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STATE-OF-THE ART SERIES ON MICROELECTRONICS

No. REPUBLIC OF TURKEY*

Prepared for the Technology Programme

by

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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

Organizations

ASELSAN	Military Electronics Industries. Inc.
EEC	European Economic Commission
ITU	Istanbul Technical University
METU	Middle East Technical University
MKE	Machinery-Chemical Industries
NETAŞ	Northern Electric Telecommunication Inc.
TAEAT	TUBITAK Ankara Electronics Research Institute
TELETAŞ	Telecommunication Industry and Trade Inc.
TESTAŞ	Turkish Electronics Industry and Trade Corp.
TUBITAK	The Scientific and Technical Research Council of Turkey

CONTENTS

SUMMARY

In this work, an attempt is made to map the current situation and future Turkish aspirations in the field of microelectronics. Government technology strategy, main subsectors of microelectronics industry, national research and development activities, national approach towards the acquisition of technology, 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 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 color TV, telephones etc.

Although there is no systematic approach to technology acquisition various incentives are 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 cooperation.

1. Introduction

Turkey, who has just applied for full 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. The Turkish Government realizing this fact has put great emphasis in electronics and designated it as a priority area. In this work, 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 adapted and the field is taken to cover eg. 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".

The report consists of ten sections. In section 2 the Government technology strategy is discussed in broad terms. After a brief history of Turkish electronics industry, recent developments are summarized section 3 deals with the main subsectors of microelectronics industry. National R+D activities are summarized in Section 4. Here, the broad lines of research are emphasized not the individual projects carried out in each institution. Section 5 deals with technology acquisition approaches and equipment procurement. Microelectronics applications are summarized in section 6 where information on a new Government project involving microcomputers in education is also given. Section 7 summarizes the current situation in raw materials and infrastructure for IC production. Manpower problems and training efforts undertaken are presented in Section 8. Regional and international cooperation is discussed in Section 9. Finally in Section 10 some conclusions and possible future developments are summarized.

The general S+T structure of Turkey is given in Appendix to provide an overall framework for the present study.

2. Government Technology Strategy

The roots of the electronics industry in Turkey goes back to the production of telegram devices by PTT at the end of the 19th century.[1-4] During the early years of young Turkish Republic (established in 1923) the army reached a level of production of its own communication equipment like combat field telephones and dry batteries. But after 1948 this promising start died off as a result of United States Military Aid.

In 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 early 1960's and in 1964 The Council of National Security has decided that the work should be started to build up Turkish Electronics Industry. At first, the Machinery-Chemical Industry Enterprise (MKE) and later the Turkish PTT was charged with this duty. PTT has submitted its report in 1967 and established, in the same year, NETAŞ Company with NORTHERN TELECOM of Canada. 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 Second Development Plan and a special commission was set up. Thus, it can be stated that the foundation of the electronics industry in Turkey is established in 1967.

The Scientific and Technical Research Council of Turkey (TÜBİTAK) is established in 1963. The Electronics Research Department of TÜBİTAK functioned within Middle East Technical University (METU) between 1968-1972 before moving to its present laboratories in Gebze, near Istanbul. Later, the Semiconductor Technology Research Laboratory (YITAL) is established within the same Research Institute in 1983. YITAL was to function as a research laboratory in close collaboration with the electronics industry company (TESTAŞ) which was established in 1976 and was producing resistors and condensators. PTT-ARLA was later turned into another electronics company TELETAŞ in 1983. Both NETAŞ and TELETAŞ shared PTT market for digital switches. The other two notable companies are TEKNIM, which is established in 1970 in the

high frequency communication equipment sector, and ASELSAN which is established in 1976 mainly for reducing dependency on developed countries in high tech defense electronics.

In 1985, TUBITAK established Ankara Electronics Research Institute (TAERI) within the campus of Middle East Technical University. TAERI is 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 1960's "import substitution" policies were employed which resulted in rapid development of consumer electronics subsector. This subsector naturally formed the backbone of Turkish electronics industry. Telecommunications subsector later developed as a result of public organizations' needs, such as PTT. R+D first flourished in this subsector which enjoyed a quaranted market. One the most important factors, which played an extremely positive role in development of R+D activities recently, is the Government's decision on an export oriented economy. Starting from quality control and standards, R+D has been felt by the industry as a must in the fight for external markets. High tariff walls protecting local industry from outsite competition created a static environment and made almost unnecessary any R+D effort by the local industry prior to 1983.[5,6]

The establishment of the Defense Industries Development and Support Fund is an extremely important step which is expected to drag along 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 to privatize state economic enterprises through the Public Participation Fund. In 1987, the Government shares in some enterprises are transfered to this fund. The first example of this practice is given in the electronics sector by privatizing TELETAŞ. It is expected that funds obtained through privatization could be used in developing new technologies.

Government has also chosen the private sector as the prime force to accelerate industrialization of the country. New tax incentives were established to motivate companies for more R+D efforts and innovation in their

products. Corporate Tax General Communique 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 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 the application by asking for the views of TUBITAK and other related organizations.

There are serious efforts to establish innovation centres and science parks around well established universities and research centres. In 1987 two companies are established in Izmir and METU-Ankara which aim at increasing University-Industry cooperation in innovation. Other possibilities are under investigation. Establishment of free zones is another important step towards regional development with possibilities of high technology development. Mersin free zone has become operational in 1987 soon to be followed by Antalya, Adana and Izmir free zones.

Considerable emphasis is given to the telecommunication field. As a result of this policy the most advanced institutions are operating in this field. Application of digital technology to telecommunications is emphasized.

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

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

Government has also created a better climate for foreign investment simplifying the legal procedures. The result has been positive and the number

of foreign companies of all fields investing has increased from an average number around 100 each year till 1980 to over 800 by 1987.

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

Despite of the recognition of the importance of electronics there are some obvious pitfals 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 a 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 crious state of Higher Council for Science and Technology (HCST). The HCST is established in 1983 by the Enforced Decree No.77 with the aim of determining the priorities for R+D in view of goals for economic, social development and national defense. The HCST, composed of seven ministers and presidents of TUBITAK, Turkish Atomic Energy Authority and Higher Educational Council and to be chaired by the Prime Minister, has not met yet.

3. Main Subsectors of 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 Products

1.1 Amplifier

Tuner, Receiver, Music Center, Equalizer, Record Player, Speaker

1.2 Recorder

1.3 Radio

Radio, Clock Radio, Car Radio, Headphone radio

1.4 Color Television

1.5 Black & White Television

1.6 Electronic Watch

Digital Wrist Watch, Analog Wrist Watch, Wall Clock, Desk Clock

1.7. Others

Video game, electronic toy

(2) Industrial Products

2.1 Computer

Calculator, Computer, Peripheral, Monitor, Display, Terminal

2.2. Measurement Equipment

Monitor television, electronics Measuring Instrument, Alarm Device

2.3 Wire Telecommunication Equipment

Telephone, telephone recorder, Switching System, Carrier telephone system, Telegraph Equipment, Teleprinter, Interphone, Intercom, Facsimile

2.4 Citizen band (CB) Transceivers,Wireless Telecommunication Equipment, Walkie, talike Transmitters, Receivers

2.5 Others

Cash registers

(3) Components and Parts

3.1 Electronic Tube

Black & White cathode ray tubes (CRT)

3.2 Integrated Circuit (IC)

Bipolar, Hybrid, metal oxide silicon

3.3 Semiconductor

Transisters, Diodes, Light Emitting diode (LED), Thermistors, Varistors

3.4 Others

Capacitors, Printed Circuit Boards (PCB), Switches, Keyboards Relays, Resisters

The Total 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 the industrial electronic goods are divided into two subgroups, namely, communication equipment and others. As it can be seen from Table 1, the total production shows an increase with slight oscillations. Table 2 clearly shows that communication equipment have the highest share in industrial equipment subsector. Table 3 shows the yearly rate of increment of production, with rather big 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 big companies are just enough for their own internal needs.

The import figures are shown in Table 4. Comparison with earlier Tables shows that production is over import figures after 1972. Import of active

circuit elements is the main item in the import of components. The main item in industrial equipment imports is medical equipment.

The exports have not reached a significant level yet. In 1983, the total exports were about 945 million $, of which 41.1 % were Communication Equipment, 27.6 % were consumer goods, 22.5 % Components and 8.8 % were industrial equipment. Before 1982 Consumer goods were leading export items. The share of electronics exports in total electronics production is below 1 % untill 1979. This figure is 1.2 % in 1984. Tables 1-4 are arranged from Reference 2.

There has been a tremendous demand for Color TV in Turkey in the last five years. 4 million Color TV were produced by the end of 1986 which corresponds to 50 % 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 to be competetive. The total production numbers for TV and Video Tapes are given in Table 5.[7]

The communications sector is the most developed one in Turkey. The total production numbers of same communications equipment in 1985 and 86 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 has started. Monitors, and limited number of auxiliary components are also produced.

4. National R+D Activities

Technology acuoisition shows differences depending on various subsectors. 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 in the country. In this case, R+D is limited to adaptation level. Communication subsector has reached a level of following the current technology. The financial resource spared for R+D in this subsector is quite substantial and quality of R+D performed is quite high. In the subsector of Industrial equipment common technology is employed and heavy engineering design work is carried out. Since special purpose equipment are produced in this subsector, the work can be considered as 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. TÜBİTAK is active in this field.

The majority of national R+D activities in microelectronics are being carried out in TELETAŞ. NETAŞ, ASELSAN, TESTAŞ and TUBITAK. There are of course other companies involved in same 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 universities is somewhat far from satisfying the needs of local industries.

The situation in different organizations are described in more detail below :

TELETAŞ

A modern R+D laboratory is incorporated into TELETAŞ organization ever since its foundation. There are active research groups in: analog systems, R/L, End units, Power electronics, optical fiber transmission, PCM-I/II, Digital exchanges hardware and software.

R+D work goes into almost all products manufactured and marketed which includes: 2.8, 34 and 140 Mb/s digital (PCM) multiplex systems, 48 channel digital telegraph multiplex systems, digital public telephone exchanges (system 12 of ITT), digital multiaccess 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 single and double sided, printed circuit boards professional grade thick film resister and hybrid circuits, thin film circuits etc.

TELETAŞ is performing continous R+D to improve its products and to come up with 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, 7 with Ph.D and 50 support personnel and technicians in R+D unit. A special emphasis is also given to the software development. BTM/ITT licensing agreement makes it possible to do joint research with ITT. But at present, this possibility is being used by sending R+D personnel abroad to participate in research projects thus educating them.

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

NETAŞ

NETAŞ has one of the largest private R+D organization in Turkey. There are four main R+D groups on Domestic products; DMS; Operations, and Design Control. Propritary product development projects include; XDAR 1975 / 80 (Operator toll dialing, subscriber toll dialing, International Subscriber dialing, gateway CCITT no 5/R2, automatic trunk testing, Larg[illegible]ADX, 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. NETAŞ has aggressive DMS R+D plans. Technology transfer from Northern Telecom include training which started in 1985 at BNR Ottowa and Maidenhead, UK initially with 1 manager and 6 designers now include 6 managers, 18 designers, 15 support engineers and 2 BNR consultants. Training goes on in areas including CC software, XPM software, H/W architecture F/F, Computer support, verification office support, field support. NETAŞ R+D unit is included in NORTHERN TELECOM network exchanging R+D results with other nodes.

When TELETAŞ and NETAŞ are compared, it is seen that NETAŞ is specialized in shorter distance communication.

TESTAS

TESTAŞ is established to manufacture discrete and linear integrated semiconductor components using planar technology. The project is so designed that the following operations could be performed by TEŞTAŞ: 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 molding, marking etc., carying out quality control. Technology transfer and licensing agreement was concluded in 1980 with EXAR of California, USA. TESTAŞ developed its semiconductor manufacturing operations in two different locations; Ankara wafer processing and testing plants and Aydın assembly and packaging plant. Both Ankara and Aydın plants have class 10.000 clean room facilities with class 100 LAF cabinets. The facilities and corresponding support services have been installed according to design and supervision of VARIOPLAN of Switzerland. The manufacturing equipment have been installed. The cost of facilities and equipment is around 12 million US $. The planned production include bipolar linear integrated circuits (Standard, custom and semicustom IC's), custom and desing bipolar integrated Injection logic circuits, and small signal bipolar discrete transistors.

With more than 500 employees TESTAŞ is the only company set out to manufacture ICs. The present production of resistors is made under technical agreement with Bultronics Corporation of Japan. Ceramic capacitors are produced under the license of Thomson CSF, France. Metallized polyester capacitors are produced under the license of ARCOTRONICS Corporation of Italy. There is same production of electronics equipment like taximeters, tachographs, converter, switching power supply units and filters mostly developed by TESTAŞ R+D engineers and support personnel. R+D team consists of qualified engineers trained and spealized 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 TESTAŞ engineers.

ASELSAN

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

TUBITAK

The research in TUBITAK is carried out in three Institutes. YITAL and Electronics Department of Marmara Research Institute (MRI), TAERI and Physics Department of Basic Sciences Research Institute (BSRI) are active in electronics related research. As already mentioned YITAL is established in 1983 to work mainly on bipolar technology. This research laboratory has been working in close collaboration with Istanbul Technical University (ITU) where

the very first IC consisting of a MOS array with 4 transistors was produced in 1977. TESTAŞ engineers are being trained in YITAL. IC production level in YITAL is small scale and packaging is done manually. The aim is to concentrate on semi-custom and custom chip production. The industrial production is expected to be carried out by TESTAŞ.Recently, design capacity is being emphasized in YITAL. There is also a 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 fiber transmission. Another project is carried out in collaboration with TELETAŞ on digitalizing 1800 channel analog radio-link systems produced by TELETAŞ. A project developed in the Department of Materials on high technology ceramics include work on ceramics utilized in electronics.

Physics Department of BSRI is currently developing a laboratory on GaAs and another one on amorphous silicon.

The TAERI is established in 1985 within the Department of Electrical and Electronics Engineering of METU. An important project on establishment of a VLSI design centre is being sponsored by NATO-Science for Stability Programme. Another notable project is on a Turkish microcomputer for educational purposes. There are also efforts 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 in the universities, where most of the R+D work is also carried out. The individual research projects submitted by researchers from 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 are usually formulated within the University Rewolving Fund mechanism. Some part of this fund is spared for University Research Fund where it is used for supporting in-house research.

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

The Department of Electrical and Electronics Engineering (EE) of METU host TAERI and collaborate heavily with ASELSAN. 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 large investment in a silicon-technology laboratory. Experimental solar cells research is also well developed in this Department. A CAD/CAM centre is being developed in METU where 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 TUBITAK-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 is to be carried out in the Faculty. A research unit in robotics in established with support from TUBITAK.

5. 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 cooperation programmes and other methods (e.g. employing foreign experts).

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

The 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, doing reverse engineering, in house or contract research.

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

There are no notable overseas branch activity which is an important way of 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 developed countries like USA.

As already mentioned, most of Turkey's technology and equipment supplies are from USA and Europe. Japan is also becoming active in Turkey, recently. Individual examples of technology and equipment procurement were given in Section 4 and will not be repeated here.

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

Tourism is another sector Turkey attaches great importance with almost endless possibilities for microelectronics applications. Transportation sector is already using microcomputers at an accelerating rate.

Turkey is currently employing a mammoth project known as "The Southeast Anatolian Project (SAP)" with biggest dams and irrigation network under construction that will transform a huge part of the country. There is a chance of setting up the best examples of information technology applications for agriculture 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 of many successful applications there is room for improvements almost in 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.

6. Main Fields of Application of Microelectronics Equipment.

Up t now, we have concentrated on the technological capacity build 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 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 application 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, refinaries and petro-chemical institutions, cement, glass factories, sugar and food industries, and textile which can easily absorp the local electronics production. In the following, a few examples from different sectors will be given.

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

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7. Raw Materials and Existing Infrastructure for Microelectronics Development.

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

(1) Silicon

Silicon ingots for wafer production are experimented with in research laboratories with no mass production in sight. All silicon ingots are currently imported from abroad.

(2) Chemical

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

(3) Metal

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

(4) Printed Circuit Board (PCB)

Few companies produce double layer PCB.

(5) Special Class

Special glass for black and white television tube is produced in quantity at Turkish Bottle and Glass Company. Special glass for color television tube is not being produced.

(6) Plastics

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

(7) Fine Ceramics

Fine ceramics is mainly imported.

Infrastructure for microelectronics development is not very well developed.

8. Manpower Problems in Microelectronics Industry and Training Efforts Undertaken.

A partial manpower statistics in electronics industry is already given in Section 4. 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 feld.

Training activities can be classified as

(1) Educational Institutions
(2) Research Centres
(3) Overseas

Educational institutions includes technical high schools, universities and graduate schools. The universities produce sufficient number of graduates. The best of graduates usually go abroad for their post-graduate work. The quality of education is not at all even in all universities. Only a few have the adequate facilities and qualified manpower. Proper training requires the use of modern equipment in the laboratories competable with modern technology. It may help for universities to specialize in various fields and cooperate among thanselves. 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.

The overseas training is provided especially as a part of technology acquisition packet. But there is a big problem in this area as the best trainies are recruted by the host company. A substantial number of YITAL researchers found jobs in EXAR Company which has given know-how to YITAL. This is a striking example of external brain drain. There is also an internal brain drain from research organizations, essentially TUBITAK, to local private companies.

9. Regional and International Cooperation

Turkey has a favourable geographical position to fulfil the role of a bridge between Europe and Middle East and between West and East. It has a special interest in almost all EEC initiatives. It participates in a number of European programmes. e,g. COST etc.

Turkey has bilataral agreements with many European Countries. It is a member of OECD, and of course NATO. Turkey participates fully in almost all Scientific NATO programmes. Two projects are operational in microelectronics under NATO-Science for Stability Programme. Turkey is planning to be more active in future European initiatives. Turkey is also active within the UN system. It 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 Organization of Islamic Countries.

It participates in regional cooperation organizations like ECO (Economical Cooperation Organization) with Iran and Pakistan. The equipment park in YITAL for example is established by a loan from Islamic Development Bank.

This "bridge" position of Turkey just underlined can be explored further to develope regional and international cooperation programmes.

There has not been much cooperation in high technologies among the countries of the region. This cooperation can take on several forms.

(1) Joint R+D Programs, Research Networks

Research groups in Universities, Government laboratories and in private companies could be linked together forming a network.

(2) Training Centres

Certain well developed laboratories can provide training facilities.

(3) Computer Networks

For information exchange and access to computing facilities.

(4) IC Design Centre

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 consultation.

10. Conclusions and Possible Future Developments.

In the following a list of some conclusions and possible future developments in microelectronics in Turkey is given.

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 even remotely reminding one of the ALVEY initiative in UK- old 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, new methods of manufacturing integrated circuits,

b. new architectures, hingh level languages and new methods of software production

c. digitization for transmission and switching functions, the introduction of opto-electronics as a transmission medium, the integration of services,

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 R+D effort will increase and individual R+D groups will cooporate more by forming consortia.

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

6. Manufacturing microcomputers will accelerate. 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 big projects. These will have an effect on development of microelectronics industry. 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 tech 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 cooperation.

10. 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 process will accelerate. A national programme to increase the diffusion of microelectronics in industry will be essential for industrial competitiveness.

In this work, an effort is made to map the current situation in microelectronics in Turkey with broad lines. There has been some omissions to keep the reading material to a healthy minimum. It is hoped that this will not cause any misunderstandings.

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

Year	Consumer	Industrial	Components	Total
1970	11.1	4.8	1.7	17.6
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	17d.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	62.9	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	3.2	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 increement

Year	Consumer	Commun.	Indust.	Components	Total
1970	- 12.0	31.2	- 52.8	-	- 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	24.2	24.2	17.5

TABLE 4. Imports (in Million US $/

Year	Consumer	Commun.	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
Color TV	1.128.092	879.770
Video Tape	152.425	196.482

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APPENDIX

Turkey, with a population of over 50 million, is situated at the cross roads of a few 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 (S+T), which is now in the portfolio of a Ministry of State, is not as strong as it is in developed countries.[6] Only 0.2 % of GNP is spent on R+D. In 1983, the total R+D expenditure amounted to 27.2 billion TL. of this sum 15.1 billion TL (%57) was spent by universities, 7.7 billion TL. (%28) by the Government sector, and 4.4 billion TL (% 15) by the industries.

In 1983 there were about 29000 people engaged in Research and Development (R+D) activities. 16955 of these were researchers, 8736 were technical support personnel and 4217 were other supporting personnel. As far as scientific papers published, Turkey ranks about 41st.

The R+D structure of the country is composed of a) Universities b) Government Research Organizations c) Research Centers in private sector. There are 29 Universities in Turkey, only one of these being private, at present. The total number of teaching personnel is about 11000. Government research organizations include The Scientific and Technical Research Council of Turkey (TUBITAK) with its Marmara Scientific and Industrial Research Institute; Basic Sciences Research Institute; Building; Ankara electronics, and Ballistic Research Institutes has a staff of about 1000 approximately, half of which being 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, 200 of which are researchers. Both TUBITAK and TAEK are attached to the Prime Minister. The Mineral Exploration and Research Institute (MTA) under the Ministry of Energy and Natural Resources has about 1000 scientists and engineers. The Ministry of Agriculture, Forestry and Rural Affairs has around 100 small research centres. Other public orga-

nizations involved in R+D include the Petrochemical Industry (PETKIM), The Sugar Company, The State Hydraulic Works etc. In private sector, the Turkish Bottle and Glass Industry, Cement Research Centres, Koç and Sabancı Holdings, TELETAŞ, NETAŞ, ASELSAN, TESTAŞ and a few others are notable examples where same R+D work is carried out.

The industrial structure of Turkey is characterized by a large number of small and medium sized enterprises. The 1983 Survey indicated that only 8 % of the manufacturing firms are large establishments.(6)

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