14954

1985

A TECHNO-ECONOMIC STUDY ON A "SILICON FOUNDRY" IN THE WESTERN ASIA REGION

prepared by

Stephen L. Gilbert and Hasan Ali Charif

Contents

The joint UNIDO/ECWA mission to the Arab States of Iraq, Egypt, Tunesia, Algeria, Morocco, Syria, Jordan and Saudia Arabia in late 1984 and early 1985 was greatly helped by the excellent planning performed by ECWA personnel Dr. Hassan Charif and Dr. Ribhi Abu El-Haj. Visits with principals in local industry and government sectors were most informative and the persons contacted were most eager and willing to discuss in detail the special problems that this issue addresses. Special mention must also be accorded the able assistance of the UNDP offices in the countries visited for their assistance in logistical matters.

Two members of a French delegation from DIELI, Dr. Gerard Matheron of the Ministere du Redeploiement Industriel et du Commerce Exterieur and Dr. Rene Micolet of the Laboratoire d'Electronique et de Technologie de l'Informatique, Grenoble, and a representative from the Technical University of Berlin , Institute of Institute of Microelectronics, Dr. Otto Manck, joined the mission and contributed both to the discussions and to an addendum included in this report.

Introduction

The silicon foundry approach to integrated circuit design is aimed at completely restructuring the semiconductor industry in such a way that anyone with a design idea can have that idea cast in silicon at a reasonable cost. To achieve this end, "thought stages" associated with design are separated from the "mechanical stages" associated with fabrication. (2)

This inovation requires comprehensive organization to establish such a new `foundry' approach to semiconductor manufacturing. Many diverse skills are required in a complex orchestration extending over many months of constant effort to realise a finished product. Each and every step must be performed precisely and in harmony, both with the step preceeding and the one following, to yield the desired results. The technology necessary to produce microelectronic devices, such as have been created within the last decade, can, at first contact, appear awesome.

It is necessary to pursue this technology slowly and purposefully with a careful eye to precisely what benefits are desired. The nature of the technology is such that half-measures generally produce little or no results; a critial mass of resources are necessary to initiate the creative process and produce results, as resources expended at the wrong time or in the wrong areas could be entirely wasted. The competition in microelectronics in `developed' countries has shown the technology to be quite a risk; albeit a necessary and profitable one. The learning experience necessary to create a sucessful indigenous microelectronics technology requires time to mature. The establishment of a regional `silicon foundry' capability will accelerate the achievement of that maturity.

A. Assessment of Current Microelectronic Technology Base

Throughout the mission in Arab States/Western Asia particular attention was paid to the operations level of semiconductor technology being performed at the various installations. It is possible to assess the level of technology in a quantitative manner by dividing along the skill levels necessary to implement a particular semiconductor operation. This is not to say that this represents a QUALITY distinction, but rather that differing skills are required to perform at each operational level.

Such a division of operations would resemble the following functional operations:

A) Assembly of complete electronic products from vendor supplied electronic subassemblies and component parts.

B) Design and production of printed circuit boards and subassemblies

C) Production of simple passive component parts, i.e. resistors, capacitors, etc.

D) Design and production of Solid State discrete active components

E) Design and production of simple linear IC's & Gate Array customization

F) Design and production of Semicustom IC's..bipolar/MOS

G) Design and production of Custom IC's..bipolar/MOS/CMOS

As one proceeds down the list, the operational level of technology necessary to successfully perform the next level is cumulative. That is to say the previous step must be performed with precision and efficiency before the next operational level can be successfully undertaken. Each successive level is dependent on the completion of the proper prior level for successful product completion.

It becomes apparent that the highest skill levels are required for design and production of fully custom IC's while minimal skill levels are required to successfully perform the assembly operations that yield a completed product. It is obvious that the initial operations attempted by developing nations concentrate on the most productive and easily achieved operational level: that of assembly operations.

More ambitious SOLID STATE operation levels require first developing a mastery of technology levels A through C before products can be achieved with any degree of success.

Algeria

A) Commissariat aux Energies Nouvelles, CEN

Hadjsleiman Cherif

B) Entreprixe Nationale des Systemmes Informatiques

Bachir Bouadjenek Mouloud Lahlou

C) Centre de Recherche Electronique, CEN

C.Ben Mahrez Mohamed Djoudi
H. Bessalah

Egypt

A) Electronics Industries Research and Development Centre (EIRDC)

The Director of EIRDC, Dr.Roshdy El Hadidy, conducted a tour of the facilities and was most gracious in his discussions about the interests of EIRDC. The organization trains about 250 people in several technical areas, the most sophisticated of which is hybrid assembly. In addition to teaching circuit design and evaluation techniques, EIRDC has a fully found hybrid assembly capability within an on-site class 10,000 clean room. At present, an indigineous design is the major product, a universal power factor controller specificly designed for regional uses.

EIRDC has experienced similar problems as other countries in converting regional designs into a successfully manufactured products. The transfer of the technology from the feasibility stage to a manufacturing scale is the weak link in introducing new regional designs into the marketplace.

Dr. Hadidy suggested several possible demonstration projects for within Egypt; power control for electrical distribution network, and control of navigation in the Suez Canal.

Egypt is the only country that requires 10% of all contracts be supplied via an Egyptian company. This state policy, while implemented with the intent to foster a growing and expanding electronics sector, has not in fact accomplished that end. The contracting company typically provides 'pre-designed' components with the engineering solutions already completed, allowing for only assembly level technology development at the local level.

B) Benha Company for Electronic Industries

The Benha Company is a major manufacturer of electronic assemblies within Egypt. The facility is very extensive, employs 300 engineers, 200 technicans, and other specialists for an overall manpower complement of 3000. It was interesting to note that although component manufacture in Egypt essentially ended in the 1960's for reasons of economy, the Benha facility continues to manufacture all other elements required in assembly. All cases, connectors, and other mechanical parts are locally produced with only electrical components imported.

Discussions with the facility chairman, Dr. Latif Moharram, and the chief engineer, Dr. Mohamed El Laftawy indicated interest in performing Joint-Venture type activities...with foreign companies providing established research and manufacturing technology support. Since Benha is such a large company, any new product considered would have to be pursued with economic profitability as a prime concern.

C) National Research Council - Electronic Research Centre

The Electronics Section is engaged in design and limited prototype manufacture of microstrip components used in communications systems. Dr. Nadia Hegazi was most gracious and explained the function of the Research Center. While the staff has considerable expertise in design of linear Bipolar and CMOS circuits, the manufacturing capability is not sufficiently developed to assimulate such products. Strong efforts are being put into programming (8080 and 8085 family in particular) and in assisting assembly operations of application-specific devices such as inverters and industrial controllers. In this respect the Research Center works in parallel with Ain Shams University. Additionally, the Research Center holds seminars to develope capablilities in identifying applications for differing technologies; there exists a great need for education in the newer technologies among the general engineering profession.

D) Engineering and Industrial Design Development Center, EIDDC

EIDDC is geared to provide consultation service and support by supplying computer aided design assistance. The facility contains quite sophisticated computer systems and capabilities such as a Hewlett Packard 9845 CAD/CAM system with software compatible with similar systems in Iraq. Additionally, a new UNIX based ATT system will be on-line configured for mechanical analysis via programs such as STRUDLE (structural analysis) and finite element analysis routines. The Centre employs 65 engineers supported by 40 draftsmen, mostly engaged in mechanical design development.

In discussions with the president, Dr. Yusef K. Mazhar, we learned that in February 1985 the Centre had hosted a seminar on CAD/CAM which drew an audience of 100 from local industry. Dr. Mazhar spoke frankly that they were strongly concerned with industrial productivity and expressed the opinion that an 'open market' (as currently in place in Egypt), inhibits local industry development. There is a strong demand for world class products which increases the competion and stiffles the small startup companies.

Cooperation on mechanical design had been attempted in conjuction with Iraq in the past but the effort had been hampered by poor communications due to the distance and unreliabile circuits. Currently there seems to be no driving force for cross-country cooperation at the design level.

Egypt has a major marketing opportunity in supplying entry level computers to educational institutions. It has been proposed that everyone in Egypt's schools be computer literate as part of normal education. Estimates of the number of small `personal computers' required approaches 500,000 units (there are five million students in Egypt).

E) National Academy for Scientific Research and Technology

Habeish Ali

F) Ain Shams University

The University has approximately 40,000 students enrolled as undergraduates out of Egypts 1,000,000 students. The program in Electrical Engineering graduates 400 students per year with emphasis in power and communications technologies. The current direction is to reduce the number of B.S. candidates in favor of an increase in the number of technicans trained. The feeling appears that at the current state of the technology, the gap in manpower is more accute at the maintenance and troubleshooting levels than in the design areas. This shift in emphasis is intended to create a more favorable infrastructure within the industry for the future. Advanced research projects, while continuing in graduate education, are not directly supported by funds from government sources. One such graduate effort visited was the laboratory of Dr. Abdelhalim Zekry, where MOS PMOS devices were being made for education in processing techniques.

Iraq

It was with some pleasure that an assessment of the Mansour facility in Baghdad, Iraq indicated an operational technology level of E; quite an advanced level.

a) Mansour Facility, Baghdad

The mission visited the Bipolar production facility and had discussions concerning the operational capability of the facility with Dr. Adib Nu'man Abdul Aziz, Assistant Manager, Dr. Munim D. Salim, Production Engineering Manager, and other staff members.

The Mansour Semiconductor facility has been very intelligently planned to take advantage of several factors:

: The facility support functions, such as deionized water purification and air liquification, have been established as separate economic operations and provide service not only for the semiconductor facility but also serve as a central source of supply for all such high quality materials in the country. This allows the cost of the installation to be shared among other consumers of these materials such as a battery plant (uses DI water as electrolyte) and welding suppliers (use hydrogen and inert gasses from air liquification plant).

: The buildings have been designed to allow additional expansion within the complex for higher level operations without having to redesign distribution systems for most facilities. The HVAC (heating, ventilation, and air conditioning) system is configured to allow adequate environmental control for existing ope[illegible]ons and quite possibly could form the basis for a more sophisticated system in the future. The facility was designed with the intention of continuing operations at the same site for the more difficult technical operational levels. (PMOS,NMOS,CMOS)

: The facility is quite remarkable in overcoming the rather severe environmental constraints; airborn particulate contamination during summer dust storms, waterborn contamination of silt from the Tigres River, and the great extremes of temperature experienced during Baghdad summers. Higher level operations that produce very small device features (high density devices) require very tight control of environmental conditions.

The Mansour facility functions at the level of discrete devices and although it produces linear bipolar devices (Simple Linear IC's) it has been hampered by the inability to design IC's within the facility. The original patterns for mask making are not only still 'laid out' or drafted by hand but are also transfered to the final optical lithography bench by painstakingly cutting the pattern by HAND into Rubylith. It is currently functioning at an operations level of between D & E. With the addition of a suitable pattern generator to transfer designs electronically to the mask and by eliminating the hand operation steps, Mansour could be operational at level F.

b) National Research Council, Electronics Section

The mission had the opportunity to discuss the organization and direction of researches of the National Research Council with its Director, Dr. Monther Takriti, who invited the mission to visit the electronics and architecture sections.

The mission was given a tour of the Electronics Section by Dr. M.S. Abdulwahab, the head of the section.

The electronics section has been in existance for one and one half years. It is currently developing applications using discrete purchased components. These applications are directed at regional and national problems, such as electric motor power-factor controllers to conserve electrical power, and robotic controls for industrial manufacturing.

The electronics section has the potential to evaluate specific design applications by building feasibility circuits. Application specific designs are currently being evaluated by breadboarding the circuits with discrete IC's purchased from foreign vendors. Availability of the more sophisticated devices is poor and the small quantities required for feasibility studies do not provide a sufficient profit incentive to ensure adequate supply. Delays in procurement also result from restrictions on importation of electronic materials. This is due in part to local political and/or military expediencies.

The lack of a local manufacturing capability for microelectronics custom chips hinders the transfer of technical applications from the research stage to the manufacturing evaluation stage. This lack of manufacturing outlets for production of completed application designs produces a sense of frustration. This institution would be a major source of semicustom designs for regional applications should a regional 'silicon foundry' come into existance.

As is common at all electrical technical institutions, in Iraq efforts are hampered by a lack of trained personnel; particularly experienced engineers at senior levels. Dr. Abdulwahab expressed a desire to have increased professional contact with electronic specialists in other Universities and institutions.

c) National Research Council, Architectural Section

The mission held discussions with Dr. R.Tabuni, Head of the Architecture Section and staff members.

The architectural section uses two-dimensional computer aided design tools (CAD) primarily as automated drafting devices. This department expects delivery of high quality Hewlett Packard computers specifically configured for drafting work along with the necessary software programs to efficiently use them. The CAD programs that perform architectural drafting are quite similar to those used to design masks for IC's and both can conveniently be run on the same equipment with little or no modifications. Hewlett Packard also sells specific CAD programs to design masks for IC customization if it is desired not to adapt the architectural drafting program for IC design use. The computer system purchased by the architectural section is quite adequate to perform design mask customization for use in semicustom GATE ARRAY TECHNOLOGY.

d) University of Baghdad, Electrical Engineering

This department is currently teaching general engineering skills necessary to form a background level of expertise. It is not, however, producing chip level design expertise rather, teaching applications of existing chip designs, and designs involving discrete devices. The programs offered should produce competent junior engineers, talent that could perform more sophisticated work in microelectronics fabrication (Foundry) if given proper direction and leadership. It is my understanding that graduates are being further trained ON-THE-JOB at the Mansour facility to improve their skills in the fabrication techniques. This is a very valuable method for increasing the level of education and extending the technology. It is not adequate however, to educate design engineers as the Mansour facility does not currently support a design function.

e) University of Baghdad, Computer Center

A very helpful discussion was held with Dr. Salam N. Salloum, Director, Computer Science Department in regards to the computational facilities available at the University and the educational programs offered there. During the discussion it was revealed that Dr. Salloum had studied aspects of 'routing' theory used to shorten lead lengths on a silicon chip to increase the signal speed.

The Computer Center at the University of Baghdad is typical of many large university centers in that there are sufficient users to support efficiently a large mainframe computer system. This type of system lends itself well to modeling studies and theoretical analysis of many aspects of microelectronic processing. However, the state-of-the-art in process simulation does not yet allow sufficiently accurate modeling of process variables. In addition to simulation modeling it is still a necessary requirement to empirically determine the values for each process step to optimize a process technology.

The most effective computer systems for design are ones that have dedicated interactive graphics capability, similar to the small stand-alone minicomputers used by the architecture section at the National Research Council. The most powerful of these mini's, the super-mini's, are generally true 32 bit machines with dedicated microprocessors for CPU, I/O, and interactive graphics display. While the systems purchased by the architecture section are suitable for design, the main-frame computer in the University center is not and we are unaware of any super-mini's in Iraq. (CPU = central processing unit; I/O = input/ output functions)

f) National Iraqi Electronics Co.

A meeting and informative discussion with Dr. Ahmed Rafe'h, Director, preceded a visit of the factory. The Company is a mix-sector effort, 50% public..50% private shareholders.

The company is primarily an assembly operation producing one quarter million telephones, radios, and fifty thousand televisons per year. The company employs 1500 people and provides 60 % of the passive components necessary for assembly. The existing technology and designs are provided via contract with offshore vendors. A small capability to modify existing designs and/or operations to account for local conditions of temperature and voltage variations has been developed at the facility. The facility operates at levels A, B, & C

g) Ministry of Industry and Minerals

An overview of the regions data processing capability was presented to the mission by Dr. Abdulilah Dewachi, Executive Director, Information Processing Center.

The Information Processing Centre serves as a central computational facility that connects all sectors of industry and government. As a central facility it can more easily access the kinds of support necessary for specific projects. The center employs twenty programers to provide service in using the systems. The purchase of all computer systems in Iraq is coordinated through the government and one vendor's equipment predominates. This makes for good compatibility between systems and facilitates the exchange of data throughout the country. A new Hewlett Packard Model 9000 system has been purchased with software support capability suitable for two and three dimensional design. Such programs could be applied to customization layouts for mask making at the Mansour facility. The prime users at this time for such software programs are mechanical engineering designers. The capability at the Center is similar to that purchased by the Architecture section of the National Research Council.

Jordan

Hasan

Morocco

Hasan

Saudi Arabia

Hasan

Syria

A) General Organization of Engineering Industries

The mission members met with Dr. Mamdoh Mounaged, the director of the Organization. In our conversation we learned that the Organization is comprised of engineering efforts in all industry sectors and technologies in addition to electronics. Dr. Maunaged informed us that in 1968-1970 an attempt was made at local manufacturing of electronic components. The result was uneconomical and the business failed within two years. Since then there has been no real effort to establish such a components industry at the manufacturing level. Furthermore, he feels that the required design infrastructure is not strong enough to create a local components industry at this time. Efforts at manufacturing have taken the direction of assembly, typically PBX public telecomunications exchanges with a French Joint-Venture partner providing the design.

B) Syronics; National Computer Centre; Centre d'Etude et de Recherche Scientifique, CERS

Due to time constrains the mission members met jointly with Dr. Nazir Koussa, Dr. A.F. Fattal, and Dr. Monamed Mrayati of the above organizations respectively. Dr. Fattal of NCC explained their function as providing data base services for government. The computers used are P & E 3230 Systems with maintenance provided by the local distributor. They also serve on a supervisory committee for introduction of Computers into the public sector.

Dr. Nazir Koussa of Syronics explained that Syronics produces primairly entertainment electronics, i.e. TV and Radio.

The Scientific Research Center was more directed in processing applications involving the Arabic language, and as Dr. Mrayati pointed out, has significant potential for data processing applications by computer if the internal computer architecture was modified to accommodate the unique structure of the Arabic language. Dr. Mrayati has been in contact with like-minded researchers in other regional arab states and is quite enthusiatic about progress. He is also intensely interested in the standardization questions regarding use of data transmission within the arab world. The Scientific Research Center has currently about 20 students involved with systems analysis.

A) University of Damascus

The University of Damascus graduates one hundred students per year from their five year Electrical Engineering program. Dr. A. Azrak described the courses as covering the broad spectrum of electrical engineering technologies including IC design, with emphasis in hybrid circuits and computer engineering.

Tunisia

A. University of Tunis;
   Ecole Nationale d'Ingenieurs, ENIT
   Ecole Normale Superieure de l'Enseignement Technique, ENSET

The higher educational system in Tunesia is well estabilished at every level. The above identified institutions train at every level from secondary school teachers to researchers in voice and speech recognition. We spoke with Dr. Ahmed Marrakchi of the University of Tunis and learned that approximately 200 to 300 engineers graduate per year from the various programs. The options for students of differing abilities range from a two year intensive "high technican" program to a six year "masters level" program. Ten or twelve students finish the six year program per year. The University's interest is primarily in education, with little emphasis on applied research.

Applied research is performed at ENIT and ENSET. ENIT has a VAX 750 computer system linked by communciations lines with the systems at Centre National de l'Informatique. Projects undertaken have included Video Fax for Satilite immage classification, visualization of speech for education of the deaf, and developing CPT standards for representation of Arabic language on keyboards. Dr. Ellouze Noureddine was most kind in arranging visits to each institution and participating in disscussions along with Drs. Annabi Mohamed and Ksouri Mekki at their respective instituions.

B. Centre National de l'Informatique, CNI

The prime purpose of the Centre National de l'Informatique, CNI, is to provide a central computational facility for government functions. The facility is quite well equipted with the most modern Honeywell Bull system (1 MIPS) and communicates over a 50 Kilobaud data communications network with remote terminals. A working example is the 120 terminal customs network linked to the central computer data bases which provide instanteous information to the remote customs inspectors. In conversations with the Director, Dr. Farouk Kamoun, the mission learned that the software applications currently operational were developed within Tunesia by Tunesian personnel. In fact it was learned that each year the Centre trains 20 to 30 personnel to the masters level in programming. The future direction of the Centres activities will focus on software engineering with emphasis on developing a workstation concept-all with little or no reliance on foreign programming assistance.

There is interest in supporting private efforts (for profit) with computational skills as well as with programming capability. While no CAD is being performed on the mainframe system, there is strong interest in estabilishing a Design/Computational center to link University workers more closely with manufacturing.

C. Tunisian & Emirates Investment Bank

The Investment Bank has a charter to assist development of an 'electronic zone' similar in concept to the 'silicon valley' in California. The purpose of such an 'electronic zone' is to provide a link between University efforts and manufacturing interests. The Banks investments will promote 'Mixed Sector' joint ventures that will accelerate microelectronics development.

The approach outlined by Dr. Samir Marrakchi and explained by Dr. Lotfi Ayari, is one of identifying potential world markets by market survey and aggressively seeking a venture partner with expertise in that particular techical area. The possiblities of cooperation could include University workers, foreign venture partners, and local industries as well. While funds for this purpose are modest several projects are underway in the following areas: assembly of PBX stations, passive component fabrication for TV and Radio consumer goods, PCM modulation communication (Cable), and packaging for MOS IC's.

D. Compagine ATHIR

This facility assembles TV and Radio sets. There is no design - not even for printed circuit boards. All of the technology is designed by the foreign designers. Dr.Armand Nataf, who spoke with us, informed us that they were able to select designs from many sources and were not restricted to using those of their partner, Thompson CNF. The facility employs 250 people, produces 9000 TV sets per year and 100,000 radios.

B. Technology Strengths

A) The Iraqi Semiconductor manufacturing facility (Mansour Unit Operations) and most likely the Algerian facility at Sidi Bel Abba are suitable for addition of MOS processing IF suitable volumes of product dictate the sizable capital investment required; the facilities are immediately suitable for an increase in the level of technology in the fabrication/design of Bipolar Linear IC's. (Note: See addendum for further details to achieve this increase)
This improvement would raise the operational level to E & F, and also allowing semicustom GATE ARRAY TECHNOLOGY to be processed at the plants.

B) Due to the selection of one vendor's computer equipment there is an overall compatability of computer systems internationly which enables educational resources in design methodology to be shared within every area of most countries and generally between countries. All sectors of the industry could be connected by the central computational facility AND could communicate design informations through this network.

C) Well established University programs exist in Algeria, Tunesia, and Iraq with excellent support provided at the national level of funding to educate and train new junior engineers locally, ensuring a continuing supply of indigenous engineers.

D) In all visited States there are technically educated administrators in many sectors of industry. It is evident that strong prioritys are given to technological considerations in deciding which directions to take in all technology sectors, education, research, and manufacturing.

E) Programmers are trained locally, and receive on-the-job training at Information Processing Centers or the University Computer Center. It is essential that such a cadre of programmers be developed to assist in transfering applications into silicon designs.

F) Regionally there exists a cadre of foreign educated and trained indigenous engineers and managers capable and dedicated to advancing the technology.

G) The region as a whole realises the magnitude of the impact microelectronic technology will have on all aspects of industrial, educational, and cultural life... and are determined to participate fully.

C. Technology Weaknesses

The current state-of-the-art in microelectronic technology in Arab States/Western Asia shows great promise and considerable expertise, however the indigenous technology effort suffers from the following problems;

A) The current production mix was not designed within the region. It was a purchased expertise which did not lead to the development of design capability locally. Tools that are supplied are used well, but the process of creating tools remains with foreign vendors. There is an attitude, apparent even to a non-native, of a certain lack of respect for locally developed products; a concern that offshore vendors products are, and will remain, superior in quality.

B) There is nc in-place procedure to maintain an up-to-date technical community by continuous training and contact with state-of-the-art institutions and industry. Current process expertise is approximately 10 years out of date AND rather than catching up, is instead falling behind more rapidly. Communication with the cutting edge of the technology is a vital necessity to retain and keep the technical skills of the individual engineer at a current level of technology.

'In this high technology enviornment it is not unusual for the technical staff to require about 15% to 20% of their work time during a year to be devoted to training.'(3)

C) When a contract is let to a foreign vendor to provide the tools to manufacture a semiconductor product the foreign vendor provides the design and the organization. The specifications may be provided by local engineers, but the bulk of the technical expertise is involved in the design and organization of the product. It is in this manner that the technilogical expertise of the foreign vendor is enhanced. By relegating the major elements of the process to foreign expertise, no local indigenous expertise is developed. By relegating the major elements of the process to foreign expertise, no local indigenous expertise is developed. Only Egypt requires foreign vendors to perform 10 per cent of their contracts using Egyptian personnel. While such a requirement is only able to stabilize the gap between vendor and customer, it is not sufficient to enable "creative" efforts on the customer part. A simplified approach to viewing this problem would be to equat e risk involved to the benefit realised. Thus if a fo' n company/industry typically supplies design and guarantees the product feasibility...the local expertise;

experiences & gains
----
no risk = no ingenuity necessary to solve problem

no risk = no incentive (professional pride)
no risk = no product advantage in market
no risk = no profitability in world market

This is not a foolproof technology; learning is accompanied by mistakes and risks must be taken to develope and improve technical expertise.

D. Regional Needs and Goals

' Many enterprises in both the public and private sectors can be expected to have a good grasp of fundamental knowledge required to have THOUGHT of the application in the first place, but not have the technical base to complete the entire application design.' (3)

It was a common complaint heard throughout the mission that efforts in several areas progressed to a certain point and then were forced to stop because the necessary connections to the next logical step did not exist. There is no continuity between research and development institutions and a distributors shelves in the marketplace. Several institutions are actively investigating state-of-the-art designs for microelectronic applications and have proceeded successfully to the feasibility stage. What remains to achieve usefulness is to link the feasibility stage with a manufacturing and distribution/service step. The region needs to make use of the potential bottled up within the research and development function without an outlet to the public sector. The region does not benefit from applications that remain only potentials.

It is desireable to create an entrepreneurial atmosphere within the technical community. This inovative spirit is directly responsible for the tremendous expansion in developed countries microelectronics capabilities. This entrepreneurial atmosphere is absent from most microelectronic installations in the region as motivation and incentives are lacking. The physical requirements for a successful design group are present at several facilities in the region; computer systems, educated professionals, buildings and the like - but they have not the entrepreneurial atmosphere to creatively define new microelectronic products.

Many developing countries loose their most talented engineers to developed countries that provide "perks" highly rewarding that talent. Each developing country should consider what indigenous "perks" could be used to retain these talented engineers.

In developing countries, such as in the Arab States, a legitimate objective to set up microelectronics manufacturing facilities, is to develop a degree of regional self-sufficiency in the technology and applications, even though such a venture may not be economically viable at the regional level or competitive at the international level. It is apparent that such an objective was behind setting up the facilities at Al Mansour in Baghdad and at Sidi-Bel Abbas in Algeria. Assessing these facilities in the light of such an objective one may state the following:

1. The facilities visited represent a tangible step in the effort to gain a degree of self-sufficiency in microelectronic manufacturing. The technical sophistication attained was comparable to similar facilities elsewhere. It was stated, for instance, that the Al-Mansour unit was attaining 92 per cent of product yield, higher than was expected in the plant design;

2. Technical capability gained in human expertise was

noticeable. The trained personnel working at the facilities were qualified to operate in any sophisticated microelectronic production facility with on-the-job training for new technologies or innovations. It can be stated that the experience gained in these facilities represents a net gain in terms of "technology transfer" and in mastering the secret of the technology. They are capable of assessing inovations in the technology, acquiring access to technology sources, select, operate and maintain imported technology in the field etc. However, both facilities in Algeria and Iraq did not realize all what was expected in terms of regional and national self-sufficiency;

3. The experience gained was restricted, not only within the same country (Iraq and Algeria), but even within the country to a very limited group of people, i.e. those directly involved in the production. Such facilities may represent a much bigger asset and a higher degree of gain in self-sufficiency if they are opened to a wider group of people within the country and at the regional level: university students and professors, researchers in R & D centers and industry etc.;

4. No design capability was developed. The facilities were manufacturing designs imported from vendors' companies, with minor adustment, if any. The real gain in technology transfer is obtained only when local personnel become capable of successful designs and of implementing new products. Design capability in microelectronic technolgy is more important to develope because of the fast changing nature of the technology and products;

5. There were no serious efforts at modifying and/or updating the imported technology, whether it be in equipment or processes. A much higher degree in self-sufficiency can be gained if local personnel can, by trial and error, succeed in modifying imported technology - to improve efficiency, reduce production cost or adapt innovations appearing elsewhere in the world. Such effort can be exerted only if a separate department for industrial research is set up within the establishment facilities.

In considering the establishment of any microelectonic production facility in a developing country, and hence in an Arab State, the economic viability of the project and the international competitiveness of the product may not be of paramount interest, except in special circumstance such as in Korea. More stress is usually given to the objective of attaining a degree of self-sufficiency in the technology. But then such an objective should be taken seriously in the implementation of the facility as well as in its operation after that. It is expected that national personnel be requested to participate in the design and installation of the facility; that national inputs be incorporated as much as possible in the operation; that the product mix be selected and/or modified to better respond to local needs. Moreover it is expected to request national experts to exert serious efforts, after the establishment of the facility; to design new products and to update the facility to cope as much as possible with innovations in the technology world-wide.

The path to success in applying microelectronics technology within the region will make demands on the technical community as a whole. The acceptance of `traditional' methods of achieving certain ends must give way and yield to new techniques. The microelectronics applications are most likely to manifest themselves in areas where the information processed is not conveniently verified by any individual, (as in the case of mask layout designs) producing a doubt in the minds of many as to the accuracy of the results. This inability to verify, to confirm the results is a condition that must be accepted to enable valuable conclusions to be applied with confidence.

Decentralized "design groups" are most appropriate for the region. Each designer needs only the particular application criteria provided by product marketing/engineering (3) and the technology design rules for the particular technological process to complete the device design. This design activity is performed in a computer-aided environment and yields a computer tape containing the information necessary to fabricate the device AND the detailed testing methods to ensure that the original application criteria are satisfied. It is necessary to produce complete testing informations concurrently with design.

Since the design groups' activities can be independent from the fabrication process it is not necessary for the design center to be located in close proximity to the fabrication area. It is necessary , however, for the design center to be staffed by a technical staff of sufficient `technical mass' to handle any applicatons that might be encountered at the particular location.

The nature of the design function is special in that solutions to individual design applications can be applied in whole or part to many other applications.

It is apparent then that sharing successful designs among several designers and maximizing their interaction would accelerate their learning and efficiency. Designers are the major "creative" elements within the microelectronics field and require a certain level of interaction among their collegues to maintain a level of "mental health". Accordingly while it is feasible to locate design installations remotely from the fabrication facility it is also imperative that good regional comunications be maintained between design facilities and the fabrication facility. By dispersing design centers throughout the region a closer contact can be maintained between the designers and the users of applications.

E. Plan of Action:

A successful plan of action in applying microelectronics technology could be organized along lines consisting of functional divisions and implemented by programs designed to achieve specific goals independently of each other. Such programs can pursue several activities in parallel when organized and executed with close coordination. To be successful it is necessary to identify quite precisely the specific goals that are desired and set priorities to control the timing and use of generally scarce resources; both technical and economic.

Let us assume a list of desireable goals that could be attained from those proposed in conversations held with industry principals throughout the mission:

1) technical proficiency of regional applicions
2) economic viability of regional application
3) regional selfsufficiency in microelectronics
4) ecomonic viability on a world scale in microelectonics

In order to achieve these identified goals one must set priorities, consider which goals have common elements among them, and then organize a program of action to achieve the common elements; thereby securing the maximum value from expended resources.

One can now consider a three fold action plan:

Define Priorities;
Identify Programme Elements;
Recommendations

1............ Define priorities;

a) To aquire advanced technology in microelectronics to intelligently direct and guide the technology applications to extract the maximum benefit from the technology for the region.

....meets goal 1

b) To develope regional self-sufficency in ALL aspects of microelectronics technology; i.e. microprocessor design and manufacturing; microcomputer design and manufacturing; assembly of region-specific applications, etc.

....meets goals 1,2,3

c) To compete on an international scale to preserve foreign capital and reduce balance of payments due to importation of electronics, both components and assemblies in the commercial and consumer sectors

....meets goals 1,2,3,4

At the present technical level of operation, attempting to achieve goals 3 and 4 would be very expensive and in our opinion totally inappropriate for the developing microelectronics industry of the region. For example this approach may have been tried before in both Algeria and Iraq with bipolar linear circuits for television applications. These activities have been only marginally successful using the then current technology and have not provided a link to new technologies. Rather, the strengths identified previously should be built on and enhanced, while improvements made in the areas' considered shortcomings. This emphasis applies to BOTH the "hardware" aspects of the technology and the "applications/design...or software" aspects.

"In the inexperienced hand any tool reverts to a hammer" (7) The microprocessor and other microelectronics "hardware" need appropriate programs and applications to fashion the technology into something more than just an expensive hammer. A demonstration project is necessary to achieve credibility and show a positive benefit from the technology. Even if offshore hardware capabilities are used to achieve results, such a demonstration would prove a valuable example throughout the region and serve as a model to emulate.

Such a demonstration design project could be implemented using "gate array technology" on VAX computer systems currently existing at several locations in the region with the help of university groups in Europe or America. The results of such a design effort could then be produced in limited quantity and at reasonable cost by offshore semicustom chip makers in the USA, Europe, and/or the Far East. A successful demonstration design project using "gate array technology" would provide necessary "credibility" to regional resources.

A particularly interesting evaluation can be made utilizing an "Added Value" concept (3) as applied to growth in engineering capability, in that if it is considered the primary yardstick for evaluating microelectronics progress due to an activity, then the evaluation becomes straightforward and successfully integrates the quite diverse factors of economics and regional selfsufficiency.

2.............Identify Program Elements

1) APPLICATIONS SURVEY to d[illegible]mine what specific applications need be addr[illegible]sed, and what quantity of devices are required to satisfy the need. Reference (3) will provide details and important insights into required informations "Product Marketing Engineering"

2) Initial DESIGN SPECIFICATIONS GROUP, reduces applicat[illegible] to semicustom gate array logical design functionality

3) Offshore supplied GATE ARRAY MASTERSLICE customized locally for the application design to gain experience in semicustom fabrication

4) SILICON FOUNDRY developes REGIONAL capability to produce PMOS/NMOS/CMOS masterslices achieving regional independence in GATE ARRAY technology.

5) Improve/establish LINKAGES between the regions Universities and industry.

6) Consideration must be made to the DISTRIBUTION, SERVICE, AND MAINTENANCE networks for products see (3)

Product Marketing Concepts are at the crux of the current consideration. "It is important to recognize that product marketing is responsible for IDENTIFYING the correct market conditions." (3) and for the inception of a solution.

Product Marketing/Engineering combines aspects of sociology, economics and advanced technology and translates an identified need into language that the technical designer can understand.

This activity is almost totally lacking in the region. The identification of possible microelectronic applications and the formulation of technical solutions is essential to making use of the advanced technology.

The main advantage to microelectronic technolgy for developing countries is that a single appplication can successfully handle many simultaneous situations even where only unskilled personnel are available. With the aid of such calculation devices the expertise of the programmer is extended and reproduced at every location where the programme is utilized. It is then obvious that the most capable and appropriate programmes need be developed. It is just this step which calls for maximum attention within the region.

It is essential that appropriate linkages are created between University workers and the developing industry. One must realise that the designers trained within the university system are the CONSUMERS of microelectronic technology. It is these engineers that will choose the particular microelectronic device used to accomplish an application. It is unreasonable to expect local engineers trained to use foreign products exclusively throughout their education, and taught that these devices are superior, to adapt locally produced devices into their application designs. If one were to use the same mindset within another industry, say chemical refining, and asked engineers to alter their choice of equipment manufacturers to ones they had no experience with, you would have a sizable argument.

University designers should contribute their knowledge to industry and help shape the capability of the industrially designed devices. This co-operation is symbiotic in that the designers benefit in receiving hardware knowledge and the hardware personnel benefit in appreciating the needs of the designers.

It is very important to realise that education in this field is not and cannot be stagnant. In other engineering fields you would not hesitate to reject outmoded techniques of construction, architecture, or transportation 30 years out of date. In the semiconductor field 5 years is equivalent to 30 in more traditional engineering fields. Design engineers must constantly improve their skills by working on successful applications, as completion of successful projects is a learning experience necessary to gain and retain competence.

It would accelerate the development of application programming and design development expertise to consider utilizing offshore vendor-supplied GATE ARRAY MASTERSLICE TECHNOLOGY, which uses a SINGLE LAYER CUSTOMIZING STEP, METALIZATION, to produce semicustom logic schemes dedicated to applications indigeous to the region.

The fabrication process at a US silicon foundry, MOSTEK, was simplified to one product, an MOS GATE ARRAY MASTER SLICE. MOSTEK had produced a variety of MOS products prior to takeover of the company by UNITED TECHNOLOGIES. After the takeover a new philosophy was imposed on the fabrication process to produce a single product suitable for almost all applications in the company. MOSTEK choose NMOS technology as its single process standard and proceeded to adapt its production to that single technology.

In order to produce the wide variety of MOS IC applications necessary for large companies, the fabrication processing of the silicon wafers is halted just before the final interconnections of transistors is performed by etching the metal interconnect layer. At this stage a special semicustom mask is used to apply the custom design pattern from the design section computer by means of a photolithography procedure. The final metal interconnections are then formed by etching metal lines between each transistor necesssary in the applied pattern, producing a semicustom device. The GATE ARRAY approach has the highest flexability in product applications primarily because changes from application to application are made only in one process step, the metal level mask, and the rest of the fabrication process remains unchanged. This approach makes minimal changes in the more difficult steps of the fabrication process and results in an optimal yield.

'The METALIZATION step is the process where all the individual transistor on the chip are interconnected into an "integrated circuit". A thin metal layer is evaporated onto the silicon wager under vacuum conditions. A photoresist step exposes a semicustom mask whose pattern defines the specific application the device will serve. The metal is etched away leaving interconnections to satisfy the logical requirements of the design engineer. It is this step in the process that differentiates gate array devices into the different applications.' (6)

This GATE ARRAY approach is viable for PMOS, NMOS, and CMOS masterslice technologies as suitable design software is developed. Logical design software can be written such that the applications designer is unaware of the particular technology actually used to construct his device.

The GATE ARRAY approach is also viable from a hardware perspective. Since the design methodology is independent from the process technology, a simpler process can initially suffice to begin indigenous production via a regional foundry such as Mansour. This would enable a PMOS masterslice process to satisfy the starting requirments for product, allow changeover to NMOS masterslice production when it becomes a viable process, and ultimately permit utilization of a CMOS masterslice process when it is supportable at a regional facility. It should be pointed out that this sequence of processes corresponds to the historical development of the technology AND reasonably expresses the relative degree of difficulty in implementing the repective technologies. I do not believe it adviseable to attempt to circumvent these process learning steps by leaping into a more advanced technology before perfecting the predecessors.

At the present time a GATE ARRAY approach could be started with no in-house masterslice processing at either the Mansour facility in Iraq or Sidi-Bel Abbas in Algeria. Both facilities have the capability to utilize vendor-supplied masterslices and also to manufacture the metal level customizing mask. What would be required is an optical pattern generator to transfer applications designs from computer tapes into processing masks to customize the purchased masterslice into a finished product.

Existing etching and mask processes currently supported in the bipolar lines and would need minor changes to implement these steps for GATE ARRAY masterslice customizing. An interactive graphics mini-computer system, possibly a HP 9000, would also be required to complete the automatic handling of design data and could also serve to make minor corrections as very few initial designs are totally error free.

It is imperative to share the scarce resource of technically trained personnel within the region. Currently technically trained persons are lost to the technical community by vertical mobility. The trained people are successful and rapidly advance to the administrative levels where there exists a great need for their talent. This advancement, while necessary, contributes a significant drain on scarce technical resources. Concurrently, the administrators find little opportunity within their administrative functions to retain their technical expertise and become `obsolete' in their fields within a short span of years.

It is feasible to share costs of such a facility by the formation of a syndicate of investors, quite similar to the approach in developed countries, that would limit the financial exposure experienced by each individual member, and would distribute income and products within the syndicated area. Several regional financial groups have expressed interest in the microelectronics technologies supported by such a silicon foundry approach. (1)

3...............Recommendations

Planning for a regional `silicon foundry' must provide a global viewpoint which connects the entire process of utilization of microelectronic technology; IDENTIFICATION/INCEPTION/DESIGN/ IMPLEMENTATION/MANUFACTURING/DISTRIBUTION/MAINTENANCE should all be considered in both a local and regional perspective. It may be productive to combine functions in certain geographic areas and separate them in others. Careful consideration should be paid to the possiblity of dividing technologies, such as bipolar and MOS operations between different member states to avoid redundancy of effort.

The development of a regional "silicon foundry" concept can be best accelerated by adopting a phased timing plan with short-term, medium-term, and long-term elements.

The short-term elements consist of technological areas which can be mastered in one to three years of effort. Such technological areas as

i. Application identification;

ii. Application engineering;

iii. Semicuston chip design and implementation via gate array technology

Midterm elements are those estimated at requiring three to five years for development of proficiency and include primarily

iv. Custom chip design

The long-term element is a "silicon foundry" for regional manufacture of local designs . The proper scheduling for the "silicon foundry" would be in five to ten years time to take advantage of the then developing local design capability.

It would be advisable to consider the experience of the French in creating a design capability where the creation of 'infrastructure' as a result of government policy does not parallel the path followed by most developed countries, where a strong profit motive and abundant venture capital provided motivation. The French experience may provide additional insight into other possible alternatives based on strong government support and national incentives.

UNIDO/ECWA could serve as a co-ordinating organization to initiate regional information exchange.

F) REGIONAL AND INTERNATIONAL CO-OPERATION

Microelectonic technology and industry represent a very prominent example of an advance field where regional and international co-operation, and interaction, is imperative due to high entree barriers to the industry, the fast changing nature of the technology, the huge investments in R&D required, and the large scale and universal scope of the market. Regional and international co-operation is more of an imperative in a developing area, such as in the Arab region, where manpower capabilities are very limited and the microelectonic industry and infrastructure are still embrionic.

The joint ECWA/UNIDO/DIELI missions on microelectronics to selected Arab States were able to identify several areas where regional and international co-operation is urgently needed, and were able to sense a common interest and readinesss for regional and international co-operation. It is proposed that ECWA and UNIDO, in co-operation with the national, regional and international institutes concerned, jointly formulate and implement a programme to promote microelectronic technologies and industries in the region based on regional and international co-operation and co-ordination.

1. Regional Co-operation and Co-ordination

It is proposed that regional co-operation and co-ordination may cover the following areas:

i. Information exchange

. periodic meetings

. regional newsletter

. regional data bank on the industry and technology

ii. Joint training programmes: particularly identification and design of specific applications; and operation and maintenance of manufacturing facilities.

iii. Regional production facilities:

. co-ordination of design and production;

. complementary product mix for established manufacturing facilities with open market agreement;

. eventual establishment fo one regional silicon foundry

iv. Above mentioned activities should lead eventually to the establishment of a regional network for production and consumption of microelectronic products.

2. International Co-operation

The needed international co-operation may cover the following areas:

i. Exchange of up-to-date information on the latest innovations in the fields:

. circulation of the Monitor;

. informative seminar;

. exchange of experts

ii. Access to Technology

- identification of international experts and international institutions ready to participate in enhancing the develpment of capabilities in the region;
- organization of a programme for exchange of personnel among institutions in the region and institutions in advanced countries for on-the-job training particularly in R&D fields;
- Facilitate provision and circulation of components particularly for R&D needs.

iii. Enhancement of industrial capabilities:

- assistance in identification of technology;
- assistance in writing specification and contracts;
- assistance in maintaining and updating available manufacturing facilities;
- training and upgrading of available capabilites.

3. Proposed Activities

The role of ECWA and UNIDO in the light of the above mentioned tasks covering various areas of regional and international co-operation, may eventually be formulated within a long-term plan as part of the proposed Regional Plan of Action for Microelectronics and Informatics in the Arab States. However, an interim programme may be formulated based on the findings of the mission and the expressed interest of institutions concerned. The interim programme would consist of:

i. Circulation of the UNIDO/ECWA joint report on the "Silicon Foundry";

ii. Organization of a consultative technical meeting in October/November 1985 to deliberate on the report and recommendations. Participation at the meeting would include:

- microelectonic industries in the region;
- universities and R&D departments concerned with electronics and microelectronics;
- regional investment and development agencies (AFESD, AIDO, AIIC,etc.)
- UNIDO, ECWA, and ECA;

(Algeria offered to host the meeting)

iii. Organization of technical visits to advanced institutions in December 1985/January 1986. (Minnesota, California and West Berlin);

iv. Development of a provisional network, among national and regional institutions concerned starting with those participating at the proposed technical meeting.

This provisional regional network, in parallel with a similar provisional network on software and computer applications, could develop into formal networks within two to three years and would be instrumental in the development of a Regional Plan of Action for 1986-1990 for promoting microelectronics capabilities in the region.

Addendum

Special Addendum in reference to Mansour Unit Production
by Dr. Rene Micolet

Laboratoire d'Electronique dt de Technologie de l'Informatique
Centre d'Etude Nucleaires de Grenoble, Grenoble, France.

The Mansour Unit has been implemented for the production of Silicon Bipolar Transistors (NPN,PNP) and linear integrated circuits. The IC's produced by this plant are based on SGS-ATES technologies, and for applications in the field of professional (operational amplifier) and entertainment equipment (radio, TV).

In fact, the field of applications of such processors is much larger than those corresponding to the present production, and there would certainly be good opportunities to satisfy other needs of the market with the same family of processes. Potentially, these processes may be used to produce perhaps nearly all circuits working with a voltage supply 1 to 45 V (depending on the characteristics of the epitaxial layer) and operating frequency approximately equal to 50 MHz and a power dissipation 0.5 to 5 Watts (depending on the package chosen). Moreover, one process could be adapted to integrate mixed linear and logic functions, the latter being based on I"Squared"L structures with bipolar transistors.

Generally speaking, it is probably not worth to continue in the area of standard ICs whose market prices are very low due to strong competition. It seems rather more promising in the future to develop original ICs for special purposes (the so-called ASIC: Application Special ICs): CMOS is, of course, the dominant technology for ASIC, but there is a niche for the bipolar ICs whose processes have been experimented in Iraq. This niche exists for example, when there is a need for low noise at the imput (to amplify small signal delivered by sensors with possibly added logic) and/or high power at the output (to drive lamp relay, motor), or relatively high frequencies. These ew trends would certainly imply the implementation of design centers with trained people, aimed at developing the creativity of engineers in close contact with the equipment manufacturers.

Bibliography

1) Final Report
ECWA/UNIDO Experts Group Meeting on Development of Micro-electronics in the ECWA Region
4-7 March 1984 Kuwait
E/ECWA/ID/WG.8/42 84-0434

2) A Silicon Foundry to Service Developing Countries' Needs: A Preliminary Approach
Prepared by the UNIDO secretariat
15 February 1984

3) Microprocessor Applications in Developing Countries
by James M. Oliphant, UNIDO consultant
UNIDO/IS.351, 2 November 1982
V.82-33260

4) Software Engineering: A Survey
by Wladyslaw M. Turski, UNIDO consultant
UNIDO/IS.446 V.84-82124
22 February 1984

5) Prospects of Microelectronics Application in Process and Products Development in Developing countries
by Michael Radnor, UNIDO consultant
ID/WG.372/1 V.82-25400
Mexico City, Mexico, 7-11 June 1982

6) A Programme of Action for Establishment of A Silicon Foundry in a Developing country in West Asian Region
by Stephen L. Gilbert, UNIDO consultant
April 1984