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REPORT

OF THE VISIT ON

MICROELECTRONICS IN ARABIAN COUNTRIES

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Contents

1. INTRODUCTION

A delegation of 4 experts visited from 24 March 1985 to 4 April 1985 the following 4 Arabic-speaking countries: Egypt, Tunisia, Algeria and Syria in order to explore the possibilities introducing their own industry of microelectronics. The delegation consisted of Dr. Hassan Scharif who also represented the EGWA interests, Dr. Renee Micolat of the French microelectronics research centre LETI representing the French government, Prof.Dr. Stephen Gilbert of the department of microelectronics, University of Minnesota, and Prof.Dr. Otto Manck of the department of microelectronics, Technical University of Berlin, the two last mentioned persons participating by order of UNIDO.

Leader of the delegation was Dr. Scharif who prepared the several visiting dates in connection with local UNDP organizations. Previously there had been a conference in Kuweit where a similar thematic has been discussed including problems of computer sciences.

Electronic companies, central research institutes of electronics and of computer science, computer centres and universities have been visited in the four countries. By means of this visiting program one tried to obtain a general view on education, research and industrial application concerning hardware and software of modern electronic systems. During an average stay of two to three days per country, only organizations near the capital cities could be reached so that the list of the institutions visited is incomplete.

Points of interest were not only design and production of integrated circuits, but also related areas such as the design of printed circuit boards and the use of computers, especially in the field of computer-aided design. Economic problems have also been discussed, including more psychological ones like developers' confidence in his own capabilities and customers' confidence in home-made goods.

After having visited a "Silicon Foundry" in Bagdad, the visit having been prepared by Prof. Gilbert and Dr. Micolat, the delegation started with the following ideas:

The production of modern microelectronic components needs a lot of know-how and high investment costs. So it has to be performed centrally. Different design centres spreaded over the countries can use this central production for their own applications.

To realize this concept persons, tools and products should be found.

2. GENERAL SITUATION

The situation in the individual countries is to some extent very different. In spite of it some of their problems can be considered as typical of all of the countries.

2.1 UNIVERSITIES

The theoretical lectures at the universities are not very different from that of the industrial countries. This seems to be a result of training of the teachers at Western European and North American universities. The computer, especially the personal computer, has been more or less adopted by the universities as well as by tne research centres. The terminal rooms are full of students and will be used the whole day through. Enthusiasm and dedication of the students are comparable. All modern languages (e.g. BASIC, PASCAL, FORTRAN) will be instructed and applied. Generally, rapid expansion of computer science can be observed. In addition to personal computers the Supermini computer generation is well represented at universities as well as at research centres.

Development of electrical circuits will be made at universities and research centres. But this hardware seems to be much less extended than at universities in industrial countries except for few well established centres. Problems of acquisition of devices have been mentioned if only few of them are needed. Obviously, problems exist in producing printed circuit boards.

Direct relations between universities and industrial companies seem to be very rare. Industrial problems are not treated by the universities.

2.2 RESEARCH CENTRES

Each of the visited countries has been provided with at least one central institute of computer science and of electronics. The equipment of these institutes regarding computers and measuring instruments is well on the whole, partly excellent if such a computer centre maintains data bases of public organizations. Research work impresses sometimes, too. So scientists continue their tasks which were started in the United States during a training course.

Without excluding in individual cases a practical application (perhaps in military area) it seems to be typical of most of the visited centres that there exist nearly no connections with industrial companies for developing a new product. Part of these centres maintain the instruments by themselves and make also effort to maintain corresponding equipment outside. Such an offer will obviously be regarded as necessary and accepted by the industry. So this service seems to be a key function for developing confidence between centres and industry. This can be applied not only to the computer centres but also to electronic departments repairing systems and printed circuit boards of foreign equipment. The term "reverse engineering" plays an important role. It means recognizing the function out of the printed circuit board itself and repairing the card or replacing it by a new one.

2.3 INDUSTRIAL COMPANIES

The universities are only partly responsible for lack of the connections between industrial countries and universities resp. research centres. In the industry, the following principles have to be applied in all these countries whether free or closed markets are concerned:

- Government authorities are not inclined to maintain unprofitable production for a prolonged period.
- Current production relies in most cases on western licences and systems. Generally, nothing but final assembly made in the country itself.
- The products themselves correspond to the western standard.
- Own development has to obtain western standard in order to be able to compete on a free market.

- Customers prefer the foreign article if there is no difference in price and performance.
- There is a lack of confidence in their own development of competitive products.

Due to this basic attitude there is a great discrepancy between universities and research centres on the one side and industrial companies on the other side. For qualified technical personnel coming out of the universities there exist neither vacancies nor motivation. The market for own products is small. An exchange of products does not take place with the other Arabian countries. It seems to be easier to reexport to western countries in connection with the licensers.

If production will be restricted to assembling under licence also in future then rationalization will destroy jobs in these countries, too. Owing to progressive automation in the industrial countries the part involving a high proportion of staff will be more and more reduced to final assembly. In future, there will be nor profit in wage when fabricating by hand printed circuit boards neither adequate jobs. There will be a depreciation in value in the country as a result of it.

To establish local industry is a problem of creating a sufficient "critical mass". Own products have to be proved as well and efficient as licensed products. Confidence in the own capabilities has to be built up.

3. POSSIBILITIES OF MICROELECTRONICS

The customer connects the term microelectronics with two applications. On the one hand it is the area of millionfold produced standard chips, e.g. memory chips and microprocessors, which the user assembles on a printed circuit board. On the other hand microelectronics may be used for the design and the production of silicon chips according to requests and ideas of the customer. From the technical point of view this two possibilities are different by the production volume of a single function or chip. Standard chips are millionfold produced and applied. Semicustom designs start with some hundred pieces and rarely obtain the volume of standard chips.

A small semiconductor factory produces according to the size of the chips at least several one hundred thousand chips every day. Such a volume can be reached only by standard integrated circuits. Production of integrated circuits is therefore concentrated upon comparatively few manufacturers of standard chips and upon few factories.

3.1 STANDARD CHIPS

3.1.1 PRODUCTION

The comparatively low world market price for standard devices is determined by the size of the silicon chips and the yield i.e. the number of working chips on each silicon wafer. In order to keep the size of the chip small and the yield high, long experience and deep know-how is necessary concerning design and production. The Europeans are not very successful in this area. Japan and the United States dominate this market. The often cited example of South Korea seems to be a special combination of working morale, state of training and knowledge which cannot be found in Europe. It cannot be recommended to start such a production in Arabian countries without help from outside. Such a factory should only be built up with full support and responsibility of an experienced semiconductor company.

3.1.2 APPLICATION

Since electronic components are only a smaller part of the final production costs of a system renunciation of own component production seems not to be critical. Standard components can be obtained for a lot of applications. This is valid for the analog bipolar integrated circuits often used in consumer products as well as for the digital circuits which are used in logic printed circuit boards. By means of the devices of the 74 LS-TTL series and of the corresponding CMOS series countless applications can be realized on a printed circuit board. At present the typical application of user designed IC's is the replacement of such an already existing TTL-board by one or more silicon chips. Therefore, an own circuit design and by that an own development of printed circuit boards is as the basis of own integrated circuits.

There have been nearly no autonomous developments of pcb's for industrial products in all of the visited countries. So the basic requirement for IC-development does not exist. To introduce user designed silicon a printed circuit board development has to be supported as first task. At present, teams which are able to do it exist only in the universities and in research centres. To find interesting product ideas is the second big problem which has to be solved in the near future.

3.2 CUSTOM DESIGN

In the development of integrated circuits for special applications a remarkable change has been occured over the last 5 years. Up to this time only the so-called "full custom" design method has been known where prototype development goes from $ 100000 up to $ 1 million. Only if the expected production volume was high enough such projects have been profitable. For full custom design this is still valid today. A chip with a production volume of million pieces does not have to be distinguished from any standard components. High development expenses are justified. There are no problems to find a qualified manufacturer. The major part of all electronics applications, however, needs a much lower number of pieces. In order to apply there custom design methods the costs for prototype development have to be reduced drastically. This so-called "semicustom" procedure has solved this problem by two means. First, the development times are considerably accelerated by automated CAD-programs. Supplementary software tools guarantee as far as possible correctness of the first design.

Second, the production cost and production time is decreased by introducing gate array technics. The two methods lead to a reduction of costs by an order of magnitude. This is not only valid to prototype production but also to the investment costs of CAD tools itself. The wide-spread application of semicustom design makes it possible that special software and hardware solutions are offered much cheaper than the classical "general purpose" computer solutions with expensive software packages. The dedicated CAD-systems are called "work station".

So the development of integrated circuits become already profitable from some hundred pieces on. The technical price for the reduced pro-

totype costs is the lower performance of the gate array chip. The silicon area is not used so effectively. A full custom design results in higher functional density and in higher speed. But this is not important for many applications.

The new possibilities developed during the last years have been very interesting for the customer. Depending on the expected production volume he has the choice of different options. Many companies offer today a lot of technologies and design procedures.

Concerning the visited Arabian countries these new possibilities seem also to be very useful. Since their own products have to be able to compete on the market and since the volume in the country itself is comparatively small, a commercial product probably has to be started with a low production volume. Products with a number running into millions are of interest to the world market. So the probability is very low to have a first idea which has not yet been realized in the industrial countries.

It should be pointed out that the methods of "semicustom" design have reduced the thresholds to go into microelectronics. Spreading over the classical industrial as well as over the developing countries is possible at economical marginal conditions. The start with expensive factories is not necessary. Design tools become cheaper and cheaper. First projects without enormous investment costs can be achieved.

4. COMPUTER SCIENCE IN THE VISITED COUNTRIES

Computer science is related to microelectronics. Most of the electronic components will be used for computers. Design of integrated circuits on the other hand is not possible without computer aid. Therefore the relations between microelectronics and computer science are very intensive.

4.1 EQUIPMENT AND TASKS OF COMPUTER CENTRES

Outside the universities the computer is used by the public administration for data base management and by the research centres for scientific-technical application. Data base management in computer

centres requires special hardware and software and is only of interest for CAD if data nets are installed corresponding to the needs of the administration. An existing data net can also be used by the design centres. The technical-scientific computers of research centres are mostly superminis, in the first place VAX-computer of Digital Equipment but also Perkin-Elmer-computer of similar power.

A very interesting hardware are the numerous personal computers being used in research centres as well as in universities. They are probably the key components for development of computer science in the countries of the third world due to its advantageous price/performance relation and its multiple applications. The most frequent projects worked on by scientists or students in the visited institutions have been bilingual systems. Hardware components have been developed like terminals and printers with latin-arabian characters but also software like an arabian learning system. General applications have been data base management systems.

4.2 EQUIPMENT AND TRAINING AT THE UNIVERSITIES

The equipment found at the universities is comparable to that of the research centres. Training is often made on the base of personal computers. This trend can also be observed at western universities and has to be welcomed. Modern personal computers offer nearly the same spectrum of higher programming language as the big classical machines. Owing to direct access to hardware and software the personal computers allow a profounder and a more practical training.

Another effect also known from industrial countries is the enthusiasm and the motivation which the personal computer will effect on the learner. Nearly each terminal in the universities and in the research centres has been in operation at the time of our visit. If there have been time-tables they showed a use of them exceeding to a great extent the usual working hours.

One recommendation should be added here: Due to the low costs and the good acceptance of personal computers CAD has to be introduc by this way. This seems to be valid for design of printed circuit boards as well as for design of integrated circuits. Modern software packages are already available on PC's.

The state of training in higher programming languages meets the demands which have been made to the operating of modern CAD-systems. As to the languages BASIC plays quite a great part but also PASCAL and FORTRAN is applied to a high degree. Utilization of bought software as well as development of own specific software seems to be possible without any problems.

5. NECESSARY STRUCTURAL ARRANGEMENTS

In the present time, there is not any industry in microelectronics in the region except for production of low-integrated analog circuits in Iraq and in Algeria. Building up an autonomous industry requires certain structural arrangements. Different investments are demanded according to the desired production steps. Not the production of components but the use of them, standard components as well as custom integrated circuits, seems to be particularly promising.

Technical demands are only one side of the problem. Confidence in the own capabilities has to increase in industry, too. The main problem today is an almost lack of products with self-developed circuits. Here, it has not to be distinguished between the use of standard components and the development of custom integrated circuits. Confidence has to be increased that a product competes on the market. Successful development of an own integrated circuit may accelerate this process. Therefore, the start of a project with the help of gate arrays can be considered.

Since infra-structure is missing up to row the start should be concentrated upon one place in the country. Universities are not the preferred partners due to its tendency to application-free research work and the extraordinary restriction of means. The installed equipment as well as the state of education predestinate public research centres. At any rate, results of developments free from industrial application have to be prevented.

5.1 HARDWARE AND SOFTWARE NEEDS

In most of the design centres of western industry VAX-computers also being used, the available hardware in the research centres is well

suited for circuit design. It has to be extended to colour graphic displays and plotters in most of the centres. Software can partly be obtained free of charge from different universities. According to design style and to the desired technology commercial programs between $ 20000 and $ 100000 have to be furnished in order to keep systems which are able to do the job. The necessary total investments for terminals and software for semi-custom design may touch $ 100000 in most of the centres, the price for a modern "work station". Without an already existing supermini, purchase of such a "work station" is probably the most favourable solution.

Software has to be suited not only for design of integrated circuits but also for development of printed circuit boards. The most important single software package is a logic and fault simulator on gate level which can be obtained from $ 20000 ..

Moreover, an additional basic equipment is necessary to test the integrated circuits. Even if most of the measuring instruments are available as standard in the centres, digital and analog test instruments may sometimes be missing. With $ 20000 such an additional equipment can be established. Besides, $ 30000 will in the long run be necessary for measurement on the silicon wafer.

Most of the existing electronic centres will fulfil the starting conditions with about $ 50000 for additional equipment.

5.2 TRAINING

To design integrated circuits a special training is necessary. At least one concrete design has to be made under guidance whereas for design of printed circuit boards only the technical possibilities have to be improved. For the last one, there must be a satisfactory solution to obtain all standard components in small numbers of pieces.

For IC-design in order to be able to pay the considerable costs for the realization in silicon - according to technology and manufacturer between $ 10000 and $ 50000 are necessary -, it is recommendable to compile several designs in one silicon wafer. This so-called multi-chip procedure is applied in nearly all of the industrial countries by the universities in order to realize practical studies with stu-

dents at a low price. In a first step co-operation in such a multi-chip project is probably the cheapest solution during the learning process. The gate array design of a 500 gate circuit needs only 2 or 3 months of time. The probably best and cheapest starting conditions are the stay of some people at a european university or the realization of a concrete project in the developing country with the help of people coming from a european university. Direct projects with semiconductor companies are also to be thought over if there exist already commercial interests in the integrated circuit which has to be developed.

5.3 PROJECTS

The experts have not been able to find for commerce interesting projects in the short time of the visit. A project has to meet the condition to cover an existing demand at market rates. Product ideas which are typical for the respective country but not in the interest of industrial nations are therefore very advantageously. Standard integrated circuits in consumer electronics and in telephone communication technics are not a good first project.

Development of bilingual personal computer components in hardware and software seems to be one of the most interesting applications. Certainly, it may happen that due to finance strength of arabian countries the major part of development and products in industrial nations is already effected. Personal computers will also play an important part in spreading microelectronics in the future. Being cheap terminal with local intelligence linked to other stations by a data net the personal computers are able to replace the superminis as well as the current generation of "work stations" at much lower prices.

Another starting project can result from demand for replacement as well as for repair for former imported products. This trend is in close touch with the raised demand for maintenance made by the centres for industrial customers. Even if most of the projects are to be related to design of printed circuit boards, semicustom integrated circuits become interesting for a production volume of more than 1000 pieces.

As product ideas have to be made by the centres themselves, having at present in general no precise ideas concerning the possibilities of custom design, it possibly is too early to require applications just at the beginning. Information exchange has to be awaited.

6. GENERAL RECOMMENDATIONS

There are different recommendations. As to future developments it has to be differentiated if short-term success is tried or if on long term an own industry has to be built up.

In the visited countries there is practically no basis for application of microelectronics. There is no electronic circuit development. Short-term success can only be made by direct co-operation with companies in the industrial countries. To use licence contracts for different products e.g. for television or telephone it has successfully been demonstrated. This way can also be extended to modern products of computer science where an interesting market exists for bilingual personal computers and corresponding periphery in all arabian countries together. For production of own electronic components a sufficient great market in the arabian countries is missing so that exports in industrial countries have to be made with the help of licencers.

The way to build up factories and to create jobs with the help of foreign know-how is not restricted to electronic industry and therefore not very typical for future development of electronics after already having supplied it to the most important markets, entertainment electronics and telephone.

Assembly of products developed abroad does not lead to an efficient capacity of engineers and therefore remains unsatisfactorily. Founding corresponding development teams, however, cannot be obtained within a short time. Confidence in the own capabilities and in the own products has to be built up. This only seems to be solvable doing many small steps of which the most important ones are mentioned as follows.

The first way to own engineer capacity leads to maintenance of imported electronic devices or of devices constructed under licence. This is already successfully realized by some of the centres visited.

So public centres seem to be the best way to do it. Such a central electronic institute quickly attains a sufficiently high "critical mass". It has to undertake besides repair of imported electronic equipment, also maintenance of computers, and it will be able to test all sorts of printed circuit boards. Due to frequent use of microprocessors in modern products the combination of electronics and computer science seems to be necessary. Such centres are already partly established, but it must be demanded that research is directly related to practical application. Obviously, confidence between industry and the centres will not be supported by high sophisticated research projects, such studies being ever so interesting for engineers who have studied in industrial countries.

Repair, respectively function recognition of printed circuit boards without sufficient documentation, or in general 'reverse engineering' is a constructive way that such a centre is able to design in a future step own printed circuit boards and own products. If confidence of the industry is made by successful maintenance, ideas for improvement and for autonomous developments will be not long in coming.

Equipment of the centre includes electronic measuring instruments and modern test equipment. It must be arranged that design and production of printed circuit boards can be made in small quantities. A sufficient store of standard electronic devices has to be taken for granted. The centre should be familiar with hardware and software of personal computers. Finally, such a centre is the ideal place to introduce the semicustom design. As there is access to superminis, especially to VAX-computer of Digital Equipment, in some of the centres visited, the additional CAD-needs can easily be implemented. Future CAD-developments should be done with the help of personal computers.

As to training in semicustom design there are two cheap short-term possibilities for which for both of them the universities or research centres of industrial countries are the qualified partners if multichip design can be made there. Either staff of the centre works on a project in the industrial country or people of the partner university supervises a project in the developing country. The project-oriented stays are short, between 1 and 3 months. They will be terminated with designs which will be produced with the help of the partner. The re -

alized chips are shipped to the centres. Own future products as well as independent negotiations with semiconductor houses will be possible after only one or two realized projects.

7. PARTICULARITIES IN THE INDIVIDUAL COUNTRIES

The general impression has to be modified in detail. In each of the countries visited there have been institutions and engaged persons who are inclined to push own developments. An intense information exchange within these centres can only be advantageous to whole development of the region.

7.1 EGYPT

Three research centres, one university and two companies have been visited.

The television and broadcasting factory ELNASR was typical of all other visited companies of this kind. Only the final assembly is made, the components or printed circuit cards will be delivered by the licenser. An own product development and autonomous circuit development does not happen.

The company BENHA LO for electronic industries which is active in the military field has been an exception. Though most of the products have been produced in connection with western licensers, some of the products represented independent developments. An own printed circuit board production as well as costly modern test equipment are furthermore remarkable.

As to the university it is generally noticed that considering the demanding training of professors in industrial countries the means for practical application are considerably restricted. By that way, electronics seem to be arranged theoretically, there is nearly a total lack of relation to industry.

The computer science department is so far supplied with a supermini and personal computers concerning hardware that practical training can be obtained. As to introduction of hardware-oriented microelectronics the university seems not to be the right institution,

since corresponding expansion and maintenance of infrastructure are too difficult.

One of the three visited central institutes, the Eng. & Ind. Design Development Centre, EIDDC, has general design and development duties. It is able to solve all kinds of general CAD/CAM problems and is also well equiped with hardware in order to demonstrate use of the computer in industry as e.g. concerning data bases, information systems processing and management problems.

The two other institutes, Electronics Research Institute, ERI, and Electronic Industries Research & Development Centre, EIRDC, are, however, specialized in development of electronic integrated circuits. Both institutions are able to pick up with minimum support from the outside the methods of the semicustom design and to apply them to products. EIRDC which has been established with the help of UNIDO seems to play an important part as to the tasks of organization and the past results if electronics development should be built up on its' own resources:

- Confidence of industry will be built up little by little by maintenance and training.
- Maintenance and repair is made as on the base of submitted printed circuit board without any documentation.
- "Reverse Engineering" will be made.
- Courage to own design and to own products is at hand. So, printed circuit boards and hybrid components are fabricated in a special laboratory for industrial buyers at a considerable procuction volume.

It seems to be promising to realize in EIRDC first semicustom designs by connecting EIRDC with european multichip projects respectively by cooperating with universities at a low cost base. After practical experience with own silicon chips it may be expected that concerning co-operation between EIRDC, ERI and perhaps BENHA first commercial projects can be realized.

As to technologies not only digital CMOS integrated circuits can be considered but also analog bipolar technology which later can be operated in full custom design e.g. in connection with the semi-

conductor factory at Bagdad. Without exactly mentioning single projects a great number of tasks for public service, however, seems to be solved by this means cheaper than by imports. The first attempts do not require high investment using only personal computers and the access to a VAX-Supermini.

7.2 TUNISIA

In Tunisia a development bank, a university, a technical school to train engineers, a computer centre and a TV receiver factory have been visited.

The development bank searches for projects and companies in order to create plants and jobs in computer science/electronics in Tunisia in a modern "science park". For such "great solutions" there is at present only accordance with a partner from the industrial countries who brings in the products as well as the know-how and also cares for export. The production of a personal computer in two languages would be of special interest for which qualified persons would be available.

As a smaller industrial project there it is proposed to found a company for the distribution of electronic standard components in order to solve satisfactorily the problem of access to IC's not only for Tunisia but also for arabian countries.

Own IC-fabrication to a great extent does not seem to be recommendable as the arabian market is not a sufficient base at present.

As dominating impression from the visit at the university, at the technical school and at the research centre it had to be pointed out that training as well as organization can be compared to western standards. The national computer centre does not differ from a corresponding centre in Europe. Data remote communication and decentral access will be practised to a great extent.

Considering the comparatively small number of inhabitants the number of students at both schools, ENIT and ENSET, is not very high. The different levels of education and the state of training are remarkable. Technologists and engineers will be instructed so that concer-

ning all tasks for maintenance and repair there will be qualified persons who will also be engaged in own electrical circuits. Unfortunately, there is a lack of industry which picks up these capabilities. The computer science field is also remarkable. Student projects in two languages will be effected on a large scale with the help of personal computers.

The CTE-EL ATHIR company produces television sets, radios and recorders. The printed circuit boards will unaided be equiped, the circuits, however, are not developed by themselves. This successfully managed factory produces normally under its own name, but also under the name of the licenser, since the customer prefers the foreign mark on equal terms. Such products will also be reexported to industrial countries. There is nearly no export to the arabian region, since in this field each country maintains an own production (under licence).

As to own electronics development in Tunisia the establishment of a centre which undertakes own development besides maintenance of imported electronic tools will be recommended. Such a department can also be incorporated in the corresponding national computer centre. Development of an own (personal) computer in two languages seems to be possible but it can only be prevailed on the market with the help of a foreign partner. The market and the financial strength in the arabian region are too immense in order not to interest western companies for such a product. Competition against famous marks seems to be very difficult after the experiences of the television company.

In combination with personal computers software development in arabic language seems to be also an interesting task. At any rate, this field should be carried on by the centre, since concerning distribution of the personal computer there will be a great demand for specific arabic solutions. The conditions for successful development in this area seem to be especially given in Tunisia.

7.3 ALGERIA

Two national research institutes have been visited.

The national centre for informatics ENSI is responsible for all computer applications in public service. The computer centre is supplied with several VAX-computers. The tasks of this centre reach from maintenance and operation of the computers for administration over guidance, purchase and sale of hardware to development planning in computer science. The technical department develops and produces own hardware, e.g. a terminal in two languages, modems and multiplexers. A personal computer on the basis of Motorola 6800 shall be changed over to the MC 68000 microprocessor. Development of a printer with the help of licences has been started.

As development of own printed circuit boards is also possible, all requirements of introduction for own integrated circuits are given concerning CAD-equipment and product application.

The second visit was held at the commissioner's office for new energy and at the related research centre. Persons instructed in industrial countries work on modern hardware for image recognition systems. Corresponding to this high level of knowledge there exist some connections with the French research centre LETI at Grenoble. This is applicable both to IC-development and to the field of solar cells.

The recommendation had to be expressed to introduce specially at ENSI the supplementary technologies of semicustom design. For economy-priced training co-operation with european institutions will be recommended, for which France plays a special role due to the existing contacts.

7.4 SYRIA

One computer centre, one university, one TV receiver factory and its superior public authority have been visited.

Syria and Algeria being socialist countries set a high value on economic aspects as the other countries do. Own products have to correspond concerning its performance and price to the standard. In order to meet this, electronic industry produces under licence. The corresponding products will be modernized again and again by entering afresh into licence negotiations in a comparatively short period. In addition to the television and broadcasting field, telephone sys-

tems will be fabricated.

The university gives the theoretical fundamentals of microelectronics. Contacts with industry and practical applications seem hardly to exist.

The computer centre with Perkin-Elmer and (Systime) VAX-computers is sufficiently supplied concerning hardware in order to realize semi-custom design. The there treated research areas in the field of computer science resemble these in the other arabian countries.

The interest in applying modern technology is very high. They have made the experience that a training in foreign countries usually does not lead to direct application in practice. In order to support confidence in the own capacity, as best form realization of projects in the country itself under temporary instruction and supervision of a specialist has been discussed especially for introduction of microelectronics. As the methods of semicustom design can be started without great efforts and, nethertheless, will lead to applied products, such a procedure e.g. in connection with european research centres or univesities can at least be recommended.

8. SUMMARY

The importance of microelectronics will be recognized in all countries. Everywhere, there is a desire to realize its possibilities and to apply it to customer products. The existing CAD-equipment and the level of training of the scientists allows the design of integrated circuits nearly without problems, especially concerning the field of semicustom design. The main problem for introduction is the lack of products with self-developed circuits. By that, microelectronics cannot be introduced as in the industrial countries by the way of compensation for the existing printed circuit boards. Development of own printed circuit boards with standard integrated circuits has therefore to be of equal importance beside the development of own integrated circuits. The organization of corresponding development teams as well as confidence of industry in such teams has to be attained. Repair and maintenance of existing systems and by that meth-ods of "reverse engineering" are a first and important step. As to such an economy-priced introduction in first own IC-design, the co-

operation with european research centres and universities in connection with their multichip projects will be proposed.