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WORKSHOP ON REGIONAL SILICON FOUNDRY AND DESIGN CENTRES IN THE ARAB COUNTRIES

Report**

Prepared by

UNIDO Secretariat in co-operation with
Economic and Social Commission
for Western Africa (ESCWA)

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I. CONCLUSIONS AND RECOMMENDATIONS

1. The workshop considered the build-up of microelectronic capability to be of strategic importance for the development of the region, due to the pervasiveness of the technology and its applications in a wide range of economic and social sectors. It noted that the effort to build up capability in microelectronics cannot be separated from the drive to build up a viable electronics industry in the region. The workshop strongly recommended that governments of the region formulate and implement policies and programmes towards the achievement of self-reliance in electronics and microelectronics in the region.

2. The workshop considered the proposal for the establishment of a regional silicon foundry-cum-design centre in the Arab region in the overall context of:

(a) strengthening technological capability in this field of technology so that such capability can acquire a self-generating momentum;

(b) upgrading and imparting dynamism to the existing electronic industries in the region; and

(c) the need to develop an integrated strategy which will fully take into account the existing and anticipated situation in the region.

3. These considerations require a long-term developmental approach to the problem. In this respect the workshop agreed with the conclusion of the ESCWA/UNIDO paper that the establishment of a regional silicon foundry-cum-design centre, with a network of national design centres will provide the critical mass to create a sound design and fabrication capability in the region. Such an approach together with related activities, will enable the region to realize the potential of microelectronics. Within this framework, the workshop recommended the following series of parallel interactive steps and underlined in this context the need for continuous review of results and for monitoring technological trends.

Design centres for IC design

4. The workshop recommended:

> the establishment and/or strengthening of design groups or centres in the countries of the region.

In this regard the following considerations are to be kept in mind:

(a) In several countries of the region there are various R&D groups which are concerned with electronics and/or microelectronics; instead of founding new ones, already established facilities should be upgraded wherever possible, and close links with industry should be established and strengthened;

(b) The hardware installed in universities and R&D centres in the region is very appropriate to serve as basic equipment. Many design software programmes, coming mostly from universities in advanced countries, are available free of charge. The most important tools of design are logic simulators, for analogue and logic IC, graphical editing and layout control programmes. The available software fulfills semi as well as full custom design conditions.

5. To facilitate strengthening of design groups, the workshop recommended the establishment of regional institutional facilities for training and the training of trainers in IC design.

6. As a first step to this end, the workshop recommended:

> A central course in CMOS design should be planned and implemented, to introduce the software and its use, testing an evaluation, as well as fabrication equipment.

This programme may be completed within an 18 month period. Through the programme the first Arab multi project chip (MPC) should be realized. Two design methods should be offered, one for semicustom and one for full custom design. Possible partners for the fabrication could be MPC-organizations in Europe. Between 4 and 6 weeks of training are expected for the design period and 2 weeks for evaluation, measurements and testing, 5 months after fabrication.

At the end of the design course each group can transfer the software package to their respective computers in each country. Thereby unified starting conditions and standards would be established to serve as a base for practical applications as well as future MPC projects.

To attain the full benefit of the training programmes, high qualifications should be requested from participants who ought to be practising designers or engineers, with a minimum of experience in the field. Moreover these participants must be familiar with using the computer, though not necessarily capable of programming. Engineers from existing manufacturing facilities in the region should be asked to participate in the training, to gain insight into CMOS technology and to establish strong ties with design groups in the region.

Besides expenses of the trainees, this training programme may cost up to US$ 100,000 for lecturers and fabrication. This sum may be shared by participating countries and regional funding agencies, as part of the scheme to set up a regional silicon foundry and a viable electronics base in the region.

The long-term development may be characterized by additional soft- and hardware collaboration with different silicon foundries in and outside the region.

The workshop further recommended:

> The bipolar factories existing in the region may expand their capabilities and create their own design groups corresponding to the needs of bipolar analogue design.

7. The workshop called on UNIDO, ESCWA and other international development agencies to provide assistance to designers in the region, in particular to:

(a) assist in placing Arab experts, for residence training in advanced centres;

(b) circulate a list of available training programmes in microelectronics worldwide, for the benefit of practising engineers in the region;

(c) assist in arranging technical visits to design and manufacturing centres in developed countries, each visit being geared to a specific activity and objective. (One such visit may be arranged as part of proposed MPC training programme.)

8. The training programme proposed above will be a part of a comprehensive strategy and a continuous programme of training that may include the establishment of a design training centre in the region, as well as training in advanced centres abroad.

Market surveys

9. The workshop strongly recommended:

> a sectoral market survey for the region, of electronic products and systems, as an essential part of defining both a system and component development strategy.

The survey should cover electronic products and components in consumer electronics, communications, computers, controls and instrumentation, in terms of both imports and local production. Individual countries in the region should address the problem within their national context with assistance from UNIDO, ESCWA and the Arab Industrial Development Organization (AIDO), in regard to common methodologies and format for data collection and consolidation.

10. The market survey should take into consideration the future market in the region as well as the fast changing nature of the technology. The feasibility study for the proposed pilot line (see para. 13 below) would thus take into account the application specific integrated circuits (ASIC) market in the region.

Systems development

11. The development of a national and regional systems capability is an essential prerequisite for any strategy to develop microelectronics technology in the region. Such capability should cover designs of a wide range of

products, including complex systems. The major application areas in the region include informatics, computer networks, oil exploration/production, mineral extraction/production, power generation/distribution and bilingual terminals and microcomputers. While in the short term existing capabilities in the region need to tackle development of the simpler systems, such as bilingual terminals and microcomputers, in the longer term capabilities to handle larger system projects need to be created. One approach which needs emphasis is that larger system projects, contracted to foreign consultants, must associate local groups, in order for the latter to develop their expertise. Furthermore, to assist the development of local systems capabilities it is essential to strengthen the national and regional infrastructure in terms of both software development and hardware in regions to which UNIDO/ESCWA can provide requisite support.

12. In this respect the workshop recommended that:

(a) UNIDO and ESCWA provide, whenever possible, technical assistance to available facilities and centres working in systems design in the region;

(b) training programmes be organized in design of Printed Circuit Boards (PCB) and hybrid circuits, as well as in methodology of systems design, along with training programmes for Integrated Circuit (IC) designs;

Participating institutions were asked to take into account recommendations made by earlier meetings on the subject, such as the Gulf seminar on "Process Controls" held in 1985.

Pilot line

13. As a step towards achieving self-reliance in microelectronics and building a viable electronic basis the workshop recommended:

the establishment of one or two pilot facilities within the region and the carrying out of a feasibility study for this purpose.

The role of such a 'pilot line' would be to introduce specific practical experience in the new technology, i.e. CMOS and NMOS, into the region, with a view towards development of a manufacturing base, ultimately resulting in a "silicon foundry". The 'pilot line' would accelerate the incorporation of all technological understanding, both from educational and from manufacturing perspectives.

The workshop called on regional funding agencies to finance the proposed feasibility study, to be carried out in co-operation with UNIDO, ESCWA and regional institutions such a AIDO and the Arab Fund for Economic and Social Development (AFESD), as part of an action programme aimed at the setting-up of a silicon foundry and promoting a viable electronics industry and its integration.

Upgrading existing facilities

14. The workshop recommended for the consideration of the respective enterprises:

> the upgradation of existing facilities for manufacturing bipolar devices at Al-Mansour, Iraq, and Sidi Bel Abbes, Algeria, with due attention to increasing their capacity for participating in regional co-operation activities and accepting designs in bipolar technology from several R&D centres in the region.

Some considerations in this respect were:

(a) The manufacturing technology relevant to the existing bipolar facilities has improved since their establishment. Newer equipment, with higher productivity and greater precision, contributing to lower product cost, is necessary to manufacture more advanced devices and should be acquired continuously and incorporated within the process flow. Currently, such equipment would include: better optical aligners, new diffusion furnaces and tubes, more automatic bonders and packaging equipment etc.

(b) industrial development groups should be established within each facility and strengthened continuously, reviewing current operations and trouble shooting, and proposing new directions and solutions for improvements in operation, increase in productivity, or reduction of cost. In particular these groups should devise solutions responding to local conditions and needs;

(c) the existing facilities may need to develop greater flexibility in incorporating a more diversified product mix. New designs may be introduced, that are compatible with the existing technology, and current designs being produced should be enhanced;

(d) technical assistance from UNIDO/ESCWA and other international agencies may be obtained, as appropriate, to assist in the implementation of recommended action.

(e) existing facilities should work closer together, exchanging information, experience and visits of staff. They should co-ordinate, as well, with systems industries in the region and consider possibilities of standardization for products and techniques;

(f) existing facilities were established, to a large extent, to promote technological capabilities in their respective countries and in the region as a whole. Bearing this objective in mind, these facilities must become the training ground to build up capabilities and human resources in various aspects of the technology and industry, establish stronger links between manufacturing facilities and universities and R&D centres, within each country and in the region, and receive designers, researchers and engineers interested in improving their familiarity with microelectronics and applications.

Monitoring technological developments

15. To enable the countries of the region to take appropriate decisions, particularly in regard to the foregoing steps, a system for monitoring technology developments in electronics, microelectronics and related software should be established. The workshop recommended that UNIDO assist in this

respect in consultation with ESCWA and AIDO, in the meantime continuing to disseminate relevant information through the Microelectronics Monitor and other documents and studies.

Moreover the countries of the region should develop their capability, through proper mechanisms and institutions, to absorb updated information and to benefit from innovations in the technology and applications. In this respect the workshop recommended:

the organization of regional seminars and conferences where experts from the region in the field are exposed to their counterparts from advanced countries and from more industrialized developing countries.

Exchange of information and experience

16. The workshop noted that there is a need for wider information exchange among experts in the region in various fields related to electronics technology and industry. In this respect it recommended:

the compilation of a detailed directory of institutions in the region concerned with microelectronics. Such a directory should include all possible information about Arab electronic industries: capacity, product mix and specifications, personnel, equipment techniques used etc.;

the compilation of a directory of Arab experts in the field and of experts of Arab origin living abroad;

updating and enlarging and disseminating the information provided by ESCWA and UNIDO on the state of electronics industries in the region;

the publication of a periodical regional newsletter (once or twice a year), to report on activities and developments in fields related to electronics and microelectronics including:

- meeting, conferences, seminars, training programmes etc.;
- progress of R&D projects;
- new products or processes introduced in the region;
- modifications in existing facilities;
- modifications in university courses and programmes;
- job opportunities and newly available expertise, etc.

17. To enhance co-operation among electronic industries in the region the workshop recommended that:

a co-ordination meeting for all electronics industries in the region (components and systems) be held before end of 1986, with the objectives of:

- exchange of information and experience;
- consideration of harmonization of standards and product specifications;
- consideration of harmonization of product mix and sharing production;
- co-ordination of development activities: upgrading facilities, innovations in techniques or equipment, introduction of new products etc.;
- formulation and implementation of joint training programmes.

Alongside such a co-ordination meeting an exhibition of all electronic products produced in the region was recommended. Such a co-ordination meeting and exhibition may be a step in a continuous programme of co-ordination and co-operation among various electronic industries in the region. The exhibition could be a preparation for participation of the electronics industries at the Arab industries exhibition organized in 1987 by AIDO in Tunisia. The Governments in the Arab Region were called upon to participate in the planned co-ordination meeting and exhibition and to support all future regional co-operation activities.

The electronic industries in the region were called upon to adopt relevant ASMO and ISO standards and codes in their products. ASMO was invited to prepare a technical paper on Arab electronic and microelectronic standards to be presented at the meeting.

The workshop noted that the Al Mansour Unit, Iraq, showed great interest in hosting the co-ordination meeting while ENIE of Algeria offered to host the meeting in the Sidi Bel Abbes premises if Iraq was unable to host the meeting in due time.

18. To lay the basis for a unified regional Arab market the workshop noted that serious efforts should be exerted, in co-ordination with ASMO, concerning standards and product specification in the Arab electronics industry. Special efforts should be made as well to harmonize standards and specifications between electronic assembly industries and components manufacturing.

19. Noting the enthusiasm generated by the workshop and its benefit in terms of opportunities to enhance personal and professional contacts among Arab experts in the field, a professional meeting among experts in the region concerned with electronics and microelectronics technology was recommended to be organized periodically (every year or two) as a step towards the establishment of an Arab Electronic Society (AES). The workshop also recommended that:

> a meeting be held in two years' time to review the implementation of its recommendations.

20. To assist in the implementation of above recommendations, Governments in the Arab region were called upon to designate a focal point in each country for microelectronics technology and applications. An immediate task of such a focal point would be to assist in collecting and disseminating information about electronic and microelectronic activities in the respective country, and to assist in carrying out the proposed market survey.

21. In the effort to develop national and regional strategies in microelectronics and electronics, Arab countries, and institutions concerned in the region, should benefit from experiences of other, more advanced developing countries in building up their capabilities in the field. This can be done through exchange of visits to institutions and facilities, exchange of experts, implementation of joint activities and through various studies prepared about such experiences by national, regional, or international

institutions. In particular UNIDO documents*/ in this respect were assessed of high value in presenting the experiences of various developing countries in the field of microelectronics.

Feasibility study for a regional silicon foundry

22. The workshop recommended that in the light of the results of the foregoing steps:

> a feasibility study for the establishment of a regional silicon foundry-cum-design centre, with a network of national centres, be carried out (within a 5-year time frame) as part of a programme to enhance the development of a viable electronic base in the region.

23. The workshop emphasized that the foregoing steps require corresponding actions at the national level, and recommended for this purpose that Governments in the region adopt appropriate policies and provide adequate financial support to the respective national and regional institutions.

24. The workshop noted with satisfaction the efforts of UNIDO and ESCWA. It requested their continued assistance in the implementation of the foregoing recommendations, in co-operation with national and regional institutions concerned, particularly AIDO and APESD, and other agencies in the United Nations development system. The representatives of AIDO and APESD, present at the workshop, expressed the concern of their organizations in the development of a microelectronics capability in the region and their particular interest in participating actively in future activities in this respect.

25. The workshop placed on record its appreciation to Hadj Sleiman Cherif and all concerned Algerian authorities for their generous hospitality and unstinting co-operation.

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* - The "State of the Art in Microelectronics" series:
No. 1. Venezuela by Roberto C. Callarotti (UNIDO/IS.489), No. 2. Republic of Korea by Kilnam Chon (UNIDO/IS.490), No. 3. India by S.C. Mehta and G.S. Varadan (UNIDO.IS.492), No. 4. Pakistan by M. Aslam (UNIDO/IS.493), No. 5. Bangladesh by T. Hussain (UNIDO/IS.497)
- Overview of the Microelectronics Industry in Selected Developing Countries by S.E. Lalor (UNIDO/IS.500).

II. ORGANIZATION

26. A workshop on the establishment of a "Regional Silicon Foundry and Design Centres" for the Arab countries was jointly organized by The Economic and Social Commission for Western Asia (ESCWA), the United Nations Industrial Development Organization (UNIDO) and the Algerian Institutions Le Commissariat aux Energies Nouvelles (CEN) and l'Entreprise Nationale de l'Industries Electroniques (ENIE). The workshop was held from 27 to 29 January 1986 at Sidi Bel Abbes, Algeria, hosted by CEN and ENIE. The workshop agenda, list of participants and list of documents are in Annexes I, II and III.

The workshop was a part of a wider programme undertaken by ESCWA and UNIDO to promote the development of microelectronics technology and industry in the Arab region. The French Direction de l'Industrie Electronique et de l'Informatique (DIELI) participated in various activities related to this programme.

27. In preparation for the workshop joint ESCWA/UNIDO/DIELI missions were undertaken to selected Arab countries in 1983, 1984 and 1985, with the objectives of:

(a) assessing available facilities and capabilities in microelectronics;

(b) studying the feasibility of establishing a regional silicon foundry and distributed design centres in the region; and

(d) consulting with institutions concerned about the interest in such an approach and the proposed course of action to be undertaken in this respect.

28. The missions covered various related institutions in industries, R&D centres, universities, investment agencies and government departments, in Algeria, Egypt, Iraq, Jordan, Kuwait, Morocco, Saudi Arabia, Syria, Tunisia and the United Arab Emirates.

29. The findings of the missions were summarized in a joint ESCWA/UNIDO/DIELI paper entitled "Silicon Foundry and Design Centres in the Arab Countries· Issues and Approaches" (UNIDO/IS.583, E/ESCWA/ID/86/CRP/1). The report included a resume of mission findings, techno-economic considerations for a regional silicon foundry and design centres and recommendations for the course of action to be undertaken.

30. The main objectives of the workshop were

(a) to consider the joint ESCWA/UNIDO/DIELI paper and discuss its recommendations, and

(b) to formulate a concrete plan of action towards the development of a viable electronics and microelectronics industry and to build up technological capabilities in microelectronics in the region,

31. The workshop was inaugurated by Algerian officials and representatives of the organizing institutions. Dr. Hadj Sleiman Cherif of CEN,who chaired the inauguration meeting, welcomed the participants, stressed the strategic importance of microelectronics technology and industry for the Arab countries and emphasized the need for regional co-operation and co-ordination to build up capabilities and promote a viable industry in this advanced technology.

32. The Special Technical Adviser of the Technology Programme of UNIDO stressed the role of international co-operation to promote advanced technologies in developing countries, particularly microelectronics. He stated that UNIDO was carrying out various activities in this respect, including the present joint effort to study the feasibility of establishing a regional silicon foundry and design centres and to build up and upgrade technological capabilities in microelectronics in the Arab region.

33. Mr. Sharif of ESCWA reviewed various joint activities undertaken in preparation of the workshop. He stated that the study prepared was the implementation of a major recommendation of a previous expert meeting on "Microelectronics and Informatics for the Arab Countries", organized jointly by ESCWA and UNIDO and held at Kuwait, 4-7 March 1984, hosted by the Kuwait Institute for Scientific Research.

34. Mr. Micolet of DIELI, stressing the importance of international co-operation in the transfer of technology, particularly in the advanced and fast-moving field of microelectronics, stated that DIELI was working closely with ESCWA and UNIDO in this field. He pointed to some relevant aspects of the French experience in acquiring capabilities in this crucial technology, and he emphasized the importance of regional co-operation, and the need, in view of the heavy international competition to select special "niches" in the market, preferably among the region-specific applications and application-specific ICs (ASIC).

35. The list of participants invited included all electronics industries in the region and many regional development and investment agencies. International institutions concerned with microelectronics in the region were also informed about the workshop with a view to securing their participation.

36. The workshop was attended by about 60 experts, most of them from universities, R&D centres and Industry. Seven Arab states were represented: Algeria, Egypt, Iraq, Libya, Saudi Arabia, Syria and Tunisia. Among the participants were representatives of the Arab Industrial Development Organization (AIDO) and the Arab Fund for Economic and Social Development (AFESD) along with experts and consultants of ESCWA, UNIDO and DIELI. All experts participated in their individual capacities.

37. A visit was organized to the Sidi Bel Abbes Electronic Complex which includes the IC manufacturing facilities which became operational in 1979.

38. The workshop adopted its conclusions and recommendations on 29 January 1986.

III. INTERNATIONAL TRENDS

Technical aspects

39. The workshop noted that the international trend in design and manufacturing of ICs was to separate the skill-intensive stages, or design stages, from the capital-technology-intensive stages, or manufacturing

stages. New "design centres" were being developed with limited requirements of capital and equipment, to produce designs, for specific applications, that can be implemented in "silicon foundries", or IC manufacturing facilities, which are the sites of expensive and technologically advanced equipment that can be operated with a limited group of skilled personnel.

40. The workshop examined the various design techniques, their consecutive steps and the level and type of skills required for IC design, noting that the "Gate Array" technique, or "semi-custom design" was considered to be cheaper for small-scale production of applications. The workshop also noted the concept of Multi-Project-Chips (MPC) in which several designs may be implemented on the same chip to reduce manufacturing cost for small-scale full custom design applications.

41. Manufacturing technologies were moving very fast into more and more advanced and complicated processes and techniques, incorporated in more and more expensive equipment. It was noted that the cost of a silicon foundry in a developing country may have to include the necessary infrastructure.

42. Noting the difference in nature between the CMOS (1 micron) technology, being considered in most IC manufacturing facilities worldwide, and the (5 micron) bipolar technology, used in the Al-Mansour Unit and at Sidi Bel Abbes in Algeria, it was pointed out that it was a large qualitative jump in equipment and human skills between both technologies. It was suggested that the region may not have to develop further its bipolar facilities, but it can not "leap-frog" into CMOS technology without mastering both the PMOS and NMOS technologies which are considered the foundation for the CMOS technology.

43. The workshop noted the following additional technical comments on issues related to the silicon foundry approach:

(a) Microelectronics technology is very complicated, very expensive and faces stiff competition on the international market; thus regional co-operation is a necessity;

(b) Application specific ICs, when they are properly identified, may present a good market, since in their case the cost is calculated not in terms of ICs alone, but other factors as well: design efforts, value added etc.

(c) Marketing, technology and design are essential aspects for a viable microelectronics industry. Design, however, may be undertaken away from the manufacturing facility, after securing needed co-operation among designers, process engineers and testing and packaging specialists.

(d) Industrial development groups close to production lines are the real nerves of any manufacturing venture, if it is to keep up-to-date in a highly competitive market and with the fast changing nature of the technology. The role of such groups should be directly related to the daily operation of the plant and aimed at:

- improving processes or introducing new ones;
- identifying new products or developing new applications;
- improving efficiency and yield, reducing cost etc.

Without an industrial development group and without tight links with universities and R&D centres, a silicon foundry cannot face the fierce competition characterizing the industry, however high the initial investment may be.

(e) Bipolar technology, like the one now available in the region, is being used in various "linear production" requirements, particularly where high voltage or power is required. New products using this technology can be identified and selected as "special niches" to reduce the idle time of available facilities.

44. The workshop noted the differences between a "pilot line", and a "production line" in advanced countries. A pilot line is usually established to test new products and processes, to introduce necessary modifications, either to make a better or a cheaper product, or to develop a more efficient process with higher yield or productivity, with lesser cost.

A pilot line may produce different products using different processes on the same equipment with very low yield, high production cost and small-scale output. A production line operates with well established processes to produce mature products on a mass production scale, to attain the highest possible yield and thus to lowest possible cost.

45. The pilot line is usually operated by highly skilled personnel who can study thoroughly products and processes. A production line is usually operated by much less specialized technicians under the supervision of maybe one highly skilled engineer. A pilot line usually stresses changes requested in products or processes with no serious considerations for cost per product in the pilot line itself,the objective being to optimize conditions for mass production in a full-scale production line. The production line usually operates with steady processes and well established product designs, with the objectives of maintaining reproductibility of parameters, quality control, yield, efficiency and product cost, or what is defined as through-put. A pilot line size varies according to the objective to be attained. A small lab-scale pilot line may have a staff of less than ten skilled engineers, while a pilot line meant as support to production lines, to introduce innovations in product, techniques or processes, may have more than a hundred skilled engineers.

46. It was pointed out that, in a developing country, a pilot line can be a training ground for designers, as well as for manufacturing personnel, in preparation for a large-scale production line. The operational cost and the actual setting, should take into consideration the objectives of the pilot line so as to reap full benefit from investments in such a line. A pilot line would cost US$ 10-20/m for 4 micron technology and US$ 5-10/m per year for operation, depending on available infrastructure and support facilities.

The experience of other developing countries

47. The workshop noted briefly the experience of other regions in the field of microelectronics, noting the relevant series on the "State of the Art in Microelectronics" in selected developing countries published by UNIDO. In this respect it was noted that conditions in Latin American countries differ tangibly from the situation in the Arab countries; Latin countries in general having started developing their industrialization and building the requisite infrastructure ahead of the Arab countries. It was also stated that the social and cultural conditions and industrial strategies in the Far East are different from what is prevailing in the Arab region and it may be misleading to try to copy the experience of Japan or the Republic of Korea. The efforts

to build up a regional microelectronics network in Latin America in co-operation with UNIDO were highly valued, noting that similar steps could be of great advantage in the Arab region. Noting as well that cultural and social conditions are closer to the Indian experience, the workshop recognized the crucial role of the Indian Government in promoting the development of microelectronics capabilities in the country. A strategy was formulated in India. Often extensive studies were made on the electronics and microelectronics industry in the country and the development of the technology worldwide. It was found that the technology was maturing worldwide into four rather well separated levels of increasing complexity in technology:

(1) systems assembly;
(2) systems design and applications developments;
(3) design of ICs;
(4) components manufacturing.

Indian experts realized that no meaningful gain in technology and know-how could be acquired without going into levels 2 and 3, while level 4 could be delayed for later stages. Thus, the Indian Government strategy in microelectronics was formulated accordingly and concrete action was undertaken in this respect to promote microelectronics capability in that country.

Advantage of the silicon foundry approach

48. The workshop considered the "silicon foundry" approach for the Arab countries from various aspects. Thus it was noted that, even if economic viability and international competitiveness were not attained, such a facility may be the vehicle to attain the following legitimate objectives, especially if human and capital resources were pooled on a regional level:

- providing a base to acquire knowledge of the technology and applications;
- training ground for expertise related to the technology;
- meeting the requirements of designers in the region;
- contributing to the overall infrastructure for the electronics and other related industries;

- avoiding restrictions that may be imposed by advanced countries on access to technology; and
- achieving a degree of self-reliance in microelectronics and related expertise.

49. The workshop noted that these objectives may be more easily attained if tasks were distributed among participating countries so as to have every country sharing the benefits of such facilities.

50. It was pointed out that design capabilities can be developed at low cost in capital and technology, relying basically on the skilled manpower that can be trained on the new technology, or recruited among experienced expatriates working in advanced countries, and with the minimum of relevant hardware and software. The "silicon foundry" approach allows the possibility of developing separately design groups, with a minimum know-how of manufacturing techniques, and before acquiring a manufacturing facility in the Arab countries. Promoting design groups can be an important step in mastering microelectronics technology, if they acquire a deep understanding of local needs and if they are capable of responding to local needs with specific microelectronics applications.

52. Specific designs developed locally may offer the best response to more pressing national needs; examples for such applications in the Arab region are various arabized or bilingual equipment - terminals, PCs, printers etc.

53. Furthermore design groups, if nurtured and properly supported, could act as focal points for creative activity in high quality science and technology and in promoting microelectronics industry, particularly if liaison units are developed within these groups to promote vertical transfer of technology to local industries.

IV. STATUS OF MICROELECTRONICS IN THE REGION

54. Reviewing the status of electronics and microelectronics capabilities and industries in the region the workshop noted the following:

(a) The electronic products market in the region as a whole is substantial enough for sustaining economically viable electronics and microelectronics industries, though the manufacturing base is still very limited and growing at a very slow rate;

(b) The region has a great potential in design capability embodied in its well equipped universities and R&D centres. However, the actual design capability is practically nil and no industrial facility had established any serious industrial design or development group; and

(c) Many specific applications were developed at various universities and R&D centres, for educational purposes. These applications remained unfulfilled laboratory models due to absence of links with industries.

55. The workshop noted that though there is a growing interest in many governmental sectors with regard to microelectronics technology and its impact on various aspects of life, almost no country in the region had adopted, as yet, a clear strategy related to this crucial technology and its penetration in local societies.

56. Participants stressed that in establishing any microelectronics production facility in the region, the immediate economic viability of the project should not be of paramount interest; and that more stress should be given to the objective of attaining a degree of self-reliance.

57. Noting the fast changing nature of the technology, the extreme competitiveness of its products and the very high entry requisites in capital and human resources, the workshop urged that microelectronics manufacturing has to be a regional-scale operation. The Arab countries must co-ordinate

efforts and pool resources to achieve a degree of regional self-reliance, for it is impossible for any country on its own to develop a viable IC manufacturing facility and to keep it up to international standards.

58. It was felt that the information contained in the ESCWA/UNIDO report was very valuable since it was the first attempt to compile and circulate information about existing facilities and capabilities. Suggestions were made to update the report, in co-operation with various institutions, and to recirculate it as an important document for exchange of information and experience. Participants at the workshop promised to co-operate in reviewing critically the report and supplying their comments and whatever extra information they might have. At the same time the participants presented additional information about their respectives countries to the workshop.

59. Reviewing the experience gained in various Arab countries, the workshop noted with interest many aspects presented by various participants:

(a) In the IC facility in Algeria engineers were circulated periodically over various tasks, to gain insight into the technology and to learn design rules; such an action was considered a fulfillment of the training objective of the facility. It was expected that some of the trained engineers may move later on into design or into decision-making positions where their experience would be very valuable;

(b) In Iraq the requisite infrastructure built for the IC manufacturing facility was used to supply the local market with some of the scarce products: deionized water, purified gases, etc.

(c) In Algeria and in Iraq, the facilities to manufacture ICs were used to assemble solar cells, considering that the technologies were similar and the acquired experience was valuable in operating the assembly of the new product;

(d) In Egypt research into solar cells was assessed as highly advanced; there was a call on Iraq and Algeria to benefit from this experience. It was also pointed out that an important experience in this field was developed in Jordan.

(e) At the "Scientific Studies and Research Centre" in Syria, experience was gained through "learning by doing" in various aspects related to microelectronics technology and applications. Specific applications were developed as laboratory models; a few were implemented into operational models. The centre gained experience in design of ICs, hybrid circuits and printed circuit boards.

(f) In Tunisia the Government is moving directly into promoting microelectronics industry, particularly in the field of informatics and communications. A national committee was established in 1984 to develop a national plan and to supervise the implementation of such a plan, hoping to benefit from the important potential latent in the educational system and in the skilled human resources available inside the country or working in advanced centres.

60. The workshop stressed the importance of regional co-operation and co-ordination in the field of microelectronics. It was pointed out, however, that a regional approach must offer a specific return to every participating country, through the development of co-ordinated regional policy and decentralized related activities wherever possible. Examples of activities that may be undertaken in various countries include: specialized higher education, specialized training centres, design of ICs, manufacturing of ICs and packaging of ICs (as in the case of Morocco). Objective criteria should be established to choose the host country for every activity, while at the same time all activities should be shared and should be open to personnel from all participating countries.

V. DEVELOPMENT OF ELECTRONIC TECHNOLOGY IN THE REGION: ISSUES AND APPROACHES

61. The workshop deliberated at length on the issues raised and the recommendations proposed in the joint ESCWA/UNIDO paper. The workshop endorsed the paper and adopted in full the proposed recommendations.

62. Emphasizing that a legitimate long-term goal for every country is to master the basics of microelectronics technology and to put it to advantage in response to national needs, the following course of action was suggested:

(a) to implement a training programme in IC design, involving designers and manufacturing engineers from the region;

(b) to undertake market surveys for regional applications and various electronic products;

(c) to move step by step through a time-bound long-term approach towards the establishment of a viable electronics base and microelectronics manufacturing facilities:

(i) securing access to manufacturing facilities outside the region to implement designs developed in the region;

(ii) upgrading existing facilities, establishing industrial development groups around them and diversifying the product mix to suit better the regional market;

(iii) establishing a "pilot line" for manufacturing of ICs using the CMOS technology within a 3-year framework;

(iv) undertaking a feasibility study for a regional silicon foundry that may be established within a time frame of some 5 to 7 years, as part of a plan to develop a viable electronics base in the region.

63. The workshop pointed out the strategic importance of microelectronics technology and the lack of capabilities in this technology in the region. Going into IC manufacturing was considered as a strategic option to gain a minimum of self-reliance and to respond to certain national needs that may not be considered by advanced countries. The workshop defined the real objectives to be attained as being: to gain insight into the technology, to develop human resources and the requisite infrastructure. It was pointed out that the

cost of any facility in the region should take these objectives into consideration. In this respect the two facilities in Iraq and Algeria were considered a net gain that need to be maintained in spite of the problems and difficulties they were facing.

64. The workshop stressed that a viable electronics industry must cover not just IC design and manufacturing; enough attention should be given to identification and design of new products, to development of region-specific applications and to building up capability in more complex systems design and implementation. Product engineering was assessed as important as IC design and manufacturing, since the market for ICs and other electronic components would be found in larger systems and new products and applications.

65. The question of standardization in electronic products and systems was strongly emphasized, not only between countries of the region, but even within the same country. It was noted that it was of utmost importance to co-ordinate specifications between components manufacturing and systems production. Participants requested all electronics industries and the Governments in the region to give due attention to the question of standards. taking into consideration the work of ASMO and ISO.

66. The workshop emphasized that the real gain in the technology was more in the development of human resources than in the acquisition of latest equipment. It was noted that the life time of any piece of equipment, in such a fast moving technology, is not more than 3-5 years, if it is to compete with innovations worldwide. Thus, human experience gained is the real target in any serious transfer of technology plan. The workshop recommended that a comprehensive training programme in design and manufacture should be formulated to build up human resources.

67. In this respect the workshop urged that training must be given utmost importance, not just in educational institutions and universities,but more so for practising personnel at all levels, noting that in advanced centres 15-20 per cent of the staff time would be devoted to training on new processes and techniques, to catch up with innovations introduced worldwide. Thus the workshop agreed on the need to formulate and implement a comprehensive training programme in various aspects of electronics and microelectronics and

related fields to build up the pool of human resources in the region, including residence exchange with advanced centres abroad. It was stated that training must be very specific and for particular tasks at a time, to avoid waste of resources and of the valuable time of skilled labour.

68. The workshop noted that due to lack of a proper market the available bipolar facilities in Iraq and Algeria were underused. It recommended to look for more applications requiring bipolar characteristics. Diversifying the product mix and co-ordinating product specification with assembly lines was seen as very important in this respect.

69. The workshop deliberated on the nature of the technological process to be adopted in the pilot line and silicon foundry and on the possibility of leap-frogging over bipolar technology into CMOS, which is considered the technology of the future. In this respect it was noted that, consideration of the bipolar technology was based on the availability of this technology in existing facilities in Iraq and Algeria. Upgrading these facilities to secure a more efficient exploitation factor was considered as a necessity to make full benefit of the investment made, particularly since many "bipolar components" are still used in various electronic products.

70. On the other hand, to master the CMOS production techniques, there was a necessity to gain insight and know-how of PMOS and NMOS technologies considered as basic for application of CMOS. Moreover, due to the complicated nature of the CMOS technology, highly qualified and experienced manpower should be recruited and trained in various aspects of the technology before going into a full production line. It was felt that a CMOS pilot line could be a corner stone in preparing the region for a full-scale CMOS silicon foundry.

71. The workshop agreed that regional co-operation was the corner stone for any viable microelectronic industry. Noting the lack of information exchange among experts in fields related to microelectronics even within the same country, the workshop stressed the importance of such activities as co-ordination meetings, seminars, annual conventions etc. The workshop recommended the establishment of an "electronic activity focal point" in each

country of the region, that will assist in collecting information about various activities in the field and circulating it to institutions concerned within the same country and the region.

72. In this respect the workshop called on the Arab Fund for Economic and Social Development (AFESD) and the Arab Industrial Development Organization (AIDO) along with ESCWA and UNIDO to co-operate in future activities to promote microelectronics technology and industry in the region. The workshop noted with satisfaction the positive concern and commitment expressed by representatives of these institutions.

73. Noting that the workshop was not attended by most consumer electronics industries in the region, it was recommended that a co-ordination meeting be convened among all electronics industries in the region, systems and components, with the objectives of:

- exchanging information and experience;
- considering harmonization of standards and specifications;
- formulating joint activities such as training etc.

74. Noting the large discrepancy between the number of electronics engineers graduating from universities in the region and those actually absorbed by local industries, the workshop recommended a review of the educational systems and curricula, to respond better to local industries' needs. Stronger ties were called for between industries, R&D centres, universities and users of electronic products. In this respect the Governments' role was seen to be of utmost importance. The development of national and regional policies in microelectronics was seen as very crucial to promote this advanced technology in the region.

Annex I

Agenda

Monday, 27 January 1986

Opening Session Chairman: Dr. Hadj Sleimane Cherif	9.00 a.m. - 10.00 a.m.
Coffee break	10.00 a.m. - 10.30 a.m.
Working session I 10.30 a.m. - 12.30 a.m. Chairman: Dr. Hadj Sleimane Cherif Rapporteur: Mr. H. Sharif Presentation of main ESCWA/UNIDO/DIELI paper DIELI comments	
Lunch break	1.00 p.m. - 3.00 p.m.
Working session II Chairman: Mr. M. Ghrib (ENIE) Rapporteur: Mr. H. Sharif Presentation and discussion of country papers (Algeria, Egypt, Iraq, Libya, Syria, Tunisia)	3.00 p.m. - 6.00 p.m.

Tuesday, 28 January 1986

Working session III, part 1 Chairman: Mr. H Sharif Rapporteur: Mr. K. Fialkowski "Proposals for Strengthening National Institutions and upgrading existing facilities" - Approach proposed by ESCWA/UNIDO/DIELI - Additional comments of DIELI Discussion	9.00 a.m. - 11.00 a.m.
Coffee break	11.00 a.m. - 11.30 a.m.
Working session III, part 2 Chairman: Mr. K. Venkataraman Rapporteur: Mr. H. Sharif Deliberation on main papers and proposed course of action	11.30 a.m. - 1.00 p.m.
Lunch	1.30 p.m. - 3.00 p.m.
Visit to ENIE facilities	3.00 p.m. - 5.00 p.m.

Meeting of Arab Delegates:	5.00 p.m. - 7.00 p.m.
Dinner reception by the Governor of Sidi Bel Abbes	8.00 p.m.

Wednesday, 29 January 1986

Working session IV Chairman: Mr. K. Venkataraman Rapporteurs: 1) Mr. H. Sharif 2) Mr. K. Fialkowski Deliberation on future action. Recommendations	9.00 a.m. - 12.30 p.m.
Coffee break	12.30 p.m. - 13.00 p.m.
Closing session	13.00 p.m. - 13.30 p.m.
Lunch	
Departure	

Annex II

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Annex III

List of documents

1. Silicon Foundry and Design Centres in the Arab Region: Issues and Approaches (UNIDO/IS.583; E/ESCWA/ID/86/CRP/1)
   by ESCWA/UNIDO secretariats.

2. Complementary Comments on the Joint Paper "On Regional Silicon Foundry and Design Centres"
   by R. Micolet, DIELI, France.

3. Report of Electronic Commission of India, Part II, 1985.

4. Microelectronics Capabilities in Tunisia
   by CETIME, Tunisia.

5. R&D of Microelectronics in Egypt
   by M.B. Saleh and E.A. Abdallah, Electronic Research Institute, National Research Centre, Cairo, Egypt.

6. Status of the Electronics Industry in SPLAJ (Libya)

7. Microelectronic Industry in Iraq
   by Munaim D. Saleh and Waleed A. Said, SOTI, Iraq.

8. Report on the State of the Art of Microelectronics in Algeria, January 1986

9. Main Requirement in the Foundation of Microelectronics Industry in the Arab World
   by Dr. A. Azrak, Syria.

10. Syrian Country Paper, January 1986.

11. Gate Array Designs.

Annex IV

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