UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org

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UNITED NATIONS
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Meeting of the Consultative Group on
Informatics Technology for Development

Vienna, Austria, 14-16 December 1987

REPORT *

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EXPLANATORY NOTES

References to dollars ($) are to United States dollars, unless otherwise stated.
References to tons or tonnes are to metric tonnes, unless otherwise stated.
The term "billion" signifies a thousand million.

The following technical abbreviations are used in this publication:

ASIC	Application-specific integrated circuits
CAD	Computer-aided design
CAM	Computer-aided manufacturing
CAT	Computer-aided testing
CIM	Computer-integrated manufacturing
CMOS	Complementary metal-oxide semiconductors
MPC	Multi-product chip
MSI	Medium-scale integration
MOS	Metal-oxide semiconductor
OSIA	Open systems interconnection architecture
PLA	Programmed logic arrays
ROM	Read-only memory
VLSI	Very large-scale integration

The following abbreviations and acronyms appear in this publication:

CMC	Canadian Microelectronics Corporation
COGIT	Consultative Group on Informatics Technology for Development
EEC	European Economic Community
ESCAP	Economic and Social Commission for Asia and the Pacific
ISO	International Standards Organization
REMLAC	Regional Network for Microelectronics in Latin America and the Caribbean
SADCC	Southern-African Development Co-ordination Conference
UNESCO	United Nations Educational, Scientific and Cultural Organization
WHO	World Health Organization

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Annexes

I. INTRODUCTION

1. In 1984 a meeting of professionals and representatives of non-governmental organizations active in the field of applied informatics technology for development proposed establishment of a Consultative Group on Information Technology (COGIT) which could advise UNIDO on an action-oriented approach to help build up indigenous microelectronics and informatics capabilities in developing countries.

2. Since then, although a number of agencies have been active, it was not clear that substantial acceleration had taken place. The COGIT group was therefore reconvened to review the status of activities in the field of informatics technology and work out means of international co-operation to speed up applications.

3. The formal objectives of the meeting, held in Vienna on 14-16 December 1987, were to:

(a) Review practical experience in the application of informatics technology for development and to identify concrete measures of co-operation at international level, including co-operation among developing countries, so as to promote such applications in a manner consistent with the requirements of developing countries;

(b) Review UNIDO's past and planned activities in this field and suggest a programme of action.

4. The participants from intergovernmental and non-governmental organizations, from selected developing countries, and experts from developed countries are listed in annex 1. The documents prepared for the meeting are listed in annex 3. Mr. R. Narasimhan (India) was elected Chairman· Mr. P. Ellwood (UNIDO) as Rapporteur.

5. Opening the meeting, Mr. Domingo L. Siazon, Jr., Director-General of UNIDO, underlined the significance of microelectronics and informatics technology to the industrialization process and the double opportunity they represented. They constituted a rapidly developing industry in themselves which (especially the software sector) countries could enter without having to invest heavily in capital equipment. And they were a force change in other industries: they transformed manufacturing processes, products and even the competitive environment itself.

6. Nevertheless, despite national and international efforts, it had to be recognized, the Director-General pointed out, that in many cases the application of microelectronics and informatics had failed to yield the results expected of them in developing countries. Similarly, the applications had not enjoyed the diffusion anticipated, thus lessening their impact on development. The task for the meeting was therefore to help UNIDO identify and spell out the details a coherent microelectronics/informatics programme for UNIDO that would contribute most effectively to the development of developing countries.

7. The Senior Technical Adviser, Department for Industrial Promotion, Consultations and Technology, noted that the meeting was part of a series of activities initiated by UNIDO in regard to microelectronics and other emerging technological advances. It was also intended to provide substantive input

to the programme module on microelectronics and informatics technology in the new UNIDO programme approach to development and transfer of technology. COGIT meetings were planned to be theme-oriented and participants would be invited according to the chosen theme and their field of expertise.

II. CONCLUSIONS AND RECOMMENDATIONS

8. After reviewing current trends in microelectronics and informatics technology and the needs of developing countries in that respect, the group adopted a number of conclusions and recommendations as inputs to the UNIDO programme in this area. It noted that developing countries were at different levels of development and would need to take action at one or more of them. International co-operation, including South-South co-operation was called for. However, selectivity was important in view of the vastness of the field of informatics technology.

General trends

9. The group agreed that both established and leading-edge technological developments in microelectronics and informatics technology had important implications for developing countries, especially in the long run. Those at the leading edge, however, such as expert systems and computer-supported production may have primarily a potential for future applications in developing countries. Governments should therefore monitor these developments with a view to keeping their professional experts informed and advising enterprises on their implications for industry. However, any applications should take into consideration the local conditions and constraints and fit into the local productive structure.

Awareness

10. It was felt that governments, producers in industry and development finance institutions had to be more aware at a practical detailed level of the opportunities, limitations and threats posed by developments and trends in microelectronics and informatics technology as well as the structural change involved. In particular governments should play a major role in that effort. They should establish policies applying to their own operations and those of enterprises, research and training institutions and users. Such policies would promote rational use of microelectronics and informatics technology generally. Governments should support those policies through public sector purchasing and preparing human resources information campaigns in areas for which they were directly reponsible, e.g. health, education, administration and state-owned industry. An awareness campaign should try to reach all sectors of the population from decision-makers down.

11. Industry should be the object of targetted awareness campaigns, drawing on the experience with such campaigns in other developing and developed countries. The general benefit of microelectronics and solutions found in specific sectors could be demonstrated both within and between countries by means of travelling exhibitions. UNIDO should also sensitize governments by means of workshops and seminars, audio-visual presentation of real developing country problems and solutions, and supporting studies. One of the most

effective ways to draw attention to microelectronics and demonstrate its effectiveness in different sectors, the group felt, was with pilot projects. UNIDO should undertake pilot projects in sectors such as small-scale industry, tourism etc.

Selection and acquisition

12. Noting that almost all informatics technology was imported by developing countries, the group found that serious mistakes had been made in the selection and acquisition of both hardware and software. It was therefore important that UNIDO continue its workshops, advisory services and preparation of manuals to strengthen developing countries capacities in this area. Software tools should be an essential part of transfer of software technology.

Maintenance

13. The group concluded that developing countries faced serious maintenance problems in both the hardware and software for microelectronics and informatics technology. Building up a maintenance infrastructure was in many cases an urgent necessity. Agreeing that rigid controls in this respect were likely to be self-defeating, the group recommended an appropriate combination of buyer's incentives and vendor obligations (such as maintaining a sufficient stock of spare parts for all hardware, plus training of local maintenance technicians until they can work alone). UNIDO should provide guidelines and advise governments on suitable strategies. Where national markets were too small for vendors to comply, UNIDO should promote subregional maintenance centres or enterprises.

Applications for development

14. To identify, promote and accelerate local applications in industry and other economic sectors, there was great need for indigenous effort, the group concluded. Not enough was being achieved for lack of skill and infrastructure. This required focused capacity building, concentrating on areas such as software, which should be considered as an industry in itself. To realise any application, demand and supply would have to be stimulated in an interrelated and dynamic fashion, hardware and software knowhow relevant to appropriate solutions would have to be acquired, and the associated skills developed.

15. The group recommended that to help developing countries build up the necessary resource base, UNIDO continue to draw attention to problems of commercialization and use of public purchasing. Key areas were software and close interaction with users to determine relevant applications. UNIDO should therefore support applications designed to improve productivity and efficiency and rehabilitate existing industries. It should address particularly the potential of informatics for small enterprises. To develop technological enterpreneurship, UNIDO should promote programmes to allow professionals to set up on their own and make governments and development finance institutions aware of the need for venture capital for software development, which was generally not considered a traditional industry.

16. The group also called on UNIDO to draw up and circulate an inventory of applications of significance to development, and inventories of application possibilities in specific industrial sectors, and continue to work with other international organizations such as UNESCO and WHO to promote and initiate microelectronics applications.

Skill building

17. The group recommended that UNIDO assist by defining the threshold level needed for skills relevant to applications, maintenance and software, and provide guidelines and training. There should be selected and inter-related skill-building in basic areas such as maintenance, software, integrated circuit design and product design. Such skills should however extend beyond applications to management of the technology.

18. In the long run, each country's greatest asset would be its body of indigenous skills in exploiting trends and developments in microelectronics and informatics technology for the benefit of its own socio-economic development. Some countries, it agreed, had developed high-level technological and managerial skills. The group felt UNIDO should support mechanisms to share these higher-level skills by networking the institutions involved. This would be supported in some cases by integrated national, regional or subregional development institutions with training facilities in each area, plus a possible silicon foundry. UNIDO should help developing countries to set up such institutions. Guidelines for setting up national or regional institutions should also be disseminated by UNIDO. The group noted in this context the UNIDO initiatives in Latin America and the Caribbean, and in the Arab Region. It was proposed that UNIDO work on subregional institutional mechanisms for African and Caribbean countries. In this connection, the representative of the Commonwealth Secretariat indicated the readiness of his organization to work with UNIDO to promote such initiatives.

Mobilization of international co- operation

19. The group concluded that in many cases international co-operation could play a major role in promoting informatics for development. It recommended that UNIDO stimulate and mobilize such co-operation between developing and developed countries in informatic applications for development, i.e. at the level of enterprises (via joint ventures and technology transfer agreements), between research and training institutions, among professional groups and between high-ranking professionals in their individual capacity. UNIDO should maintain and enlarge its roster of experts available for problem-oriented activities and develop other mechanisms. The group noted in this connection that UNIDO was working on an international project for micro-electronics applications and software development, which would link scientific institutions and enterprises in helping developing countries. It urged that an international project should be formulated and implemented soon.

III. PRESENTATIONS BY PARTICIPANTS

20. Each of the invited participants presented or made available a short paper giving a brief account of ongoing or planned programmes of his group, the background to the methodologies chosen, the future goals and long-term objectives. The experts from developed countries presented papers on current trends in their special fields. Participants from developing countries outlined their priority needs in the area of microelectronics and information technology. The UNIDO Secretariat presented an issue paper and made available experts' reports, state-of-the-art studies in selected developing countries and reports of expert group meetings (see annex 3 for complete documentation list).

<u>International Programme for Applications of Informatics for Development</u>

21. With a view to expanding the UNIDO programme in informatics technology in line with its potential and implications for developing countries in future years, the Secretariat presented an issue paper outlining some of the considerations the meeting should take into account in recommending the main elements of that programme.

22. Based on the needs of developing countries, actions to be taken by them would comprise both short- and long-term measures. Short-term measures included monitoring policies for acquisition of technology and for public purchases. In the long-term four important skills were required, namely to:

- o Identify and specify applications of microelectronics;
- o Identify, adapt and develop software;
- o Promote wide adoption of microelectronic systems among local users;
- o Service and maintain microelectronics systems;

23. Policy measures to stimulate and facilitate appropriate use of microelectronics systems should reflect:

- o A practice-up application approach, i.e. begin with well-identified user needs and current practices, and with products, processesses and services already in use or locally produced;
- o The need for methodologies to optimally promote the programme structurally as well as operationally, e.g. a linked regional structure and a learning-and-improving-by-doing strategy;
- o Advantages in harnessing and exploiting source of technology assistance in other developing as well as developed countries;
- o A goal of self-sustaining capacity based on programmed training and build-up of experience and confidence among users as well as producers.

24. In this context the issue paper suggested the meeting could identify the content and modalities of a possible framework for action comprising:

- o A set of government policies to monitor acquisition of technology and public purchases and to develop endogenous capability in the field;
- o Specific programmes of action, e.g. to develop human resources, to be implemented by appropriate agencies and institututions;
- o Possible institutional arrangements for developing endogenous capability such as interdisciplinary core groups or a centre for microelectronics application.

25. In support of this, the UNIDO programme could include technical assistance and advisory services for establishing microelectronics and assembly and manufacture, and to help develop human and institutional capabilities, particularly in software and basic design. It could promote international co-operation in applied R and D of software, promote exchange of information and provide advisory services in the areas of public purchases of equipment and components and acquisition of technology. And it could advise on policy formulation, including preparation of programmes and plans.

26. Not all aspects of informatics technology deserved attention in the development context. Important areas were: electronics and microelectronics applications, software as a small-scale industry, new production technologies

for integrated circuits and other components, standardization and legal aspect of hardware and software, flexible automation of factories (i.e. special attention to CAD/CAM, CIM and robotics) and monitoring the development of new informatics technologies. For developing countries four types of application were especially important--those that improved the efficiency of industry, assisted small- and medium-scale industry, that increased exports and that generated industrial products for essential development objectives, namely education, healthcare, telecommunications and transportation.

Trends in informatics technology

27. The current status and trends in microelectronics technology were summarized by the Chairman as follows:

- Microprocessor chips had grown continuously in power and speed; memory chips had grown steadily in storage capacity. Together this added up to significant improvements in performance-to-price ratio;
- Supermicros were beginning to eroded the distinction between microcomputer and minicomputers; if the promise of high-temperature super-conductors were realised, the gap between present-day supermicros and future desktop supercomputers would narrow in price range considerably;

28. The Chairman noted that the rapid development in technology at the chip fabrication and system packaging level meant that computing power and primary storage capacity would not be the limiting factors in determining how computers were used. In particular the limitations hindering breakthroughs in artificial intelligence (AI), namely inadequate computing and memory power, would be removed. Nevertheless real life applicability of AI would be determined by our understanding of what human intelligence was all about and the kind of computation processes undermining our capabilities in vision, hearing, speech, manipulation and locomotion.

29. In his view the current trends and possibilities for the near future could support generic applications in four category levels:

<u>Level I</u> -- Complex computations
Operaton with very large data bases (querying, retriving etc)
Large volume transaction processing
Text processing, text layout, document production etc

<u>Level II</u> -- Circumscribed intelligent support for: design, drawing, scheduling, diagnosing, decision-making and control
Computer integration of a distributed production environment
Use of programmable tools in production and control

<u>Level III</u>-- Automation of production processes
Knowledge-intensive computing and control

<u>Level IV</u> -- Open-ended AI

30. In one of the UNIDO consultant's view, recent developments in the design of integrated hardware-software systems (known also as firmware) opened new opportunities for product development in the area of embedded real-time control systems. As an example, ten years ago, design and construction of a

special-purpose computer tailored to a particular applicaton was a major, expensive project. Today, using standard microprocessors, standard peripheral chips and high-level very large scale integration (VLSI) design tools, it was much easier. Tomorrow, when VSLI design technology had matured even further, it would be standard practice to design and construct integrated hardware-software devices for specific applications involving real-time control systems for the volume market.

31. In real-time control systems, software and hardware needed to be integrated in order to increase reliability and functionality. Already in home appliances, special-purpose machinery and automobiles there were embedded computer applications that interfaced directly with the lay user. This called for: (1) special-purpose, simple user-interfaces with focussed functionality (i.e. something much simpler than the normal general purpose terminal); (2) high dependability, and (3) minimal installation effort (e.g. software frozen into the hardware in the form of a ROM).

32. The design tools that would make integrated hardware-software design feasible existed in early form with VLSI design tools that already enabled design of specific VLSI chips of moderate complexity within a matter of weeks. Current efforts focussed on integrating them with classical software approaches. Integrated software-hardware design would then begin with a computer-aided requirement specification, followed by details of system functions and system architecture. Implementation (depending on volume) would proceed by way of classical microcomputer plus standard hardware (small series), a gate-array solution (medium series) or a custom VLSI design (for large series).

33. Distributed systems were another driving force for integrated hardware-software design. Local area networks of identical single-board computers represented an opportunity to bring together many standard operating system functions and communication system functions and integrate them into component hardware.

34. The importance of integrated-hardware developments was such that only if a country was in a position to take part in their production would it fully participate in the benefits of the revolution brought about by information technology. In this context educational institutions had an important role to play. Only if engineers of the required background in software and hardware were trained in given country would the industry of that country be in a position to take advantage of these new trends. This meant courses of study on integrated software-hardware design techniques in trade schools and at university level. Any educational initiative would, however, have to be supported by the necessary computer equipment and software and access to a silicon foundry for VLSI manufacturing.

35. In his paper on Forseeable Applications of Integrated Circuit Technology for Developing Countries, another UNIDO consultant also underlined the need for developing countries to develop the people who could exploit changing technology as a came along. These skills may not be an exportable commodity, he pointed out. The true payoff of informatics technology for developing countries, he said, would only be realized if the tchnology led to applications to meeting their specific requirements. This called for a technological capacity on their part that encompassed software development, applications involving standard chips and, equally, design capacity for semi-custom or custom chips.

36. In addition to developing a good skill base, the consultant said that to exploit integrated circuit technology developing countries should look at two semi-custom approaches—gate array and standard cell methodologies—as the most promising short-term routes. The bulk of applications did not require state-of-the-art technology and fabrication of application-specific integrated circuits (ASICs) could be arranged through brokers, thus avoiding the high cost of local fabrication. To facilitate this, good communications links were essential and, as demonstrated by the experience with Canadian Microelectronics Corporation, a Government-funded non-profit organization, and the CDNet operated by Queen's University in Canada joint co-operative programmes were beneficial.

37. The role application-specific integrated circuits (ASIC) were likely to play in product design in future was illustrated by the experience of a large New Zealand washing machine manufacturer. The problem it faced was that its machines were becoming expensive and that they contained are large number of mechanical parts. The solution was complete redesign of the mechanical agitator system, and the control and timer systems. ASIC was adopted for the control system. The result was a less expensive, more reliable washing machine that could be exported to Australia.

38. What this also illustrated, the consultant added, was that local applications would only be recognized locally, and that local skills and awareness were required to recognize the need for a technological solution to problems and to find an appropriate way to satisfy that need.

39. Reviewing trends in the two semi-custom approaches, he said that the gate array of standard logic circuits, in which only the metal layers needed to be designed in order to define a function, was growing rapidly because of its low cost. Between 1982 and 1987 the number of vendors had increased from 35 to 250 and they were especially popular for ASICs. The cost, currently 0.17 to 0.2 cents/gate was dropping by half each year, the turnaround time of 14 weeks (design, 7 weeks; fabrication, 5 weeks; packaging and testing, 2 weeks) may be cut to 4 weeks. Availability of computer-aided design (CAD) and testing (CAT) software added to their popularity.

40. Standard cell methodology in which circuits were constructed from standard building blocks, on the other hand, made available specialized cells often not obtainable in gate array form (e.g. analogue blocks, PLAs and multiport memories). Advantages compared to gate arrays included flexibility regarding the shape of the circuit, the function and pad count and position. There were also more packaging options. Disadvantages of the standard cell approach were that it required the complete fabrication cycle, more masking stages to produce the desired circuit pattern, longer prototype time and manufacturing turnaround time, high cost and more sophisticated CAD and CAT techniques. There were also fewer vendors.

41. Trends in custom design multiproduct chips (MPC) included increasing size (due to increasing complexity) and a switch from NMOS to CMOS. The best CMOS technology available today had a minimum feature size of 1.2 micron and cost $610 per sq mm. The process technology was yielding smaller feature size, increased circuit density and increased circuit speed. On the other hand this meant increased design complexity, design time and added testing problems. The cost of protyping was therefore increased: more sophisticated packages were required, MPC was not possible without a computer-driven direct-write E-beam system, and there were fewer suppliers, i.e. less competition.

42. MPC fabrication programmes were now running in Australia, Belgium, Canada, France, the Federal Republic of Germany, Italy, Japan, Scandinavia, United Kingdom and United States. A French facility was building prototype chips for Algeria, Brazil, Federal Republic of Germany, Italy, Indonesia, Portugal, Spain and Switzerland

43. The essential ingredients for any country contemplating (ASIC or custom design MPC) were access to hardware and software, communications, access to fabrication for prototyping and centralized purchasing to obtain economies of scale and efficient solution of common problems.

44. In his paper on an international development application in health, the participant from the United States drew attention to the use continuing medical education systems of the future would make of microcomputers and communications technologies. They would give users access to a vast number of medical holdings in a timely manner and such holdings would be retained in both industrialized and developing countries, thus affording both language and cultural sensitive information at regional level. Artificial intelligence capabilities would be designed to nable individual health practitioners to retrieve information through simple user interfaces; graphic, pictorial, text and interative information would be available through online networks. Today, network building was still viewed as a hands-on approach (through meetings, telephone conversations, visits etc.); the health world of tomorrow would link institutions and individuals and cross language and national boundaries.

45. One of the Swedish participants warned of the unique opportunities for computer manufacturers to control the computer market with their marketing and product development strategies. As a consequence of growing and deliberate incompatibility between production originating from different manufacturers, users preferred often to keep to one manufacturer in order to eliminate the risk of decreased performance. An example of this was the manufacturers' limited compliance with ISO's proposed Open Systems Interconnection Arichitecture (OSIA) which was designed as an international standard for interworking between data communication systems and to serve as a common base for developing computer network products. Consequently, as computerization was becoming more communications oriented, the bonds between user and manufacturer tended to tighten.

Informatics technology for development

Microelectronics as the gateway to a tooling culture

46. Analysing the practical aspects of applying microelectronics technology for development, the Chairman drew attention to two defining characteristics of developing countries: their range of problems--from abject rural poverty at one end to the need for modern scientific research at the other--and their product-oriented manufacturing base. A true industrial culture was missing in most developing countries because a tooling culture--the ability to conceptualize and make appropriate tools--was absent. As a result manufacturing reflected trading practices rather than practices relating to tool design and technological innovation. It was therefore important at one level to confront rural poverty and make systematic efforts to come to grips with it. At another level, development meant laying the foundations for growing an industrial culture.

47. The aim should be to modernize the non-urban life-style through technology so that the quality of life and the productivity of occupations was improved. This meant selecting and deploying relevant technologies to

modernize agriculture and other rural occupations, and services such as primary and secondary healthcare, primary and secondary schooling, communication, transport etc. In particular access to a modern telecommunication infrastructure was an essential prerequisite to any viable attempt tomodernize the non-urban life-style.

48. Traditional crafts could be modernized by equipping craftsmen with modern tools and design capabilities, hospitals and schools could be modernized with microcomputer-based technqiues. Modern managment techniques could be employed through computerized task-monitoring and task scheduling practices. Tranportation systems could be improved with computerized scheduling, reservation etc. Similarly banking and postal systems could be modernized through deployment of appropriate information technology. The issues involved, were not primarily technological: since nearly all initiatives to transform the non-urban sector had to come governments, ultimately the problem reduced to one of changing government culture and modernizing the thinking and practice within this sector.

49. The Chairman presented a list of applications of importance to developing countries that could be supported by microelectronics technology in the more organized sector of industry and services (see table 1). This could provide a framework for formulating specific initiatives and action-oriented programmes for individual developing countries.

Problems in education and applications selection

50. In his consideration of computers for development and the consequences of increased vendor dependency, one of the Swedish participants noted that manufacturers and vendors were uncertain in their long range business commitments such as product adaptation and dedicated marketing strategies towards developing countries. Incompatability was equally a problem for those countries, but in addition their small markets offered suppliers little inducement to spend resources on development-oriented activities in education or long-range marketing. Probably they would not introduce produce with above-average maintenance requirements either.

51. This contributed to the limited applications of computers to the particular problems of developing countries. Computer manufacturers restricted their own application development to the dictates of marketing considerations and strategical thinking; local computer suppliers did not deviate too much from the marketing plans and strategies compiled at coporate level. In developing countries themselves, computer applications from industrialized countries needed considerable adaption to differences in technical, economical, social and cultural conditions. Too often, however, identified applications were highly theoretical or did not apply feasibility considerations such as hardware and software performance. In particular potential computer applications in developing countries' rural regions were extraordinarily rare.

National experience

52. Illustrating the experience, constraints and planning for microelectronics and informatics technology developing in developing countries, papers were provided by participants from Algeria, China, Pakistan and Trinidad and Tobago. The Asian experience was summarized in a study by the Commonwealth Secretariat.

Table 1. Generic application categories for microelectronics technology

Level I

1. Complex computations
2. Operations with very large data bases - querying, retrieving etc.
3. Large volume transaction processing
4. Text-processing, text layout, document production etc.

Level II

1. Circumscribed intelligent support for
   . designing
   . drawing
   . scheduling
   . diagnosing
   . decision-making and control
2. Computer integration of a distributed production environment
3. Use of programmable tools in production and control

Level III

1. Automation of production processes
2. Knowledge-intensive computing and control

Futuristic

1. Open-ended AI

Computers for city management: applications in China

53. A paper on computer applications in the Beijing Urban Management Information System (BUMIS) presented by the Chinese participant illustrated the scope and a systematic approach to introducing computers to help solve developing countries' large-city problems. He explained that Beijing was in transition from an ad hoc to a modern scientific management system. A key point in the preceding research had been how to adapt the concepts of scientific management and decision-making and how to apply the latest technology to the best advantage. Beijing's experience could serve as a model for other multimillion population cities at a similar stage of development and provide the basis for international co-operation in its main areas.

54. The general model for BUMIS comprised five subsystems covering decision-making, management information, consultancy, urban service and office automation. It was a computer-aided urban management system based on data communication networking technology. Management information provided first-hand data to the other subsystems and served as a foundation for them. Its task was to control and respond to four flows—of people, materials (including energy), money and data.

55. To provide better urban services such as urban planning and construction, education facilities, commercial network, healthcare, public traffic, birth planning, public security, food supply etc. or the population (including Beijing's 130 million visitors predicted for 1990) several population databases were being constructed. A microcomputer-based household database was completed in 1986 with data on 100,000 people: it was now used in six administrative regions. In the current phase, a centralized star network was being created to connect eight small administrative regions with a minicomputer as the mainframe. This would process data on 1 million people. The third phase, the municipal population information system, due for completion in 1990 would be based on a large-scale computer and process data on 6 million people.

56. Employing computers as a tool for comprehensive traffic control was considered an urgent problem. The plan was to develop six individual systems separately and then connect them horizontally in a network. The six areas were: optimized dispatch of buses and trolleys, optimized dispatch of transportation vehicles, "green wave" control of traffic lights, subway operation management, a communications network covering the urban area and key tourist regions, and optimized dispatch of postal vehicles and their management.

57. In late 1987 the first automatically-controlled traffic signal system started in the eastern part of Beijing city, providing real-time self-adapting control over 39 main intersections in a 15 sq km area. A second system in the city centre covering 58 intersections would start in 1988 and others were planned successively between 1990 and 1995.

58. China intended to complete a fingerprint management system by 1990 with a database for 800,000 inividuals. Using locally-developed methods, the system could compare fragmentary finger prints and convert vague images into detailed determinations.

59. A hotel management system with a network linking 26 work stations permits online processing of room reservations, registration, meals and drinks, laundry, telephone, checkout and inquiries had started in 1986. At end-1987 more than 30 hotels operated China-developed software systems.

60. In the materials area plans included computer management of large-scale warehouses for goods, materials and food systems, and of storage, wholesale and retail data for the city's commercial department. An energy resource management information system would permit real-time management of gas, heat, electricity and water. A master plan had been developed to set up an automatic air pollution monitoring network.

61. In the area of money flow, microcomputer-processed cards were being developed to expand the original function of credit cards--bringing convenience to users and providing qualitative changes in the management of money circulation. In banking, the Beijing I & C Bank Computer Networking Engineering project to handle all banking and insurance business would complete in 1991-1993. At the end of 1988 two mainframes would connect 14 branches and 106 savings stations. An information processing centre would cover western Beijing in 1998-1990 with two large mainframes connecting 25 branches and 101 savings stations. From 1989 two more large mainframes would link the existing processing centres and 11 county local area networks. Part of the hardware and all the software had been developed in China.

62. The Beijing Tax Collection Information System, which was to play an important role as price reform takes effect, was being developed in conjunction with the Beijing Commission for Science and Technology, the Beijing Tax Bureau and the Swedish National Tax Board.

63. Other than the taxation area, co-operation with external agencies and companies had occurred only in the case of traffic control, where inputs came from Canada, France, Japan and the United Kingdom. Beijing sought international co-operation in all aspects of the urban management system. The China Computer Federation had links with several major computer suppliers (IBM, Digital, Wang and others) to strengthen exchanges and promote collaboration.

64. In particular it was China's intention to boost co-operation in the area of software--building on exports to Japan, United States and other developed countries. In the area of computer technology application and development generally, the following co-operation areas are envisaged: contractual software development, data entry and data conversion, joint ventures to develop hardware and software, assignment of software experts abroad, assignment of senior hardware and software specialists for joint R and D on foreign projects, and academic exchanges and consultancy.

Planning an R and D programme: choices for Algeria

65. Summarizing the objectives of the informatics industry in Algeria, the Algerian participant told the meeting that the enterprise responsible for electronic equipment, consumer products, professional equipment (exclusing computers) and electronic components was to double its turnover to reach $500 million and employ a staff of 8,600 by 1990. Semiconductors (bipolar circuits using MSI technology) had first priority and were consumer oriented. In the medium term efforts would be directed to improving existing processes in co-operation with other institutions and integrating the needs of other Algerian enterprises including those making computers and related systems, and telecommunications equipment.

66. The task of developing informatics technology in Algeria was given to the High Commission for Research which was developing a coherent strategy for the whole economy. The programme for the microelectronics and informatics technology sector is summarized in table 2.

Table 2. Algeria's development programme for microelectronics

Design and realization of computers	8-bit microcomputers for small applications 16- and 32-bit microcomputers for profession use (using MC 68000, MC 68020, INTEL 80286, and INTEL 80386) Multiuser and multiprogramming environments
Software development	Standardization, adaption, languages, compilers, CAD software and others
Office information systems	Text processing Data exchanges
High-speed data processing	Concurrent systems with unique processors Mulitprocessor systems Networks
Peripherals	Smart bilingual terminals, software and hardware interfaces, modems and others
Discrete electronic components	Microprocessors, memories, special purpose circuits and others
Robotics and manufacturing	Technology and control of industrial robots Robotics applied to medicine Robotics in hostile environments Computer-aided manufacturing
Telecommunications	Technology--discrete semiconductor components such as power silicon components, silicon sensors, submicronic structures for integrated circuits, microwave components Modelling and simulation techniques VLSI technologies and corresponding materials
CAD methodologies and software	Simulation and verification techniques Layout strategy Computer-aided design
Design of VLSI systems	Cell library development Digital systems for data processing Systems for digital signal processing and telecommunications

67. The goal of a possible computer industry was firstly to satisfy the internal market for specific applications such as computer-aided education, games, basic programming, editing, graphics etc. In Algeria, this was a bilingual market. Another goal was to use local product such as monitors, keyboards and specific software where possible. Standardization was generally not a problem since most machines used 8- and 16-bit systems from two suppliers. Other requirements were ease of performance upgrading and ease of repair.

68. In high-performance computers discussion focussed on standardization and compatibility. In robotics, intense research aimed at sensors to improve their intelligence. Hardware development in general was hampered, however, by lack of development systems, test equipment and qualified engineers trained in microprocessor-related techniques. Another urgent need was for operating systems.

69. Of three ways to access microelectronics technology--implantation of foreign firms, direct technology transfer and own R and D--Algeria had chosen the latter. This presupposed an existing electronics industry, trained manpower in microelectronics and a market for the products. Algeria was structuring and co-ordinating manpower development in universities, research centres and industry and providing work stations and (eventually) a silicon foundry to finalize their work. The internal market in telecommunications, consumer products, transportation and other information processing areas existed if applications in daily life were strengthened.

70. Among the technological choices for designing integrated circuits, the best compromise was the standard cell approach. Teams of engineers and researchers were active, using software systems such as LUCIE to generate mask layouts. Other CAD tools were being developed and a cell library for complex circuits was underway. MOS technology had been chosen, starting with nMOS because of its density, speed and topological properties and easy access to nMOS wafer manufacturing. Once architectural skill in mapping functions in forms has been acquired, it could be extended to cMOS and other technologies.

71. A major constraint in Algeria was lack of a means to manufacture specific circuits and to customize them. The obstacle was chip integration of locally made systems and it resulted in, for example, microcomputers that were too expensive. There was an urgent need for a silicon refinery to develop and master technological processes such as nMOS and cMOS, train engineers and technicians, organize multiproject chips, and master CAD tools.

<u>Informatics technology monitoring: Trinidad and Tobago's strategy</u>

72. Plans for information technology in Trinidad and Tobago stemmed from a national workshop held in February 1987, the participant from Trinidad and Tobago told the meeting. Calling for electronics to be declared a strategic industry it had proposed an institutional monitoring/co-ordinating mechanism for national development of informatics technology and related public policies geared to the following:

- creating massive literacy in informatics technology
- developing a world-class software industry
- fostering indigenous capability for upgrading industry and the service sectors
- standardization of hardware, and to a lesser extent software
- development of an efficient service and maintenance capability
- provision of fiscal incentives.

73. This meant activities in four broad areas: development of an institutional infrastructure and policy foundation, developing technological manpower at various levels, accelerating application of imported technologies (under satisfactory transfer conditions), and stimulating R and D activities. Underlying this consensus was the realization that most problems could be attacked and solved with local resources. But if technology had to be imported, it had to be fully understood and made relevant by adapting it to local requirements.

74. Trinidad and Tobago's National Institute of Higher Education, Research, Science and Technology (NIHERST), partly because of its role as the nodal point for Trinidad and Tobago in PEMLAC, was recognized as the organization to establish a core of expertise to develop and advise on long-term strategy, provide information services, and be the co-ordinating agency for training needs and all facets of software and hardware. The NIHERST Centre for Information Technology, which serves as the focal point in guiding long-term development of informatics technology, subsequently developed a national programme of activitivities based on the workshop recommendations.

75. NIHERST itself undertook monitoring of global developments and assessment of whether and how they could be exploited. It would also develop the capacity to forecast technological development, estimate the status of technological manpower, determine strategies for diffusion of informatics technology, and offer guidance on which R and D activities should be pursued. Its 1987-1988 work programme called for continuous surveys and policy options for advice to the Government.

76. For Trinidad and Tobago, training and retraining in informatics technology was of paramount importance: the 1987 workshop identified the shortage of skilled staff as the biggest obstacle to its effective use. It proposed that education curricula be reassessed and restructured and that educational institutions play a key role in a campaign against professional obsolescence and in preparing new graduates. They would be assisted in this by NIHERST, which would also provide retraining programmes in computer science and information technology as post-graduate courses and advanced short courses aimed at widening the knowledge and skill base of practicing professionals.

77. The 1987 workshop having stressed the need for more widespread diffusion of informatics technology, priority was given to sound and effective utilization of available imported technologies taking advantage of the experiences of other countries. Here, the NIHERST Centre for Information Technology acted as a catalyst to transfer information and productive use of microelectronics tools and techniques to industry. NIHERST collaborated with other public and private organizations to introduce informatics technologies to individual firms.

78. Because microelectronics-based automation technologies were a key element in productivity raising, a maintenance capability was being developed at both board and component level to support users' maintenance needs. This would minimize the downtime of equipment and ensure higher returns on invested capital.

79. Because it was assumed that Trinidad and Tobago would benefit considerably more from informatics technologies if it undertook some advanced activities itself, the NIHERST Centre for Information Technology promoted adaptive research in other organizations. As recommended by the 1987 workshop, these currently included:

- development of an indigenous application software industry;
- building up a systems design capability, including networking for data communications
- hardware product design for microprocessor applications.

80. Recognizing the advantages of international co-operation as a way to avoid duplication, pitfalls and unnecessary competition, Trinidad and Tobago had also agreed to participate in specific studies within the framework of REMLAC.

Impact in government systems: an overview of Asian experiences

81. The status of informatics technology and its impact in government systems in seven Asian countries--China, India, Malaysia, Philippines, Singapore, Sri Lanka and Thailand--was reviewed in a paper presented by the representative of the Commonwealth Secretariat. Covering the infrastructure (major computer centres, availability of computers, R and D centres, manufacturing and indigenous development), organizational processes (mechanisms, procedures for acquiring technology and finanacial measures such as import duties), applications, human resources and building public awareness, the study came to seven main conclusions:

- Governments should develop a mechanism to prioritize applications in the light of national development strategies and goals;
- Investment and phasing of the informatics technology infrastructure should be linked to the priority applications areas;
- Governments should create agencies to assist user departments in the system development of priority applications;
- Governments should consider having a single focal point agency for channelling procurement of computers and development of indigenous technology;
- Human resource development should include training users for end-user computing and choice of applications; specialized manpower for hardware, software and application developments; integrating computer-related training in professional and administrative manpower development schemes; and developing management skills for planning and managing tasks in information systems.

International co-operation

Expert systems for healthcare

82. An example of an advanced application of microelectronics in healthcare, presented by an UNIDO consultant, was an expert system being developed for health workers in Ethiopia. The experience to date demonstrated both the opportunties and the limitations of artificial intelligence (AI) as a tool for development, the meeting agreed.

83. The aim of AI was variously a system to make computers clever, to develop computer models of human intelligence, and to build machines that simulated human intelligent behaviour. In computer terms this meant using extensive, high-quality knowledge about narrow problem areas to create very specialized programmes--of which expert systems were one example.

84. Problem solving with expert systems embodied these components in an interactive system that linked users to a knowledge base. This required a user interface, an explanation component, an inference engine (a software package enabling reasoning) and a knowledge acquisition module as shown in Fig. 1.

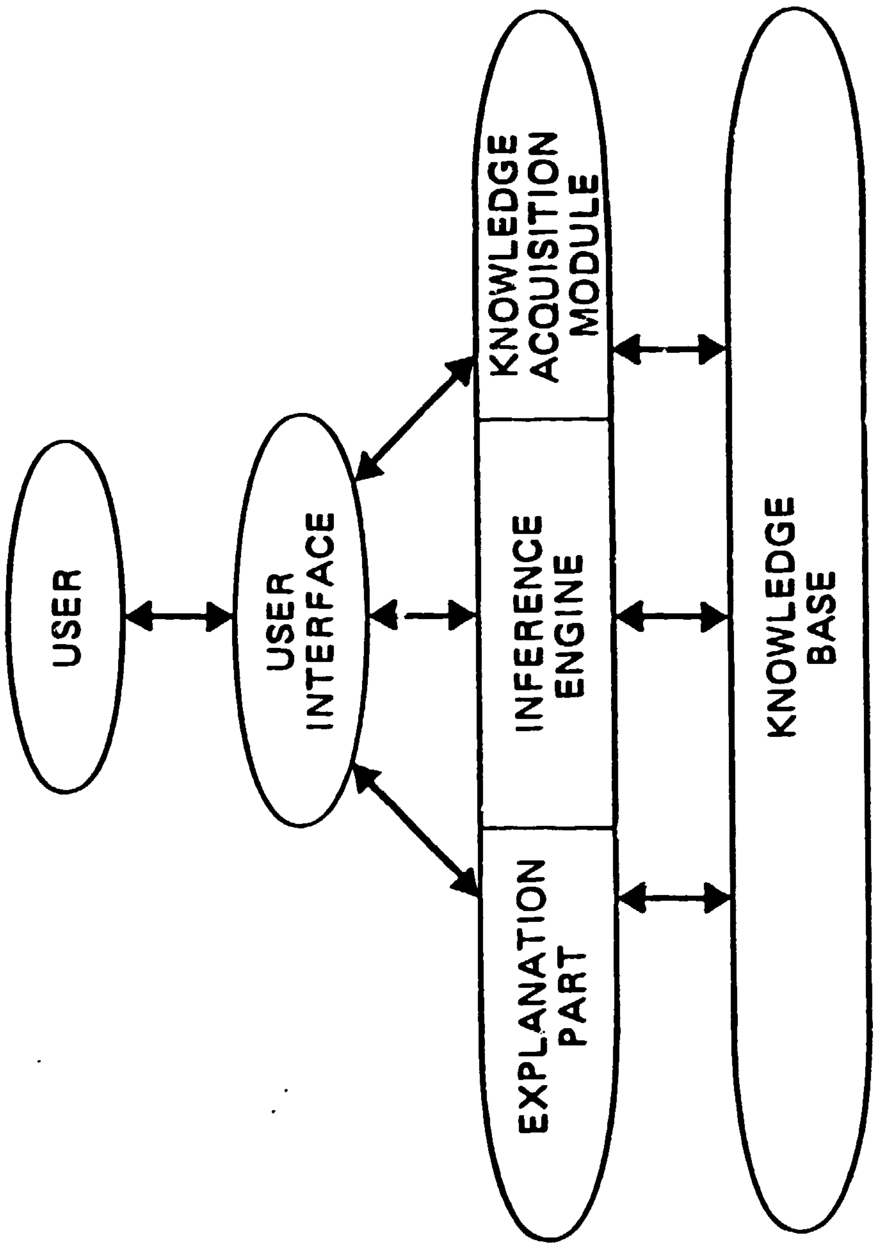

Fig. 1 Components for problem-solving with expert systems

85. The expert system developed by the Austrian Research Insitute for Artificial Intelligence for use in northern Ethiopia was a modular consultation system that provided decision support for diagnosis, therapy and drug prescription. The users were medical or paramedical personnel (rural health workers) facing problems such as diarrhea, infestation with worms, and deseases affecting the eye and skin as well as several kinds of infection diseases. Operated using a rugged and portable personal computer independent of a power supply, it offered a potential remedy to ease the problem of porting medical knowledge to the location where it was needed most.

86. The system was design to take care of nearly half the cases encountered at an ambulatory care centre. By concentrating on good quality of healthcare in those areas, overall performance would be significantly improved. It was emphasized, however, that the disease distribution pertained specifically to the situation in one geographical area, i.e. featuring high country, civil war, poverty and famine, rural health centres closed but two town hospitals available. It was not possible to devise a detailed generic general purpose knowledge based system susited for rural health workers in different countries. The main unsolved problem was to develop a user-friendly interface tailored to the education level of rural health workers. An icon-based approach seemed promising but was difficult to achieve.

Pilot transnational electronic application in health

87. Reporting on the experience of Baylor University Medical Center, Dallas, Texas, the participant from the United States explained that Baylor had signed an initial understanding with the Pan American Health Organization, which was responsible for co-ordinating health programmes in the Americas. Its objective was to exchange information and develop joint programmes that would benefit the peoples of the region. Similar memoranda were subsequently signed with ministries and agencies in Brazil, Costa Rica, Uruguay and Venezuela, and there was co-operation with groups in Chile, El Salvador and Mexico.

88. Communication difficulties with telephones, postal services and language led to an international network trial as a means of communicating time-sensitive and critical information. Today, physicians in most the countries logged into this network daily in order to exchange information, request bibliographic searches--with consequent increase in the quality of patient care.

89. Discussions were underway between Baylor Research Foundation, the University of Texas at El Paso (UTEP) and WHO with a view to utilizing the resources of each and developing an electronic gateway with Latin America using the UTEP mainframe computer. This would enable phsycians in Latin America to access the network via a packet-switched network, providing them with email, bulletin board, asynchronous and synchronous conference and database capabilities. Member institutions would be expected to support the development of the health application by uploading, downloading and disseminating information and taking part in groups on cancer, infectious diseases and other project areas.

Access to informatics developments

90. In a related development, International Informatics Access (AII) was devoted to promoting processes and undertaking activities that would improve the quality of life by bridging the gap between the theory and practice

of informatics. Specifically it provided a forum for discussion and interchange of information and ideas regarding informatics for development, promoted general awareness of the technologies available, organized conferences and seminars on specific issues, and communicated its collective viewpoints and recommendations to national, regional and international policy makers. Supported by private funding, IIA planned activities to strengthen interactive communication, seed projects at local and regional level, participate in country demonstration projects, maintain forums for exchange of ideas, success stories and methodologies and to strengthen the applicability of computer-mediated communications technologies.

Proposal for a Computer Competence Centre

91. As a solution to problems of growing vendor dependency, supplier reluctance to engage in long-term development-oriented activities, and constraints on applications selection generally, one of the Swedish participants proposed a system of regional co-operation featuring Computer Competence Centres. Modelled partly on the UNIDO REMLAC approach developed for Latin America, such centres would constitute an interface between a developing region and countries for transfer of competence and skills relevant for indigenous development of computer usage.

92. Such centres would be staffed by data processing professionals and appropriate additional experts, all having the competence to provide support and guidance to current and potential computer users in the region. A permanent joint project between countries in the region (South-South co-operation) and between the region and a very limited number of developed countries (North-South co-operation). Developing countries would be represented by unversity researchers, local data processing consultants and other qualified professionals; developed countries would participate via a consultant company, researchers and perhaps also a computer manufacturer. Funding would be primarily the responsibility of the countries involved.

Aims and activities of the centres would include:

- Transferring user demand and requirements to computer suppliers, software houses and consultancy firms where products were being designed and developed; establishing and promoting co-operation with those suppliers that actively contribute to the advancement of computer technology in the region.
- Developing a computer procurement philosophy for the region, which in turn would lead to a procurement programme comprising hardware and software evaluation, feasibility studies, contracts and testing procedures. They could also suggest regional standards for maintenance and service agreements, education and training requirements and support issues as a basis for negotiations between users and vendors.
- Developing and maintaining, for planning purposes, a database on reference computer installations (including the less successful ones). It would advise users on procurement of computers and provide other support such as reference to consultancy firms and software houses.
- Providing opportunities for researchers from the region to participate in the centre activities on a temporary assignement basis.
- Fostering development of application software and of basic need-oriented computer applications. By acting as an interface between small industrial enterprises and external counterparts such as consultant companies in developed countries, the centres would create a base for indigenous software development.

International project for transfer of microelectronics and software technology

93. The Secretariat drew special attention to its proposals for an international project for microelectronics applications and software technology (IPTMS). IPTMS would assist developing countries to elaborate plans of action in the two related areas and evaluate their results. The plans themselves would be time- and funds-related specifications of activities, having two main objectives:

- Strengthening or creating the technological capacity of developing countries in the area of IPTMS activities; and
- Implementing co-operation among developing countries and between developed and developing countries in this respect.

94. Applications of microprocessors were emphasized because, while they radically enhanced the capabilities and functions of products, in many applications the cost of microprocessors was negligible in the price of a product. Functionally, microprocessor-controlled machines were more versatile, had better performance and, in many cases, was more energy effective. They also enabled developing countries to use less qualified operators at technician level. Software was a necessary complimentary component. Both therefore, microprocessor applications and software, were priority developmental tasks for developing countries.

95. In comparing software production with other modern technology products that could be manufactured in developing countries, the low investment level needed for software production gave it a substantial advantage. At the same time, for the forseeable future labour would remain the priority input for software development. Therefore developing countries may have a comparative advantage in their production based on their lower labour costs.

96. The one substantial obstacle for software production in developing countries was the market for the products: local markets were usually limited; export markets, mostly in developed countries, were difficult to enter without a proper marketing and product dissemination network.

97. Thus to develop software supply in developing countries, several planning objectives had to be met:

(a) Self-supporting software production;
(b) Local staff trained in advanced programming technology;
(c) Local utilization of computers to solve optimization problems, inter alia, of small and medium-sized industry as well as other applications;
(d) Exchange of software among developing countries (South-South co-operation); and
(e) Export of software from developing countries.

Two pivotal considerations for an indigenous software industry were personnel training and identification of appropriate applications.

98. To assist developing country planners, IPTMS was forseen to have a small permanent professional core group (i.e. a maximum of five professionals). Activities in selected countries would be conducted through consultative

groups created ad hoc for 3 to 6 month periods on a consultatancy basis from leading specialists whose qualifications optimally matched the needs of a given country. The consultants would be selected and monitored through a roster.

99. All IPTMS activities including selection of areas and modalities of assistance, would be supervised by a group representing governments, entrepreneurs and scientific and university institutions. This group would meet annually.

100. It was expected that some developing countries would require assistance in setting up institutions or groups relating to microprocessor applications and software. A flexible approach was foreseen and would be worked out from case to case, e.g. regarding supplies of equipment by local participating institutions and assistance from IPTMS. After provision of training and advisory services (typically for periods not exceeding 6 months) and establishment of appropriate, operating structures and mechanisms inside the country, IPTMS services would be redirected to another country except for possible general back-up support. All local costs would be borne by the country requesting IPTMS assistance.

101. It was expected that over a period of five years, groups and institutions in at least 15 countries would be strengthened and assisted. Each participating country would choose the scientific institution and enterprise to which the co-operation would be directed. The choice of equipment and its source would also rest with the participating countries. The project could thus provide for a variety of arrangements suitable for different countries.

102. As the result of a UNIDO initiative, a Regional Network for Microelectronics Co-operation had already been established in Latin America and the Caribbean (REMLAC). This network could be used to enhance South-South Co-operation in the scope of the project.

UNIDO programme on microelectronics for development

103. In his paper on The UNIDO Programme on Microelectronics for Development: Suggestions for Some New Initiatives, the Chairman offered three proposals for consideration by UNIDO and developing countries: (1) training projects geared to the managerial and engineering needs of application sectors listed in table 1; (2) further work along the lines of REMLAC, including regional centres for software development and training; and (3) projects in which microelectronics technology upgraded craft-based activities.

104. In most of the sectors identified as socio-economically relevant and amenable to solutions using microelectronics, the problem was not lack of highly complex and long-term scientific technological and industrial effort but lack of managerial and engineering initiatives. In addition to organizational and management competence this meant system analysis and system design. Here South-South transfer of models for adaption and implementation, and South-South co-operation in system analysis and design seemed of great value. Building on training projects such as Project Interact (International Education and Research for Applications of Computer Technology, a project of the Government of India), UNIDO could consider other such highly-focused design-level training projects.

105. Citing REPLAC and design centres structured around silicon foundries as appropriate iniatives to promote technology-oriented design culture in developing countries, the Chairman noted that the ability to system-engineer microelectronics technology-based support called for expertise in hardware and software system design. Another UNIDO initiative could therefore bring together regional groups to help them establish regional centres for software development and training, and for design of systems for well-identified applications.

106. Use of microelectronics technology to upgrade and modernize craft-based activies would contribute to improving the quality of life in rural regions. This required three kinds of input: (1) design competence and design facilities; modern and more productive tools; and (3) an organizational framework to link, co-ordinate and provide management support for invidiual craftsmen or small famiolity groups. Three successful examples that belnded traditional skills and occupations with modern technology were:

- o the Prato textile project in Tuscany, Italy linking 10,000 micro-concerns;
- o Anand Cooperative Dairy in Gujarat, India with a comprehensive data base on all animals and participating farmers;
- o Rubber Industry Smallholder Development Authority in Malaysia with a data base and computer-aided agricultural planning facility.

107. Communication played an essential role in such schemes and they could be combined with computerized data banks, design facilities, computer-supported tools, document preparation and information dissemination services. UNIDO could consider promoting such schemes in other industrial sectors and services such as healthcare.

108. A number of project concepts related to the above wre discussed by the meeting. They are attached as annex II.

IV. AGREED ISSUES

109. Following discussion of the Secretariat paper and presentation of the participants papers, the meeting agreed that developing countries at different levels of development would need to take action in one or more of the following areas. They should also be the target of international co-operation:

- o Awareness--(a) Within a country, what was the target audience and what tools could be used to crease awareness? How could producers and users be sensitized? (b) What role could international co-operation and UNIDO in particular play? What kind of demonstration projects could be envisaged?
- o Policy formulation--Given that this was essentially a national effort involving governments, enterprises, research and training institutions and users, what types of assistance could be given?
- o Selection, acquisition and use of hardware and software--since almost all of the informatics technology would be imported by developing countries, what were the factors involved and how could an organization like UNIDO help?

- Capacity building--To promote local applications in industry and other economic sectors, what was the scope for indigenous effort and what strategies and tactics should be adopted? On what areas should capacity building concentrate (for example software as an industry)? How could the demand and the supply sides for applications be stimulated in an interrelated and dynamic fashion? What were the skills to be developed (e.g. systems, ASIC design)?
- Infrastructure--what were the needs in terms of training and research institutions, facilities for maintenance of hardware and software, the legal framework, standardization etc.

110. Within the above framework the following issues were considered of particular importance:

- Improving the productivity and efficiency of existing industries and services;
- Improving in particular the efficiency of the small-scale sector;
- Promoting technological enterpreneurship;
- Software production and applications;
- Stimulating public purchasing mechanisms and linking them to indigenous production and development.

111. International co-operation activities could address each specific area. To stimulate it, how could the following be mobilized:

- Enterprises in developed and developing countries;
- Research and training institutions in developed and developing countries;
- Professional groups;
- High-ranking professionals in their individual capacity.

112. Consideration of these issues led to the conclusions and recommendations set out in chapter II.

Annex I

List of participants

Mr. Erik Baark
Senior Research Fellow
Research Policy Institute
University of Lund
P.O. Box 2017
S-220 02 Lund
Sweden

Telex: LUNIVER S 33533
Telex: LUNIVER S 33533
Telephone: 046-10 76 17
046-10 70 00

Mr. Cherif Benmehrez
Head, Systems Architecture
Haut Commissariat à la Recherche
Présidence de la République
2 Bd. Frantz Fanon
Algiers
Algeria

Telex: 65303 CEN DZ
Telephone: 61 14 18

Mr. Hasan Charif
Regional Adviser
Economic and Social Commission
for Western Asia (ESCWA)
P.O. Box 27
Baghdad
Iraq

Telex: 213468 UNECWA IK
213389 ESCWA IK
Telephone: 556-9400

Mr. Carlos Maria Correa
Subsecretario de Informatica y
Desarrollo
Programa Nacional de Electrónica
Cordoba 831, 7º piso, Buenos Aires
Argentina

Telex: 25272 CEYTAR
Telephone: 31204142

Mr. Herbert Henke
Head, Divison of EDP/Organization
Deutsche Gesellschaft für
Technische Zusammenarbeit (GTZ)
P.O. Box 5180
Dag Hammersköld-Weg 1
D-6236 Eschborn 1
FRG

Telex: 407501-61 GTZ D

Mr. Paul Imende
Kenya Industrial Research and
Development Institute
P.O. Box 30650
Nairobi
Kenya

Telephone: 557988/557762

Mr. Kang Feng
Vice-President
Beijing Commission for Science and
Technology
Beijing
China

Telex: 22616 BEFP CN

Mr. Mohan Kaul
Director
Management and Development Training
Commonwealth Secretariat
Marlborough House
Pall Mall
London, SW1Y 5HX
UK

Telex: 27678 COMSECGEN

Mr. Hermann Kopetz
Institut für Technische Informatik
Technische Universität Wien
Gusshausstrasse 30
A-1040 Vienna
Austria

Telephone: 58801-0

Mr. Pär Lind
The Royal Institute of Technology
Dept. of Industrial Economics and
Management
Fack-S-100 44 Stockholm
Sweden

Telephone: (8)-787 7662

Mr. James L. Mason
Electrical Engineering Dept.
Queen's University
Kingston
Canada K7L 3N6

Telephone: (613) 545-29-40
545-20-00

Mr. R. Narasimhan
NCSDCT
Tata Institute of Fundamental Research
Homi Bhabha Road, Calaba
Bombay 400 005
India

Telex: 11 3009 TIFR IN

Mr. John C. Oeffinger
Vice President
Baylor Research Foundation
3500 Gaston Avenue
Dallas, Texas 75246
USA

Telex: 6503069529 MCI

Mr. Sitthichai Pookaiyaudom
Dean of Engineering
Faculty of Eng., King Mongkut's
Inst. of Technology
Ladkrabang Campus, Ladkrabang
Bangkok
10520 Thailand

Telex: 84967 INSMONG TH
Telephone: 52 50 820
52 50 160-2
3939829

Mr. Glenn Tikasingh
Information Centre
National Institute of Higher
Education
(Research Science and Technology)
NIHERST
Trinre House
52 Jerningham Avenue
Belmont
Trinidad and Tobago

Telex: 22549 TRINAGO WG
Telephone: 625-8108, 4156

Mr. M. Tomak
Exec. Secretary, Engineering
Research Group
The Scientific and Technical
Research Council of Turkey
Istanbul Caddesi 88, Iskitler
Ankara
Turkey

Telex: 43186 BTAK TR
Telephone: (4) 34 20 879

Mr. Robert Trappl
Director
Austrian Research Institute for
Artificial Intelligence
Schottengasse 3
A-1010 Vienna
Austria

Telephone: 535 32 81-0

OBSERVER

Mr. Othmar Brigar
International Committee for European
Security and Cooperation
O'Briengasse 34-44/9
1210 Vienna
Austria

Annex II

List of project concepts

1. Multi-country pilot project for application of informatics in small and medium industries;

2. Technological co-operation of small and medium enterprises between developed and developing countries in the field of informatics;

3. Preparation and application of software package for tourism industry in developing countries;

4. Subregional informatics resource centres (e.g. African countries and the Caribbean);

5. INTERACT- follow-up and promotion of similar projects;

6. Assistance in establishment of software houses;

7. Advisory services on legal aspects of software production and purchasing;

8. Assistance in maintenance of hardware based on co-operation between developing countries and establishment of subregional manufacturing centres;

9. Inventory of applications.

Annex III

List of documents

Provisional agenda

Provisional list of participants

Provisional list of documents

Aide-Mémoire

Notes on an International Programme for Applications of Informatics for Development and the Role of UNIDO, by the UNIDO secretariat

Integrated Hardware/Software Design, by H. Kopetz

The UNIDO Programme on Microelectronics for Development: Suggestions for Some New Activities, by R. Narasimhan

Expert Systems for Developing Countries: Helping Health Workers Help, by R. Trappl

UNIDO/IS.439	Guidelines for Software Development in Developing Countries, by R. Narasimhan
UNIDO/IS.440	Guidelines for Software Production in Developing Countries, by. H. Kopetz
UNIDO/IS.574	Trends in Commercialization of Software in Developing Countries, by C.M. Correa
UNIDO/IS.631	Technology Trends Series: No. 1 Selected Aspects of Microelectronics Technology and Applications: Custom and Semi-custom Integrated Circuits, by J. Sigurdson
UNIDO/IS.632	Technology Trends Series: No. 2 Selected Aspects of Microelectronics Technology and Applications: Numerically Controlled Machine Tools by J. Sigurdson
IPCT.15 (SPEC)	Strengthening Negotiating Capabilities in the Acquisition of Hardware and Software, by S. Soltysinski
IPCT.29 (SPEC)	The UNIDO Programme of Technological Advances: Microelectronics, by the UNIDO Technology Programme
IPCT.31	Technology Trends Series: No. 4 The International Telecommunications Industry: The Impact of Microelectronics Technology and Implications for Developing Countries, by M. Hobday

IPCT.33 Technology Trends Series: No. 3
Global Trends in Microelectronic Components and Computers, by K. Guy and E. Arnold

IPCT.45 (SPEC) Some Considerations for the Establishment of Silicon Foundries and Design Centres, by O. Manck

Study on Organization and Modalities of Software Production, by H.-J. Schneider (draft)

Microelectronics Monitor, Issue No. 23, 1987/III.

In-session documentation:

An International Development Application in Health and International Informatics Access '87, by John C. Oeffinger, N. Rao Machiraju, Jorge Litvak

An Introduction to Sample Computer Applications in China, by Kang Feng

Computer Competence Centre - A Model for Regional Co-operation, by Pär Lind

Impact of Information Technology in Government Systems: A Regional Overview of Asian Experiences, by Mohan Kaul

The Application of Information Technology for Technological Development in Trinidad and Tobago, by Glenn C.E. Tikasingh