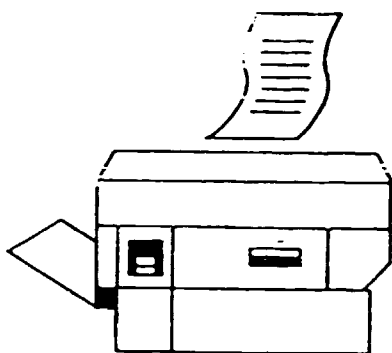
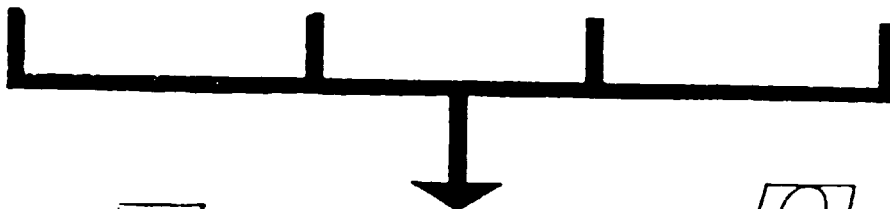
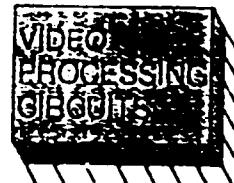
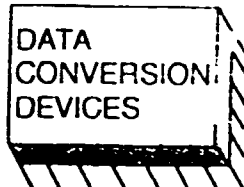
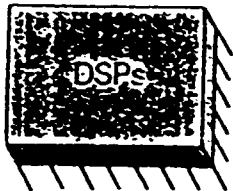
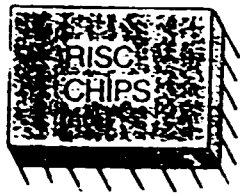
In 1989, total sales and exports by the MAEI companies increased by 13 per cent to M\$6.7 billion. This was consistent with the growth of 13.9% forecast for the electronics sector in Malaysia.

Table 2 and Graph 2 show that the expected growth in 1990 will be approximately 13.1% and approximately 14% in 1991. By 1992 sales and exports will have almost doubled in value since 1987.

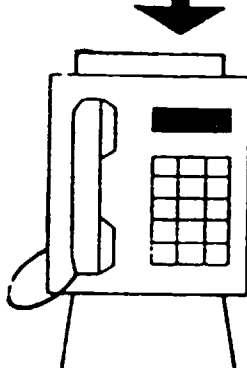
TABLE 2

| TOTAL SALES AND EXPORTS | |
|-------------------------|-------------|
| YEAR | M\$ MILLION |
| 1987 | 4,978 |
| 1988 | 5,969 |
| 1989 | 6,748 |
| 1990* | 7,631 |
| 1991* | 8,696 |
| 1992* | 9,485 |

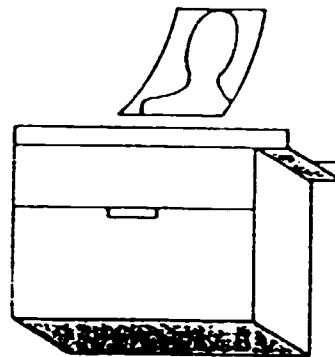
Forecast



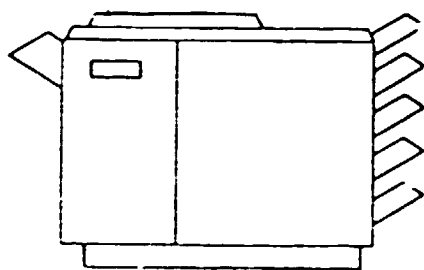
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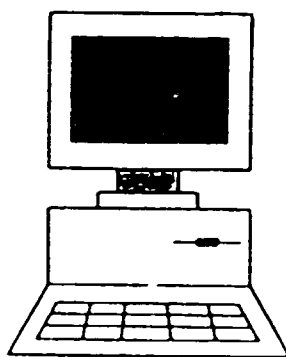
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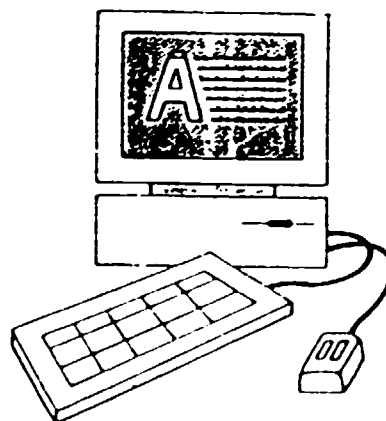
SCANNERS



DIGITAL COPIERS



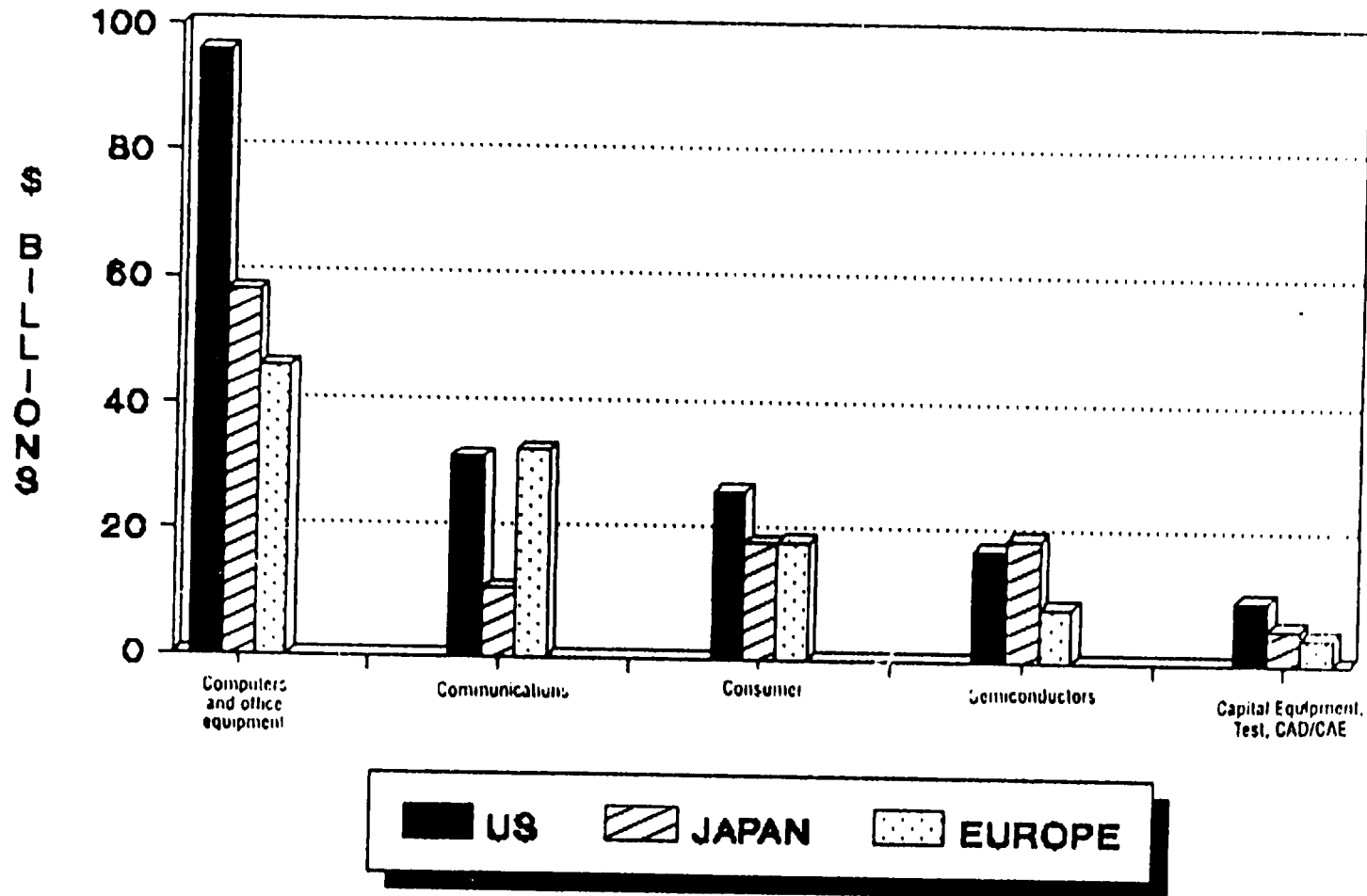
MULTIMEDIA PCs



DESKTOP PUBLISHING

ABUNDANT APPLICATIONS

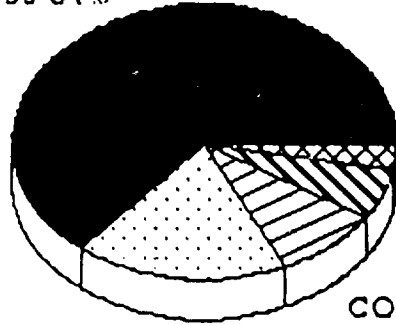
MAJOR WORLD ELECTRONICS MARKET IN 1991



SOURCE: ELECTRONIC, JANUARY 1991

EMBEDDED PROCESSOR MARKET SHARE

SYSTEM CPUs 64%



MASS STORAGE 18%

1988

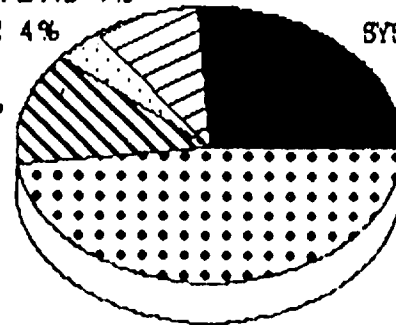
(TOTAL UNITS: 4.3 MILLION)

COMMUNICATIONS 9%
MASS STORAGE 4%

OTHER 13%

IMAGING 3%
OTHER 6%

COMMUNICATIONS 9%



SYSTEM CPUs 26%

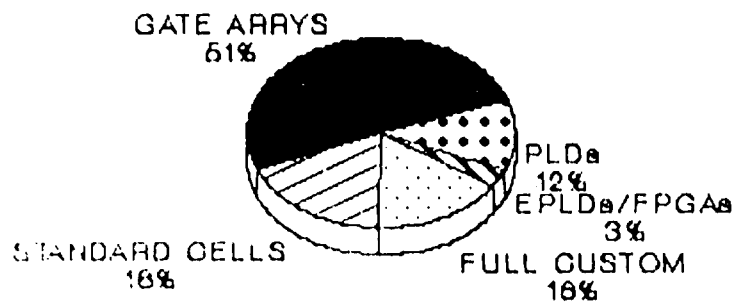
IMAGING 48%

1993

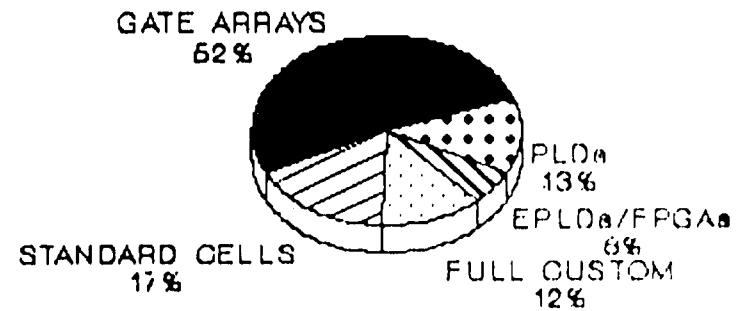
(TOTAL UNITS: 28 MILLION)

SOURCE: DATAQUESTING/ ELECTRONICS.
JUNE 1990

ASICs MARKET



1990
\$7.3 BILLION



1995
\$12.6 BILLION

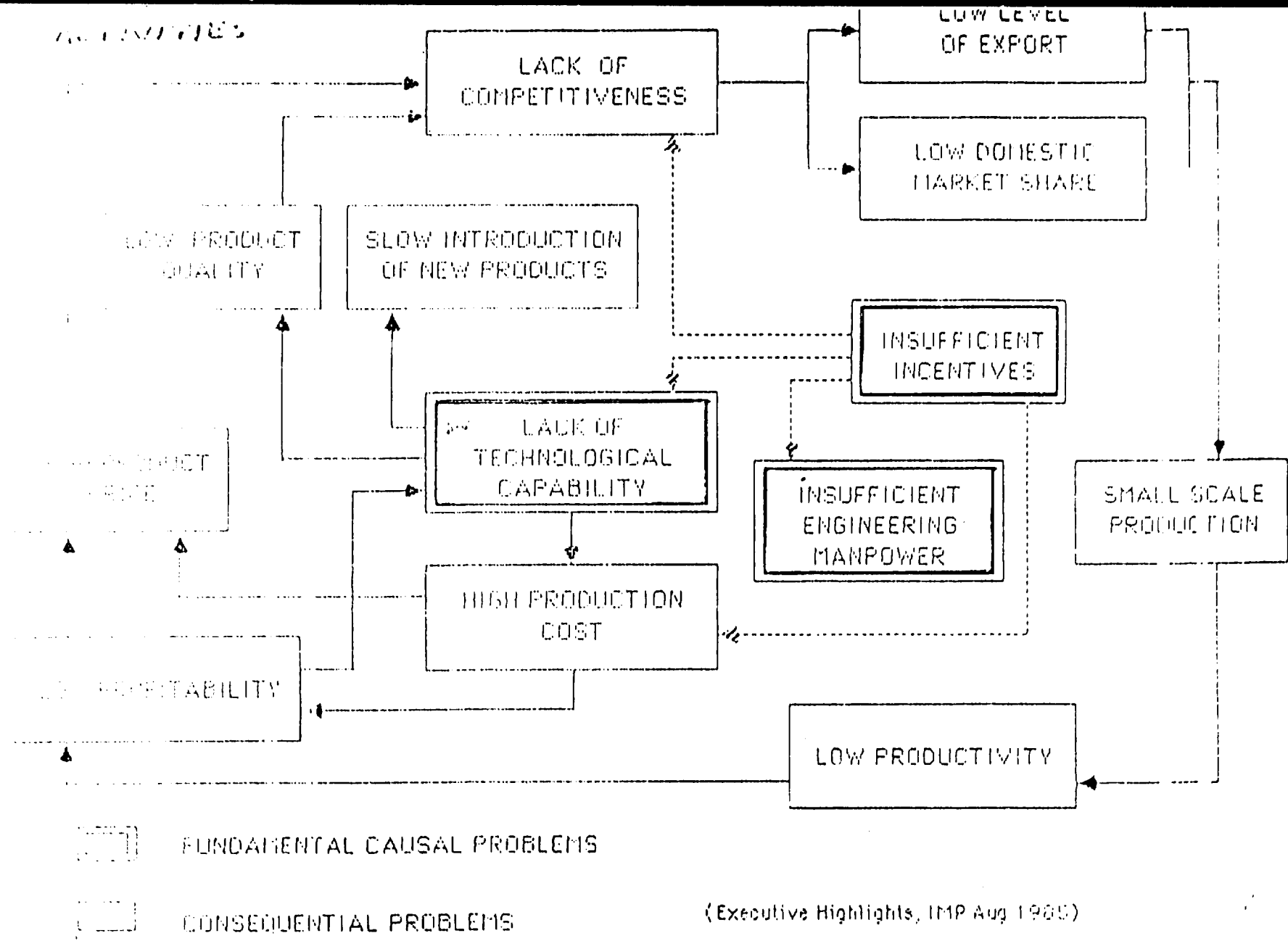


Figure 9