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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

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STATE-OF-THE-ART SERIES ON MICROELECTRONICS

No. 6 REPUBLIC OF TURKEY*

Prepared for the Industrial Technology Development Division

by

Mehmet Tomak, Professor, Department of Physics
Middle East Technical University, Anakara, Turkey
UNIDO Consultant

* The views expressed in this paper are those of the author and do not necessarily reflect the views of the secretariat of UNIDO. Mention of firm names and commercial products does not imply an endorsement by UNIDO. This document has not been edited.

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EXPLANATORY NOTES

Abbreviations

CAD	Computer Aided Design
CAM	Computer Aided Manufacture
CMOS	Complementary Metal-Oxide Semiconductor
CRT	Cathode Ray Tubes
ESS	Electronic Switching Systems
IC	Integrated Circuits
LED	Light Emitting Diode
MOS	Metal Oxide Semiconductor
PBX	Private Branch Exchange
PCB	Printed Circuit Boards
VLSI	Very Large Scale Integration
R+D	Research and Development

Organizations

ASELSAN	Military Electronics Industries. Inc.
EEC	European Economic Community
ITU	Istanbul Technical University
METU	Middle East Technical University
MKE	Machinery-Chemical Industries
NETA	Northern Electric Telecommunication Inc.
TAER	TUBITAK Ankara Electronics Research Institute
TELETA	Telecommunication Industry and Trade Corp.
T/AK	The Scientific and Technical Research Council of Turkey

CONTENTS

SUMMARY

In this work, an attempt is made to map the currentsituation and future Turkish aspirations in the field ofmicroelectronics. Government technology strategy, the main subsectors of the microelectronics industry, national research and developmentactivities, a national approach towards the acquisition of technology, the main fields of application, existing infrastructure,manpower problems and international cooperation in the field are summarized.

Although there are efforts by the Government to support the microelectronics industry through various measures Turkey lacks a comprehensive national programme.

The most notable R+D work is being carried out in the telecommunications subsector where Turkey is rapidly becoming self-sufficient. Export capacity is being reached in same consumer electronics goods like colour TV, telephones etc.

Although there is no systematic approach to technology acquisition, various incentives are being developed by the government in this field.

The existing infrastructure for integrated circuit production is not very favourable as far as raw materials are concerned. There is also a need for qualified technicians.

The strategic geographical position of Turkey and her ties with West and East makes Turkey a natural focal point in regional and international co-operation.

I. INTRODUCTION

Turkey, who has just applied for full European Economical Community (EEC) membership, has chosen industrialization as a goal to improve its economy. The electronics industry is seen by many as a driving force for industrialization. Realizing this fact, the Turkish Government has put great emphasis in electronics and designated it as a priority area. In this study, an attempt is made to map the current situation and future Turkish aspirations in the field of microelectronics. The term microelectronics will be used here essentially to mean integrated circuits, but, a wide treatment is adopted and the field is taken to cover e.g. the manufacture of components, including custom designed chips; applications computers, and software. Consumer electronics, industrial controls and applications, telecommunications applications and special techniques such as computer aided design (CAD), computer aided manufacture (CAM) are included under the broad term "applications".

This report consists of ten chapters. In Chapter II the Government technology strategy is discussed in broad terms. After a brief history of the Turkish electronics industry, recent developments are summarized. Chapter III deals with the main subsectors of the microelectronics industry. National R+D activities are summarized in Chapter IV. Here, the broad lines of research are emphasized but not the individual projects

carried out in each institution. Chapter V deals with technology acquisition approaches and equipment procurement. Micro- electronics applications are summarized in Chapter VI where information on a new Government project involving microcomputers in education is also given. Chapter VII summarizes the current situation in raw materials and infrastructure for integrated circuit production. Manpower problems and training efforts undertaken are presented in chapter VIII. Regional and international co-operation are discussed in chapter IX. Finally, in Chapter X, some conclusions and possible future developments are summarized.

The general science and technology structure of Turkey is given in the Appendix to this paper to provide an overall framework for the present study.

II. GOVERNMENT TECHNOLOGY STRATEGY

The roots of the electronics industry in Turkey goes back to the production of telegramme devices by the Post Telephone Telegram (PTT) at the end of the 19 th century (1-4). During the early years of the young Turkish Republic (established in 1923), the army reached such a level that it could produce its own communication equipment such as combat field telephones and dry batteries, but after 1948 this promising start died as a result of United States Military Aid.

In the 1950's radios were being assembled from imported kits as consumer products. The relative absence of the electronics industry was noticed by the State in the early 1960's and in 1964 the Council of National Security decided that work to build up the Turkish Electronics Industry should begin. At first, the Machinery-Chemical Industry Enterprise (MKE), and later the Turkish PTT was charged with this duty which submitted its report in 1967 and in the same year, established the NETAS Company with NORTHERN TELECOM of Canada. The PTT also established its Research Laboratory, PTT-ARLA, at the same time.

Electronics was considered as a separate sector for the first time in the preparations of the Second Development Plan and a special commission was set up. Thus, it can be stated that the foundation of the electronics industry in Turkey was established in 1967.

The Scientific and Technical Research Council of Turkey (T/AK) was established in 1963. The Electronics Research Department of T/AK functioned within the Middle East Technical University (METU) between 1968-1972 before moving to its present laboratories at Gebze, near Istanbul. Later the Semiconductor Technology Research Laboratory (YITAL) was established within the same research institute in 1983. YITAL was to function as a research laboratory in close collaboration with the electronics industry company (TESTAS) which was established in 1976 to produce resisters and condensation. PTT-ARLA was later turned into another electronics company, TELETA in 1983. Both NETAS and TELETAS shared the PTT market for digital switches. The other two notable companies are TEKNIM, which was established in 1970 in the high frequency communication equipment sector, and ASELSAN which was established in 1976 mainly to reduce dependency on industrialised countries in high technology defense electronics.

In 1985, T/AK established the Ankara Electronics Research Institute (TAERI) within the campus of the Middle East Technical University. TAERI has turned into a rather active centre in a short span of time.

With this background in mind, we can summarize various Government initiatives which are relevant in this field. In the 1960's the introduction of "import substitution" policies resulted in the rapid development of a consumer electronics subsector. This subsector naturally formed the backbone of the Turkish electronics industry. The telecommunications subsector later developed as a result of public organizations' needs, such as the PTT. Research and development first flourished in this subsector, which enjoyed a guaranteed market. One of the most important factors is the Government's decision on an export oriented economy. Starting from quality control and standards, R+D has been considered most essential by the industry in the fight for external markets. High tariff walls protecting local industry from outside competition created a static environment and almost made any R+D effort by the local industry prior to 1983 unnecessary (5,6).

The establishment of the Defense Industries Development and Support Fund is an extremely important step which is expected to foster the Turkish electronics industry. This fund provides a huge financial resource for the Turkish defense industry.

In 1985, the Government passed a law providing guidelines for the privatization of state economic enterprises through the Public Participation Fund. In 1987 Government shares in some enterprises were transferred to this fund. The first example of this practice in the electronics sector was in the privatization of TELETA It is expected that funds obtained through privatization could be used to develop new technologies.

The Government has also chosen the private sector to be the prime force in accelerating industrialization of the country. New tax incentives were established to motivate companies to more R+D efforts and innovation in their products. Corporate Tax General Communion No. 31 (CTGC) published according to the Corporate Tax Law states that tax, up to an amount spent for R+D, may be postponed without interest and may be paid in three instalments. CTGC-31 states that R+D should be towards new technology and applications should be submitted to the Ministry of Finance and Customs. The Ministry evaluates each application by asking for the views of TUBITAK and other related organizations.

There have been serious efforts to establish innovation centres and science parks around well established universities and research centres throughout the country. In 1987 two companies were established inzmir and METU-Ankara with the aim of increasing university-industry co-operation in innovation. Other possibilities are also under investigation. The establishment of free zones is another important step towards regional development with possibilities of high technology development. The Mersin Free Zone became operational in 1987, soon to be followed by the Antalya, Adana andzmir Free Zones.

Considerable emphasis is given to the field of telecommunications and as a result of this policy the more advanced institutions are carrying out work in this area. The application of digital technology to telecommunications is particularly emphasized.

The project, commonly known as "one million microcomputers in education", is seen by the Government as a strategic investment that could further motivate the local electronics industry. The local production of software is an integral part of this project and will have a considerable impact on both hardware and software production.

The introduction of venture capital is being considered to essentially finance small-and medium-sized enterprises (SME) with a high profit potential. Since the banking system in Turkey is not familia- with this mode of operation it is envisaged that a new holding company will invest venture capital in SMEs to commercialize innovative scientific and technological ideas.

The Government has also created a better climate for foreign investment by simplifying legal procedures. The result has been positive and the number of foreign companies in all areas interested in investing has increased from an average amount of around 100 each year up to 1980, to over 800 by 1987.

Government procurement is one of the most important tools supporting the electronics industry, but the fact that this is planned only on a yearly basis by the state sector, procludes long term production plans by the producers.

Despite recognition of the importance of electronics, there are some obvious pitfalls in the overall approach since Turkey lacks a comprehensive science and technology policy. Technology is changing extremely rapidly in this field and the goals set out can only be reached by a solid technological infrastructure and very effective R+D work. After choosing the products to manufacture and specific market segments to conquer, the country must pass through compulsory technological points. To be able to do this the country needs a carefully prepared, optimal and
dynamic plan with clear national targets.

The lack of a comprehensive national programme is reflected by the curious situation of the Higher Council for Science and Technology (HCST). The HCST was established in 1983 by the Enforced Decree No. 77 with the aim of determining the priorities for R+D in view of the goals for economic, social development and national defense. However, the HCST, composed of seven ministers and presidents of TUBITAK, the Turkish Atomic Energy Authority and the Higher Educational Council, and chaired by the Prime Minister, has not yet met.

III- MAIN SUBSECTORS OF THE MICROELECTRONICS INDUSTRY

The following classification of electronics products could be used for Turkey (2):

(1) Consumer equipment
(2) Industrial equipment
(3) Components and parts

The detailed classification is as follows:

(1) Consumer equipment

1.1 Amplifiers
Tuners, Receivers, Music Centres, Equalizers, Record Players, Speakers
1.2 Recorders
1.3 Radios
Radios, Clock Radios, Car Radios, Headphone Radios
1.4 Colour Televisions
1.5 Black and White Televisions
1.6 Electronic Watches
Digital Wrist Watches, Analog Wrist Watches, Wall Clocks, Desk Clocks
1.7 Others
Video Games, Electronic Toys

(2) Industrial Equipment

2.1 Computers
Calculators, Computers, Peripherals, Monitors, Displays, Terminals
2.2 Measuring Equipment
Television Monitor, Electronics Measuring Instrument, Alarm Device
2.3 Wire Telecommunication Equipment Telephones, Telephone Recorders, Switching Systems, Telegraph Equipments, Teleprinters, Interphones, Intercoms, Facsimiles
2.4 Citizen Band (CB) Transceivers, Wireless Telecommunication Equipment, Walkie Talkie Transmitters, Receivers
2.5 Others
Cash Registers

(3) Components and parts

3.1 Electronic Tubes
Black and White Cathode Ray Tubes (CRT)
3.2 Integrated Circuits (IC)
Bipolar, Hybrid, Metal Oxide Silicon
3.3 Semiconductors
Transistors, Diodes, Light Emitting Diodes (LED), Thermistors, Varistors
3.4 Others
Capacitors, Printed Circuit Boards (PCB), Switches, Keyboards Relays, Resisters

The total microelectronics production of Turkey and the share of different subsectors are shown in Table 1. The percentages for different subsectors in total production is given in Table 2 where industrial electronics goods are divided into two subgroups, namely, communication equipment and others. As can be seen from Table 1, the total production shows that communications equipment has the highest share in the industrial equipment subsector. Table 3 shows the yearly rate of increment of production, with rather large oscillations.

The production of components is mainly restricted to passive elements and electro mechanical parts. Active elements are not being mass produced. The production by large companies is just sufficient to cover their own internal needs.

Import figures are shown in Table 4. Comparison with earlier tables shows that production is above the import figures after 1972. Import of active circuit elements is the main item under the import of components. The main item in industrial equipment imports is for medical equipment.

Exports have not yet reached a significant level. In 1983, total exports were about 945 million Turkish Liras (T.L), of which 41.1 per cent were for communications equipment, 27.6 per cent were for consumer goods, 22.5 per cent components and 8.8 per cent for industrial equipment. Before 1982 consumer goods were the leading export items. The share of electronics exports in total electronics production was below 1 per cent until 1979. This figure was 1.2 per cent in 1984.

There has been a tremendous demand for colour TV in Turkey over the last five years. Four million colour TVs were produced by the end of 1986 which corresponds to 50 per cent of the total demand. The present industry can produce 1.6 million units/year without any new investment. Therefore, there is certainly an export capacity in this sector, but the production costs must be brought down by extensive R+D work in order to be competitive. The total production numbers for TV video tapes are given in
Table 5 (7).

The communications sector is the most developed in Turkey. The total production numbers of communications equipment in 1985 and 1986 are given in Table 5. Although high technology is used in this sector, most of the active components of equipment produced are imported.

Microcomputers are usually imported but in 1986 semi knocked-down production started. Monitors and limited numbers of auxiliary components are also produced.

IV. NATIONAL R+D ACTIVITIES

Technology acquisition shows differences depending on various subsectors. The consumer goods subsector involves common technology products through licensing agreements. The equipment, whose technology is solely in the hands of few multinational companies, is assembled within the country. In this case, R+D is limited to the adaptation level. The

communication subsector has reached a level of being able to follow current technology. The financial resources accorded for R+D in this subsector is quite substantial and the quality of R+D performed is relatively high. In the subsector of industrial equipment, common technology is employed and heavy engineering design work is carried out. Since special purpose equipment is produced in this subsector, the work can be considered as being mainly R+D.

R+D is a must, especially in the components subsector. The existing technology is rapidly changing in the semiconductors field which can only be followed by extensive R+D. T BITAK is active in this field.

The majority of national R+D activities in microelectronics are being carried out in TELETA NETA ASELSAN, TESTA and TUßITAK. There are, of course, other companies involved in R+D work, but the companies mentioned above represent the bulk of R+D efforts in electronics. There are also notable research groups in universities which are traditional centres for any type of research activity, but the level of R+D work carried out in these universities is far from being able to satisfy the needs of local industries.

The situation in the different organizations is described in more detail below :

TELETAS

A modern R+D laboratory was incorporated into the TELETAS organization ever since its foundation. There are active research groups in analog systems,radio link,end units, power electronics, optical fibre transmission, pulse coded modulation (PCM-I/II), digital exchanges of hard and software.

Research and Development work goes into almost all products manufactured and marketed, including 2.8, 34 and 140 Mb/s digital (PCM) multiplex systems, 46 channel digital telegraph multiplex systems, digital public telephone exchanges (system 12 of ITT), digital multi-access radio systems for rural applications, digital radio link systems, power supplies, telephone sets, pay phones, electronic teleprinter machines, data modems at various speeds, professional grade thick film resister and hybrid circuits, thin film circuits, etc.

TELETAS is performing continous R+D to improve its products and to create its own know-how. The emphasis given on design capability is extremely important. R+D manpower and laboratory capabilities are at a satisfactory level. There are 77 engineers, seven with Ph.Ds and 50 support personnel and technicians in the R+D unit. Special emphasis is also given to software development. A BTM/ITT licensing agreement makes it possible to carry out joint research with ITT, but at present this possibility is being used to send R+D personnel abroad to participate in research projects to further their education.

Optical fibre technology and the production of VLSI ICS are two future projects the company is working on. This is extremely important for the future of the microelectronics industry in Turkey.

NETAS

NETAS has one of the largest private R+D organizations in Turkey. There are four main R+D groups on domestic products;digital multiplex system (DMS), Operations, and Design Control. Proprietory product development projects include; XBAR 1975 / 80 (Operator toll dialing, subscriber toll dialing, international subscriber dialing, gateway CCITT no 5/R2, automatic trunk testing, large private automatic branch exchange (PABX), very small office electronic registers, electronic metering and rate circuits, centrex and electronic operation position) ELECTRONIC 1980/85 (electronic PABX EX 30/50/100/200 space net, key system Ex-16, side telephone, Bodrum intelligent telephone, rural central office Elif-I); DIGITAL 1985/PRESENT (PABX EX-2000, Central office Elif I-II, III) DMS INTERNATIONAL(DMS-100, 200, 100/200). Fully digital voice/data is planned for 1989. Technology transfer from Northern Telecom includes training, which started in 1985 at BNR in Ottawa (Canada) and Maidenhead, United Kingdom, initially with one manager and six designers, but now includes six managers, 18 designers, 15 support engineers and 2 BNR consultants. Training goes on in areas including central control (CC) software, new peripheral module software, H/W architecture, firm ware, computer support, verification office support, field support. The NETAR+D unit is included in Northern Telecom network which exchanges R+D results with other nodes.

When TELETA and NETA are compared, it is clear that NETA specializes in shorter distance communications.

TESTA

TESTA was established to manufacture discrete and linear integrated semiconductor components using planar technology. The project is so designed that the following operations may be performed by TESTA Wafer processing and testing, epitaxial growth, thermal oxidation, passivation, photolithography, etching, diffusion, vacuum deposition, wafer-sort probing, probe and final testing. Assembly and packaging by sawing, die and wire bending, lead frame moulding, marking etc., carrying out quality control. Technology transfer and licensing agreements were concluded in 1980 with EXAR of California, USA. TESTA developed its semiconductor manufacturing operations in two different locations: The Ankara wafer processing and testing plants and the Ayd assembly and packaging plant. Both the Ankara and Ayd plants have class 10.000 clean room facilities with class 100 (LAF) cabinets. The facilities and corresponding support services were installed according to the design and supervision of VARIOPLAN of Switzerland. The manufacturing equipment has already been installed. The cost of facilities and equipment is around 12 million US$. Planned production includes bipolar linear integrated circuits (standard, custom and semicustom IC's), custom and design bipolar integrated injection logic circuits and small signal bipolar discrete transistors. With more than 500 employees, TESTA is the only company at present set out to manufacture ICs. The present production of resisters is made under a technical agreement with the BULTRONICS Corporation of Japan. Ceramic capacitors are produced under the license of THOMSON CSF of France.

Metallized polyester capacitors are produced under the license of ARCOTRONICS Corporation of Italy. There is some production of electronics equipment such as taximeters, tachographs, converters, switching power supply units and filters, mostly developed by TESTA R+D engineers and support personnel. The R+D team consists of qualified engineers trained and specialized on microprocessor based equipment and power electronics.

IC related R+D is carried out in collaboration with YITAL-TUBITAK, which also serves as a training centre for TESTA engineers.

ASELSAN

ASELSAN Military Electronics Industries, Inc. is a high technology multiproduct corporation which supplies the Turkish army with modern electronics equipment. Early activities were centred on VHF/FM combat area radio equipment which later expanded to a product line which now includes various military and professional radios, encryption equipment, data terminals, field telephones, central alarm systems, siren systems, exchanges and electronic warfare systems. ASELSAN is also an active participant in many state of-the-art defense programmes, such as F-16 combat aircraft and missile electronics. A well developed R+D unit concentrates on telecommunication systems, control systems, digital systems and electronic warfare. R+D activities are co-ordinated with leading technical universities of Turkey, mainly METU in Ankara.

TUBITAK

The research in TUBITAK is carried out at three institutes. YITAL and the Electronics Department of the Marmara Research Institute (MRI), TAERI and the Physics Department of the Basic Sciences Research Institute (BSRI) are all active in electronics related research. As already mentioned, YITAL was established in 1983 to work mainly on bipolar technology. This research laboratory has been working in close collaboration with the Istanbul Technical University (ITU) where the very first IC consisting of a MOS array with four transistors was produced in 1977. TESTA engineers are trained in YITAL. The IC production level in YITAL is on a small scale and packaging is done manually. The aim is to concentrate on semi-custom and custom chip production. Industrial production is expected to be carried out by TESTAS. Recently, design capacity is being given more emphasis in YITAL. There is also some preparation to move towards CMOS technology. The necessary equipment park for this purpose is established.

The Electronics Department of MRI is involved in a number of important projects. A laboratory on thin film and optical communication technology (MOCVD) is being developed. This laboratory will concentrate on gallium arsenide and other III-V semiconductor compounds and develop lasers and avalanche photo-diodes necessary for optical fibre transmission. Another project is carried out in collaboration with TELETA on digitalizing 1800 channel analog radio-link systems produced by TELETA A project developed in the Department of Materials on high technology ceramics includes work on ceramics utilized in electronics.

The Physics Department of BSRI is currently developing a laboratory on Gas and another on amorphous silicon.

The TAERI was established in 1985 within the Department of Electrical and Electronics engineering at the METU. An important project on the establishment of a VLSI design centre is being sponsored by the NATO-Science for Stability Programme. Another notable project is on a Turkish microcomputer for educational purposes. There are also efforts underway to establish a software centre which will constitute an important milestone connected with the microcomputer project and other industrial support projects.

UNIVERSITIES

Most of the engineering work force is being trained at the universities where most of the R+D work is also carried out. The individual research projects submitted by researchers from a university may receive support from TUBITAK. In addition to this modality, TUBITAK may formulate guided research projects and try to identify centres of excellence in universities for special support.

University-industry relations are generally weak. The contract research carried out in universities is usually formulated within the University Revolving Fund mechanism. Some part of this fund is allocated to the University Research Fund where it is used to support in-house research.

Although there are 29 universities in Turkey, only a few have adequate manpower and infrastructure for R+D in microelectronics. The METU and ITU are the most notable ones. Bo'zi in Istanbul and Bilkent in Ankara also give special emphasis to electronics.

The Department of Electrical and Electronics Engineering of the METU host TAERI and collaborate heavily with ASELSAN. The Biomedical applications unit in this department collaborates with local hospitals in developing new electronic medical equipment and serve the existing ones. There is a big potential in the Physics Department with a large investment in a silicon-technology laboratory. Experimental solar cell research is also well developed in this Department. A CAD/CAM centre is being developed in the METU where the education and research programme will be coupled with the needs of the industry.

ITU in Istanbul is traditionally active in electronics. There is a working collaboration with T/AK-YITAL. The most recent initiative is to establish a foundation to improve collaboration with private companies active in electronics so that more relevant R+D work may be carried out in the Faculty. A research unit in robotics was also established, with support from TUBITAK.

V. NATIONAL APPROACH TOWARDS THE ACQUISITION OF MICROELECTRONICS TECHNOLOGY

Technology transfer to Turkey is done through patents, licensing and know-how agreements, foreign investments, equipment procurement, technical co-operation programmes and other methods (e.g. employing foreign experts).

Technology acquisition shows some variation, depending on the different subsectors. Common technology products are entering the consumer electronics subsector through licensing agreements. In the telecommunication and industrial electronics subsector where there is sizable R+D, some technology is produced indigenously.

Large companies import their technologies through patents, licensing and know-how agreements or establish joint ventures with multinational firms. Medium-sized firms resort to other methods of technology transfer, such as equipment procurement, reverse engineering, in-house or contract research.

There are some examples of comprehensive technology acquisition where all necessary technologies to produce a product are transferred. This is usually the case for TV or video production. The problem with this approach is, of course, the fact that design know-how cannot really be acquired. The natural result is that the country undergoes repeated technology transfers for the same product of different generations.

There is no notable overseas branch activity which is an important method for technology transfer. Some serious concern is developing in this direction. The overseas branch activity seems to be rather important, especially for setting up marketing analysis offices, design centres and pilot plants in industrialised countries.

As already mentioned, most of Turkey's technology and equipment supplies are from the USA and Europe, although Japan is also becoming active in Turkey recently. Individual examples of technology and equipment procurement were given in chapter IV and will not be repeated here.

The application of telecommunications has already been emphasised. Computerization of the voting system has already been started and may end up with an automatic voting network. The other facilities such as a seismic data network may be incorporated into such a network.

Tourism is another sector to which Turkey attaches great importance, with its almost endless possibilities for microelectronics application. The transportation sector is already using microcomputers at a growing rate.

Turkey is currently involved in a mammoth project known as "The Southeast Anatolian Project (SAP)", with a huge dam and irrigation network undergoing construction which will transform a great part of the country. There is a good chance of setting up one of the best examples of information technology applications for agricultural and rural development within this project.

There is an overall sensitivity in Turkey to use advanced technologies wherever possible. The Ministry of Finance and Customs recently announced that tax collection will be monitored by a computer network.

Despite the many successful applications there is room for improvement in almost all sectors mentioned. The UNIDO efforts in this field should also be mentioned here as a fine example of how international organizations can contribute towards national and regional efforts to apply information technology for development.

VI. MAIN FIELDS OF APPLICATION OF MICROELECTRONICS EQUIPMENT.

Up to now, we have concentrated mainly on the technological capacity built up in the country. The application of the technology, so that it meets the specific requirements of the country over a wide range of economic sectors, is equally important. To map the current situation in Turkey on education, agriculture and rural development, manufacturing and small industries, public health, transportation and other services sectors should be investigated in detail. There are unfortunately no studies to map out the extent of industrial diffusion of microelectronics in Turkey

The wide field of industrial applications of electronics equipment and systems can be classified as :

(1) Quality control/stock control/process control
(2) Systems engineering
(3) Equipment used in production (continous power, measurement equipment etc.)
(4) Electronics within the product

Some examples in each application field can be given. There is a wide area in Turkish industry, such as iron-steel, refineries and petro-chemical institutions, cement, glass factories, sugar and food industries, and textiles which can easily absorb local electronics production. In the following, a few examples from different sectors will be given.

Almost all the computers used in Turkey are imported and it is safe to state that these computers are usually under utilized. Recently there was great interest in the production and use of microcomputers. This interest resulted from the Government's ambitious project on the wide use of microcomputers in education. Although details of the project are not yet clear, the aim is to introduce about one million microcomputers into the secondary education system. This is a huge number by any standard. The Government is hoping to further accelerate the development of the electronics industry through this project.

VII. RAW MATERIALS AND EXISTING INFRASTRUCTURE FOR MICROELECTRONICS DEVELOPMENT

Raw materials needed for the microelectronics industry are not readily available in Turkey. The situation for some materials is summarized below.

(1) Silicon

Silicon ingots for wafer production are being experimented with no mass production anticipated. All silicon ingots are currently imported from abroad.

(2) Chemicals

No fine grade chemical products are produced locally for integrated circuits.

(3) Metals

No metal products for the 99.99 % grade are available in the country.

(4) Printed Circuit Boards (PCB)

Few companies produce double layer PCB.

(5) Special glass

Special glass for black and white television tubes is produced in quantity at the Turkish Bottle and Glass Company. Special glass for colour television tubes are not produced.

(6) Plastics

Resin is produced in quantity, but epoxy resin is 100 % imported,

(7) Fine ceramics

Fine ceramics are mainly imported.

Infrastructure for microelectronics development is not very well developed.

VIII. MANPOWER PROBLEMS IN MICROELECTRONICS INDUSTRY AND TRAINING EFFORTS UNDERTAKEN.

Partial manpower statistics in the electronics industry was already given in Chapter IV. The microelectronics field is in need of well qualified engineers and support personnel. The need is especially great in the case of qualified technicians. In the very near future, the need for specific personnel trained in the fields of solid state physics, optics, acoustic and related fields, and in command of a foreign language will be strongly felt.

Training Activities can be classified as :

(1) Educational institutions
(2) Research centres
(3) Overseas

Educational institutions include technical high schools, universities and graduate schools. The universities produce a sufficient number of graduates, the best of whom usually go abroad for their post-graduate work. The quality of education is not the same in all universities as only a few have adequate facilities and qualified manpower. Proper training requires the use of modern equipment in the laboratories compatible with modern technology. It may help if universities were to specialize in various fields and co-operate among themselves. On-the-job training of those working in the industry is important and all technological possibilities, e.g. interactive video, could be used to provide this service properly.

Overseas training is provided specifically as part of a technology acquisition packet, but there is a big problem in this area as the best trainees are usually recruited by the host company. A substantial number of YITAL researchers found jobs in the EXAR Company which has given know-how to YITAL. This is a striking example of an external brain drain. There is also an internal brain drain from research organizations, essentially T BITAK, to local private companies.

IX. REGIONAL AND INTERNATIONAL CO-OPEROTION

Turkey has a favourable geographical position in which to fulfil the role of a bridge between Europe and the Middle East and between West and East. It has a special interest in almost all EEC initiatives and participates in a number of European programmes. e.g. European Co-operation in the field of Scientific and Technical Research (COST), etc.

Turkey has bilateral agreements with many European countries. It is a member of the Organization for Economic Co-operation and Development (OECD),and North Atlantic Treaty Organization (NATO). Turkey participates fully in almost all scientific NATO programmes. Two projects are operational in microelectronics under the NATO-Science for Stability Programmne and the country is planning to be more active in future European initiatives. Turkey is also active within the UN system and enjoys support from UNIDO on a number of important projects.

Another point of extreme importance is the fact that Turkey also has a distinctive position within the family of Islamic countries. It is actively involved in the Organization of Islamic Countries.

It participates in regional co-operation organizations such as ECO (Economical Co-operation Organization) with Iran and Pakistan. The equipment park in YITAL for example was established from a loan from the Islamic Development Bank.

This "bridge" position enjoyed by Turkey can be further explored in order to develop regional and international co-operation programmes.

There has not been much co-operation in high technologies among the countries of the region, but it could take several forms.

(1) Joint R+D programmes and research networks

Research groups in universities, government laboratories and in private companies could be linked together to form a network.

(2) Training centres

Certain well developed laboratories could provide training facilities.

(3) Computer networks

For information exchange and access to computing facilities.

(4) IC design centres

For designing custom and semicustom IC's

(5) Pilot plant for wafer production

For custom chip production and to function as a regional silicon foundry.

(6) Consulting

Institution for consultations.

X. CONCLUSIONS AND POSSIBLE FUTURE DEVELOPMENTS

The following list provides some conclusions and possible future developments in microelectronics in Turkey.

1. One of the most important difficulties in assessing the Turkish electronics industry is the lack of data. The classification of subsectors does not reflect today's industrial reality. Assessment of public and private R+D expenditures is extremely difficult.

2. There exists no national programme that could even remotely remind one of the ALVEY initiative in the UK or the Plan CALCUL of France, etc. The result is a diffused effort in microelectronics without clear national targets.

3. In parallel with national priorities to be selected, the country must pass through the following technological points:

(a) Miniaturisation and integration, new MOS AND GAAs technologies and new methods of manufacturing integrated circuits;

(b) New architecture, high-level languages and new methods of software production;

(c) Digitization for transmission and switching functions, the introduction of opto-electronics as a transmission medium and the integration of services and

(d) The development of numerical control, robots and CAM systems.

4. Technological autonomy in microelectronics is only possible through a strong research and development effort. It is expected that this effort will increase and individual R+D groups will co-operate more by forming consortia.

5. It is expected that the total production in the electronics sector will show increases. This stems from the emphasis given to the telecommunications sector. The components subsector will be developed rapidly. Raw materials needed for IC production will be produced increasingly within the country.

6. Manufacture of microcomputers will accelerate. A Turkish microcomputer will be developed and locally manufactured. The project on microcomputers in education will have a tremendous effect in this respect.

7. There will be a collection of National Defense related large projects. These will have an effect on the development of the microelectronics industry and the high standards required will make R+D absolutely necessary.

8. Government procurement will be used as an incentive to develop certain key technologies. SMEs will receive essential support to develop high technology products.

9. Industrial support units and innovation centres will be established within campuses of developed universities and research centres. There will be a move towards increasing university-industry co-operation.

10. The Government will be active in providing incentives for more foreign investment in Turkey. Legal procedures will be further simplified to promote joint ventures.

11. Diffusion of microelectronics applications in products and processes will accelerate. A national programme to increase the diffusion of microelectronics in industry will be essential for industrial competitiveness.

In this study, an effort was made to map the current situation of microelectronics in Turkey along broad lines. There have been same omissions to keep the reading material to a healthy minimum. It is hoped that this will not cause any misunderstanding.

TABLE 1. Production in the electronics industry (in millions of US$)

Year	Consumer	Industrial	Components	Total
1970	11.1	4.8	1.7	17.16
1971	3.13	7.5	1.3	22.1
1972	22.5	10.3	1.7	34.6
1973	54.5	14.1	2.4	71.1
1974	116.5	21.0	4.3	141.7
1975	191.4	26.2	4.0	221.8
1976	192.2	41.4	5.3	239.1
1977	195.9	53.0	5.9	254.7
1978	179.4	56.1	19.4	254.9
1979	201.6	54.7	19.0	275.0
1980	142.5	70.0	19.0	231.7
1981	178.5	87.7	23.8	290.3
1982	150.2	142.8	14.8	307.7
1983	265.2	167.1	21.8	454.1
1984	380.0	137.5	26.1	543.6
1985	428.7	151.0	29.2	608.9

TABLE 2. Percentages for subsectors in total electronics Production

Year	Consumer	Communication	Industrial	Components
1970	62.0	24.7	2.5	9.9
1971	60.3	26.6	7.2	5.9
1972	65.1	23.1	6.8	5.0
1973	76.7	15.4	4.5	3.4
1974	82.2	11.4	3.4	3.0
1975	86.3	10.0	1.8	1.8
1976	80.4	15.0	2.3	2.2
1977	76.9	18.6	2.2	2.3
1978	70.4	19.5	2.5	7.6
1979	73.3	17.8	2.1	6.9
1980	61.5	25.0	5.2	8.2
1981	61.5	25.0	5.2	8.2
1982	48.8	43.2	3.3	4.8
1983	58.4	33.6	3.2	4.8
1984	69.9	22.1	3.2	4.8
1985	70.4	21.6	3.2	4.8

TABLE 3. Yearly rate of production increment

Year	Consumer	Commun.	Indust.	Components	Total
1970	12.0	31.2	62.8		-34.4
1971	34.2	50.0	302.2	15.7	39.9
1972	40.8	13.6	22.7	10.7	30.5
1973	111.5	19.3	18.9	19.9	79.3
1974	59.2	10.0	12.5	51.5	48.6
1975	53.0	28.4	20.5	-9.6	45.8
1976	-2.0	57.3	32.6	25.0	5.0
1977	-4.5	24.0	-7.3	6.4	0.0
1978	-25.4	-14.7	-4.8	164.0	-18.5
1979	-16.7	27.0	34.8	27.6	-20.0
1980	-33.2	12.0	101.1	4.5	20.1
1981	36.0	36.0	36.2	34.6	36.1
1982	-0.6	116.0	23.7	-12.3	25.1
1983	88.9	22.8	51.6	56.7	57.9
1984	74.6	-3.7	38.1	38.1	46.0
1985	18.4	14.4	14.2	24.2	17.5

TABLE 4. Imports (in millions of US$)

Year	Consumer	Common.	Indust.	Compon.	Total	Share in Total Import %
1970	2.0	12.3	6.3	10.9	31.5	3.8
1971	3.1	4.6	12.9	11.3	32.0	2.9
1972	11.6	8.5	24.5	17.8	62.4	4.1
1973	11.1	15.7	32 6	28.0	83.2	4.0
1974	8.4	20.5	31.5	72.9	133.3	3.6
1975	3.6	35.3	46.3	106.7	192.0	4.1
1976	1.8	19.8	48.0	97.1	166.7	3.3
1977	0.8	21.5	45.6	99.0	166.9	2.9
1978	0.4	11.3	18.9	71.8	102.4	2.2
1979	0.4	16.9	20.1	65.2	102.7	2.0
1980	0.3	14.0	48.4	62.3	125.0	1.4
1981	0.6	15.1	51.5	91.4	158.5	1.7
1982	1.6	13.0	59.3	85.5	159.1	1.8
1983	0.7	13.9	87.0	141.4	243.0	2.6
1984	4.5	28.0	110.0	224.0	377.9	-

TABLE 5. Total production numbers of some electronic equipment in 1985 and 1986.

Equipment Produced	1985	1986
Telephone exchanges	376.939	896.641 Lines
Telephone sets	493.860	945.521
Telex machines	5.100	31.36
Transceivers	22.375	34.834
Black/white TV	32.431	13.004
Colour TV	1.128.092	879.770
Video tape	152.425	196.482

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8. Development Plans (II-V), State Planning organization (in Turkish)

APPENDIX

Turkey, with a population of over 50 million, is situated at the cross roads of the Euro-Asian and African continents. Its strategic location makes it all the more important to establish a strong scientific and technological base in the country. The present national effort in the field of science and technology, which is now in the portfolio of a Ministry of State, is not as strong as it is in industrialised countries.(6) Only 0.2 percent of GNP is spent on Research and Development (R+D).In 1983, the total R+D expenditure amounted to 27.2 billion Turkish Liras (T.L), of this sum 15.1 billion Turkish Liras 57 per cent was spent by universities, 7.7 billion Turkish Liras (28 per cent) by the Government sector, and 4.4 billion 15.1 billion T.L. (15 per cent) by industry.

In 1983 there were about 29,000 people engaged in R+D activities. Of these 16,955 were researchers, 8,736 were technical support personnel and 4,211 were other support personnel.

The R+D structure of the country is composed of:

(a) Universities;
(b) Government research organizations; and
(c) Research centres in the private sector.

There are 29 universities in Turkey, only one of these being private at present. The total number of teaching personnel is about 11,000. Government research organizations include the Scientific and Technical Research Council of Turkey (T BITAK) with its Marmara Scientific and Industrial Research Institute; the Basic Sciences Research Institute. Building, Ankara Electronics, and the Ballet Research Institutes have a staff of about 1,000, half of whom are full-time researchers. The Turkish Atomic Energy Authority (TAEK), with its two nuclear research training centres and one in veterinary sciences, has a staff of about 500, of whom 200 are researchers. Both T BITAK and TAEK fall under the authority of the Prime Minister. The Mineral Exploration and Research Institute (MTA) within the Ministry of Energy and Natural Resources has about 1,800 scientists and engineers. The Ministry of Agriculture, Forestry and Rural Affairs has around 100 small research centres. Other public organizations involved in R+D include the Petrochemical Industry (PETKIM), the Sugar Company, and the State Hydraulic Works. In the private sector, the Turkish Bottle and Glass Industry, Cement Research Centres, Koc and Sabanc Holdings, TELETA NETA ASELSAN, TESTA and a few others are notable examples where some R+D work is carried out.

The industrial structure of Turkey is characterized by a large number of small-and medium- sized enterprises. This is verified by the 1983 Survey which indicates that only 8 per cent of the manufacturing firms are large establishments. (6)

The State Planning Organization of Turkey was established in 1963. The priorities of the country in different sectors are stated in five-year and yearly development plans, in general terms.(8)

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1977	76.9	18.6	2.2	2.3
1978	70.4	19.5	2.5	7.6
1979	73.3	17.8	2.1	6.9
1980	61.5	25.0	5.2	8.2
1981	61.5	25.0	5.2	8.2
1982	48.8	43.2	3.3	4.8
1983	58.4	33.6	3.2	4.8
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