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UNITED NATIONS INDUSTRIAL
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MINICOMPUTER SYSTEMS TO MANAGE INDUSTRIES 1/

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1. Introduction

The 1975 Lima Declaration and Plan of Action on Industrial Development and Co-operation adopted at the Second UNIDO General Conference, placed particular emphasis on the mobilization of national and international resources for the rapid industrialization of developing countries to attain the objective that the share of developing countries in the total world industrial production should be increased to the maximum possible extent and as far as possible to at least 25 per cent by the end of this century against the present rate of 7 per cent.

The achievement of this target places great responsibility on top executives and managers in the developing countries for high management performance at all levels in the industrial and related sectors. For this purpose effective decision-making in all areas of industrial organization activities is of prime importance. Adequate information handling, including its collection, communication and timely processing is a necessity to arrive at the right decision and forsee its implications.

The computer can be a helpful tool to extend the human mind and help managers in this respect. Computers are important in reducing the disparities that exist between developed and developing countries because, as it is put in a UN study, "so many computer applications have a direct bearing on some of the main facets of the development process and reflect certain aspects of the technology that has facilitated the growth of the economically advanced countries." /1

In the second UN Report on the Application of Computer technology for development, a role of computers in raising management performance is specifically stressed by saying that "in almost every sector of activity, as well as in the more important management functions of Governments, institutions and corporations, the computer - once its advantages and its limitations are fully appreciated - can be a most helpful tool". /2

Along with the spread of traditional large computers a new generation of aides small in size and powerful in capacity made to extend the human mind and performance is rapidly coming to the foreground. Their development

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/1 The Application of Computer Technology for Development, UN ACAST E/4800, New York, 1971, p. 13.

/2 The Application of Computer Technology for Development, second Report of the Secretary General, UN, ST/ECA/176, New York, 1973, p.p. 7-8.

is so fast that people are too much in a hurry to pause for a moment and think of a meaningful name for them. They are generically called minicomputers. However, the most recent developments in electronic technology have split this class of computers singling out microcomputers, on the one side and maximinis and midicomputers, on the other side of the spectrum.

This alone puts a manager, especially an eager but unsophisticated one in a developing country, in a quandary. Moreover, this technology being new for the so-called advanced countries is already penetrating the developing countries and this will be a major trend in the years to come.

On the one hand, it may be taken as a commendable trend since the fast diffusion of new computer technology, its almost simultaneous application in both developed and developing countries, may close a technology application gap between them and lead to increased industrial production in the latter. On the other hand, one should be careful not to repeat costly mistakes of the past when large computers were purchased without good understanding of their advantages and limitations, which lead to under utilization and sometimes misuse of computers.

The Asian Productivity Organization made this subject a theme of its recently held symposium on computer applications in management (in May 1977). Announcing the conference it pointed out that contrary to the expectation traditional computers did not produce meaningful results in the absence of due considerations given to inherent constraints typically found in developing countries, viz., scarce capital resources, labour surplus economy, the lack of qualified manpower, etc.

Minicomputers are cheaper pricewise but bought in quantities in a country may as well bring a frustrating experience.

With the above in view one may wish to take a bird's eye view of current computer penetration in general in developing countries, then take a quick look at computer development trends and, especially, at the outlook of minicomputer management applications in industry and, finally, one may wish to know whether developing countries would be left alone to face minicomputer suppliers or they would be able to get independant and unbiased advice. The latter point would make us touch upon activities, both present and planned, of the United Nations Industrial Development Organization.

The acknowledgement is made of the contributions to this paper of the International Institute for Applied Systems Analysis, Laxenburg, Austria and EXEC AG., Basel, Switzerland.

2. Computers in Developing Countries

The number of computers installed in developing countries is rapidly growing. The rate of growth in the number of computers for the 1963-1971 period was somewhat faster than the current rate of economic growth in a number of countries, both developed and developing ones. The rate of increase corresponded to a doubling in the number of computers in three to four years. The biggest rate of increase in the number of computers used was noted for the areas of industry (inventory, distribution and management) and in business administration. Lower rates were in the areas of education and public administration. A statistical relationship between the number of computers in a country and its gross domestic product (GNP) was observed for that time period. /3 The number of computers installed in developing countries was estimated at less than 12,500 in 1970, i.e. less than 1 per cent of the world computer population. /4

Attempts have been made to determine the degree of a country's computerization. /5 The UN ACAST Working Group on Computer Technology postulated the existence of the following four levels of computer usage: initial, basic, operational, and advanced. Recently, a computer industry development potential (CIDP) index was suggested to be a measure of the infrastructure necessary for supporting a data processing industry. /5 The index with a scale of 100 is a weighted composite of economic, educational and technological variables. Further work was done to define the characteristics of the dp industry at any one levelof computerization taking into account eight key variables which define the level of dp activity and the role of five core organizations considered to be important channels for the transfer of computer technology. The key variables are number and size of computers, state of dp education, computer applications, computer utilization by government, degree of technology in hands of nationals, official policy towards computerization, international assistance in computer technology, existance of professional dp groups and user organizations. The five core organizations are government, universities, computer manufacturers, multinational enterprises, UN agencies or other foreign assistance organizations.

/3 Ibid, p.p 25-38
/4 Scientific American, Oct. 1970
/5 R.C. Barquin, T. Nishimura, K. Whitney, Model for Progress in Developing Countries, Datamation, Sept. 1976, p. 190.

In accordance with a CIDP level selected countries, most of them are developing nations, are placed as follows:

Initial: Afghanistan, Bangladesh, Bhutan, Botswana, Burma, Burundi, Cambodia, Cameroon, Central African Republic, Dahomey, Ethiophia, Haiti, Laos, Lesotho, Liberia, Malawi, Mali, Nepal, Niger, Rwanda, Senegal, Somalia, Southern Yemen, Togo, Tonga, Uganda, Upper Volta, Western Samoa, Yemen.

Initial to Basic: Albania, Algeria, Bahamas, Barbados, Bolivia, Congo, Cyprus, Costa Rica, Dominican Republic, Ecuador, Egypt, El Salvador, Fiji, Gabon, Gambia, Ghana, Guatemala, Guinea, Guyana, Honduras, Indonesia, Iraq, Ivory Coast, Jamaica, Jordan, Kenya, Libya, Malagasy, Mauritania, Morocco, Nicaragua, Nigeria, Pakistan, Paraguay, Saudi Arabia, Sierra Leone, Sri Lanka, Sudan, Swaziland, Syria, Tanzania, Thailand, Trinidad, Tunisia, Zaire, Zambia.

Basic: Chile, Colombia, Cuba, Iran, Lebanon, Malaysia, Panama, Peru, Philippines, Republic of Korea, Singapore, Turkey, Uruguay.

Basic to Operational: Bulgaria, Greece, Hong Kong, Hungary, Puerto Rico, Rumania, Venezuela.

Operational: Argentina, India, Mexico.

Operational to Advanced: Brazil

A correlation of stages of growth in dp with the CIDP index was further made (Exhibit 1). Thus, one can see that in the majority of countries in the sample, computers were not only introduced but showed diffusion and proliferation. While some other countries are way ahead in computerization.

3. Outlook of Minicomputer Management Applications

Although the above indicated UN Report discussed the computer situation in the beginning of the 1970s when relatively large and costly computers were spread, it also considered the availability of mini-computers which were broadly defined as costing less than $ 25,000. However, in the tabular form the Report combined in one column data for both mini and small computers, thus covering a price range to $ 150,000. The data shows that that range of computers was spread in developing countries at that time (Exhibit 2). Naturally, many computers were on the higher side of the price range.

The latest trend in the computer industry caused by innovations in the semiconductor technology is towards the rapid growth of minicomputers market. Minicomputers today are growing in power and its size and price are falling. (Exhibits 3, 4) The number of minicomputer suppliers is growing in both market and centrally planned economies, in particular in USA, UK, France, Italy, Japan, Denmark, USSR, Hungary, Poland, FRG, Czechoslovakia.

While in the beginning of the 1970s the share of minicomputers in the computer market was only 6 per cent, this figure is expected to achieve 40-50 per cent by 1980 and their production will reach 1 million units. /6 (Exhibit 5) Some sources quote a figure of 3/4 million units. /7

As regards the definition of a minicomputer there is some disagreement within the industry, primarily, because any minicomputer definition would be of a very temporary nature with its capacity and price changing in the opposite directions. A frequently used criterion is the purchase price which is sometimes set at less than $ 20,000 and sometimes within the $ 50,000 range, the latter being applied to the so-called midicomputers. /8 In this case, the prefix "Mini" seems to refer more to the price range than anything else. There is also an attempt to define the minicomputer assessing its technical performance, the major feature being its memory capacity in bytes and the length of words used, which determines data path widths and, therefore, the effective throughput.

The typical minicomputer has a parallel, binary, single processor. It uses words of 16 or 18 bits or less (though 24 and 32 bits word lengths are also used) in a central processing unit, memory and input/output buses. It offers from 8 to 64K bytes of magnetic core or semi-conductor storage with a cycle time of 0.9 to 1.5 microseconds. This description closely corresponds to the classification given in exhibits 3 and 4.

Some sources elaborate on a minicomputer configuration pointing out that today's typical minicomputer uses a one-address instruction format and has two accumulators, a single index register, and a multi-level indirect

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/6 Butler, R.E. International Co-operation and Regulation for Development, paper presented at the Conference of the International Council for Computer Communication, Stockholm 1975.

/7 Kallis Stephen A., Jr. Mini, midi, vici, Data Management, vol. 14 No. 2 1976, p.p. 26-27.

/8 All about Minicomputers, DataPro Research Corp. Report 70C-010 Computers, Sept. 1975.

addressing facility. /9 The add time for 16 bit operands is 1 to 3 microseconds. Hardware multiply/divide instructions are optional, as are power-failure protection and a real time clock or timer. Floating point arithmetic requires the use of software subroutines.

Input/output operations in the typical minicomputer are facilitated by an optional direct memory access (DMA) channel, which accommodates I/O data rates of up to about 1,000,000 words per second. The typical complement of standard peripheral equipment consists of a teletypewriter, disk storage unit, magnetic tape drive, card reader, paper tape reader and punch, line printer, and an assortment of interfaces for communication and control applications.

Software support for today's typical mini-computer is limited to a symbolic assembler, a BASIC or FORTRAN compiler, a simple batch-mode operating system or real-time monitor, and a modest assortment of utility routines.

One of the classifications of minicomputers breaks them down into interactive business computers, office computers, including personal computers, and intelligent terminals, the latter being used where remote job entry is the primary function of the system with local processing held to a minimum. /10

Many business minicomputers are designed to operate in an interactive mode which is achieved through a CRT display with a typewriter keyboard. They cater for two types of applications: standalone or autonomous, which can be worthwhile for a small company and the first-time computer user and as a part of a distributed data processing network for the sophisticated user.

Office computers is another area for minicomputers. Their major application is for accounting functions such as accounts payable, accounts receivable, and payroll. The personal desk-top computer for a manager also represents a new development. However, it is often designed to be most effective in connection with time sharing networks.

An essential feature of a minicomputer system to be considered is its capability to expand with the information processing needs of a company.

As has been demonstrated by many years of using computers (of various levels) in industrial management, their basic effect is revealed not in the

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/9 Ibid p.b.
/10 Auerbach Buyer's Guide to Business Minicomputer Systems, winter 1976-77, Auerbach Publishers Inc. 1977.

reduction of personnel as such, but rather in the reduction of general costs of production, in improving its management, and in a significant growth of the enterprise's economic stability and production flexibility under the necessity of executing maneuvers in the assortment of goods produced and in the structure of the enterprise's economic connections.

The features of minicomputers make them a useful tool in directing the management of industry in developing countries toward the use of the possibilities offered by modern computer technology. Moreover, other alternatives as a rule turn out to be inaccessible under the conditions of the developing countries.

The effective use in developing countries of medium-size or large computers turns out to be difficult because of their big cost, their need for a large number of highly qualified specialists, and the general complexity and high cost of using them. Applying them in a time-sharing mode is practically impossible because developing countries at present lack computer networks in all their basic elements (central processors, communication networks, message switching centers, etc.)

Software offered by computer manufacturers is often very comprehensive assuming a high degree of industrial development. It is made, sometimes, for industries with multiple and varying products of variable volume, with very conventional purchasing and marketing arrangements and tight control over internal manufacture and subcontractors. None of these conditions often apply in developing countries.

When minicomputers become accessible to the basic industrial centers and companies in developing countries, the fact that the users already have and are exploiting minicomputers would make it possible if needed to use them effectively as "buffer" computers (taking upon themselves a corresponding share of the tasks) and as "intelligent" terminals. The most important thing is that we can expect (as a positive effect of rapidly applying mini-computers in the practice of industrial management in developing countries) a real possibility of beginning already now to reduce the gap in the scientific and technological level of management relative to the developed countries, and a possibility of training and educating national cadres of specialists in the use of computers in industry.

The utilization of minicomputers is becoming easier because they are more user-oriented than larger previously designed computers. Of course, the minicomputers have not yet achieved a good level of perfection in their utilization. Minicomputer system programmes are not always adequate. /11

However, minicomputers applications for management in industry is a new rapidly growing and promising area. They are being introduced in developing countries. For example, the importance of data-base software being available on mini-computers was emphasized by a number of speakers at the South East Asia Regional Computer Conference, SEARCC 76 in Singapore. Some speakers discussed their experience with minicomputers systems. /12

At the same time since the area of minicomputer applications in management of industries is new, very little is known about the experience so far gained both in developed and developing countries. Therefore, the exchange of experience may be useful for all countries. That means that the minicomputer applications gap between developed and developing countries may not be big. However, the minicomputer production gap is enormous. The technology involved is very sophisticated and requires a specialized know-how. A working group of the Indian Electronics Commission, referred to in the above mentioned UN Report, in December 1966 recommended that a three-tier strategy should be pursued. "In broad terms, an indigenous minicomputer industry should, if considered, be developed. For medium computers, collaboration with foreign firms should be worked out to ensure a further transfer of technology to local manufacturers, and for large computers, a strategy to minimize the drain on foreign currency resources should be adopted." /13 As the UN second report on computers stated: "Clearly, indigenous manufacture of even the smallest computer of today has little immediate relevance to the problems of the least developed among the developing countries, where any such project would lack a suitable substructure for manufacture. Concentration should therefore be on applying computers successfully so as to get the most out of the foreign currency expenditure." /14

The recent advances in the electronics industry, in particular, the trend towards molecular electronics with the advent of large scale integration

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/11 F. Withington, Trends in 1977, Datamation, Jan. 1977,(p. 47)
/12 Some guidelines for emergent nations, Computer Weekly, Oct. 14, 1976, p. 28.
/13 The Application of Computer Technology for Development, UN, ST/ECA/176, op. cit., p.p. 67, 69.
/14 Ibid., p. 69.

devices has resulted in subdividing the electronics industry into the components industry and the systems industry. For example, a processer in a number of cases has become a component of a computer, rather than of a computer system.

While setting up a components industry in developing countries can be a very difficult, though not an impossible task in the long run, establishing a computer systems industry, i.e. assembling computers from purchased components is within easier reach.

As regards the application of minicomputers in industrial management, the developing countries should develop this capability on a cost/benefit basis, as early as possible.

The above indicated UN Report on the Application of Computers pointed out problems in selecting objectively computer hardware in developing countries. It singles out two major problems: "First, a majority of competent people in the country are familiar with only one manufacturer's products, and, unless he is grossly incompetent, will often be reluctant to try another manufacturer's equipment. Thus, purchasers may often be unwittingly biased in their views. Secondly, a large proportion of the most competent people are to be found working for manufacturers in many of the developing countries. The user often encounters great difficulty in obtaining independent advice at the critical stage of deciding on the investment in a computer." /15

For that purpose developing countries often turn to consultancy organizations, which is also a costly way. In addition, the experience with minicomputer systems has been so far limited and published materials on the subject are scarce. /16 That is why, a number of Governments also turn to the United Nations and its agencies for help.

4. UNIDO Minicomputer Systems for Management Programme (MCSM)

Computer-based management information systems in industries have been recently discussed at two UNIDO sponsored international meetings. One of them was held in Kampala (Uganda) in December 1975, /17 and the other in

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/15 The Application of Computer Technology for Development, UN, ST/ECA/176 op. cit., p. 69.

/16 see, for example: Garfoot D. Purchasing a minicomputer system, Minicomputer Conference Proceedings, 1975, Uxbridge, p.p. 465-469.

/17 Final report of the Joint Consultation on the Promotion of Industrial Management Clinics for the Least Developed Countries of Africa. Kampala, Uganda, 14-19 December 1975. ID/WG.222.7.

Budapest (Hungary) in December 1976. /18 While both Conferences basically dealt with MIS based on traditional computers the latter specifically referred to minicomputers. In fact, one recommendation pointed out that "since MIS are of importance to industries of developing countries UNIDO should carry out surveys and studies designed for practicing managers, on the application of new techniques and technologies in MIS and, in particular, on the use of minicomputers in management systems. Special attention should be paid to exploring possibilities of using minicomputers for management of small companies." /19 Another recommendation suggested a meeting be organized under the auspices of UNIDO on prospects of minicomputer-based MIS.

Taking into account the above indicated developments UNIDO is expanding its capability to assist developing countries in selecting, implementing and using minicomputer-based management systems in manufacturing industries. This capability would include normal components of the UN assistance such as sending experts to developing countries, providing fellowships for acquiring the knowledge of the subject, equipment procurement, etc. In addition, a UNIDO consulting service with a data bank for UNIDO member countries would be set up to supply them with the information about the expertise available world-wide in minicomputer systems hardware, software and organizational requirements (orgware). As the first step, a handbook on business applications of minicomputers designed for top managers of industrial enterprises is being prepared. The handbook is expected to be regularly updated.

The above programme is aimed at contributing to the Lima Conference development target referred to at the beginning.

The adequate application of minicomputers in management of various industries will definitely contribute to raising their performance and to increasing the share of developing countries in the world industrial production.

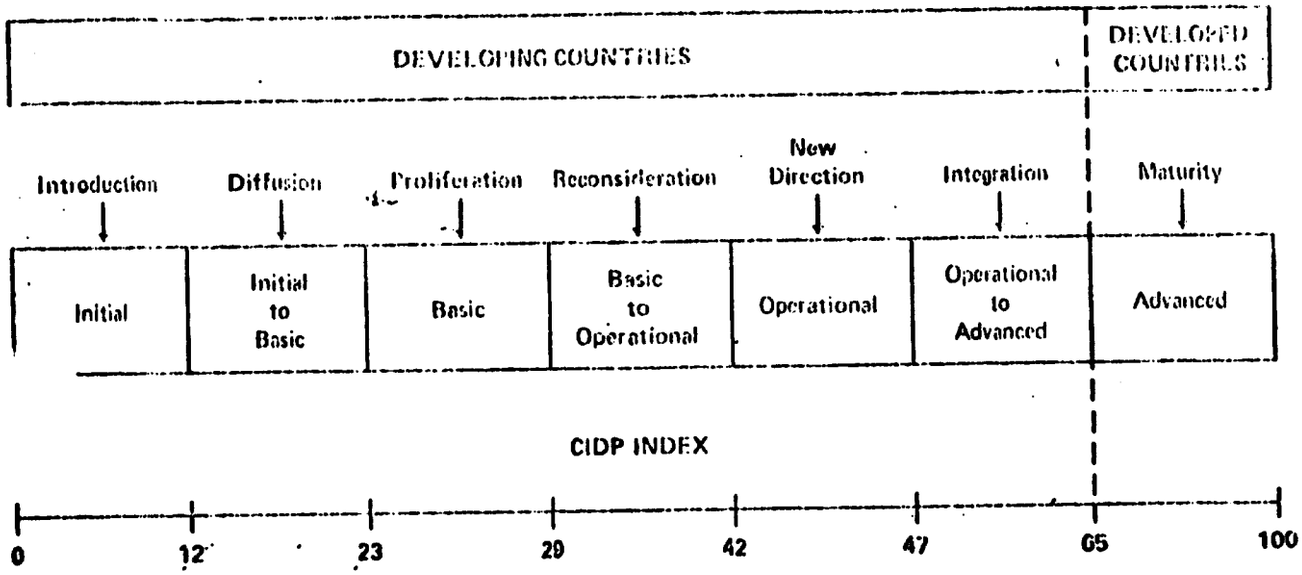
/18 Report of the Consultation Panel on the Use of Management Information Systems (MIS) for raising Industrial Performance, Budapest 29 November 3 December 1976. ID/WG.230/11.

/19 Ibid., Recommendation 6, p. 5.

(EXHIBIT 1)

THE MODEL

A Correlation of Stages of Growth in Data Processing With The CIDP Index



(EXHIBIT 2)

Table Computer statistics: breakdown by number and usage

Country	Total number of computers	Mini/small	Medium	Large	Very large
Algeria a/	63	31	22	5	5
Australia	1,231	...	...	...	...
Austria	690 b/	...	...	...	...
Belgium	151 a/	...	...	...	...
Bolivia*	6	6			
Botswana a/	1	1			
Brazil*	1,219	981	195	21	24
Bulgaria a/	30	...	...	...	...
Cameroon f/	10	7	3		
Canada a/	4,406	2,169	1,504	356	377
Central African Republic*	3	3			
Chad f/	1	1			
Chile h/	57	...	...	...	...
Colombia*	82	18	44	16	4
Congo f/	4	3	1		
Cyprus*	5	3	2		
Czechoslovakia i/	186	...	...	...	...
Dahomey f/	1	1			
Ethiopia i/	9	8	1		
Fiji*	6	5	1		
Gabon f/	5	4	1		
Ghana a/	16	16			
Greece*	174	154	16	5	
Hungary*	161	76	55	28	2
Iceland*	17	10	6	1	
India i/	183	177	5	1	
Iraq*	7	6	1		
Iran i/	49	42	6	1	
Israel	257	...	...	...	...
Italy a/	3,168	...	...	...	...
Ivory Coast f/	36	30	6		
Jamaica*	34	29	5		
Japan	11,257	...	...	...	...
Kenya a/	18	15	3	2	1
Kuwait*	17	4	4	9	
Lebanon*	29	20	7	2	
Madagascar*	15	11	4	1	
Malaysia*	28	17	10	1	
Mexico	402	...	...	...	...
Morocco*	52	45	7		

(Table continued on following page)

(EXHIBIT 2 contin

Table (continued)

Country	Total number of computers	Mini/small	Medium	Large	Very large
Netherlands	1,980	...	...	...	...
Nicaragua*	14	6	8		
Niger 1/	1	1			
Nigeria e/	30	...	...	...	...
Pakistan	19	...	...	...	...
Peru e/	35	...	...	...	...
Philippines e/	120	...	...	...	...
Poland*	245	115	64	62	4
Senegal f/	12	8	4		
Singapore*	34	10	12	10	2
South Africa g/	580	380	196	4	
Sri Lanka e/	9	9			
Sudan*	4	4			
Swaziland d/	1	1			
Thailand*	27	16	11		
Togo f/	1	1			
Tunisia e/	25	25			
Turkey* h/	82	71	7	4	
United Arab Republic i/	27	...	...	...	...
United Kingdom*	7,000 j/	...	...	...	...
United Republic of Tanzania e/	7	5	2		
United States m/	83,500	...	...	...	...
Upper Volta*	1	1			
Yugoslavia*	147	123	5	1	7
Zaire*	19	11	7	1	
Zambia d/	5	5	2		

(Foot-notes on following page)

(EXHIBIT 2 continued)

(Foot-notes to table)

Note: The classifications in the Secretary-General's questionnaire under "mini" and "small" have been combined for convenience in this presentation.

* Data supplied as official government figures in the form requested in the Secretary-General's questionnaire.

a/ International Federation for Automatic Control.

b/ Of which, 80 in government.

c/ In government only.

d/ Private communication in background paper (Henderson).

e/ International Labour Office background paper.

f/ Institut africain d'informatique.

g/ As of May 1972. Source: Canadian Information Processing Society, 1972 Computer Census (Toronto, 1972).

h/ Background paper (Duran Reyes).

i/ International Labour Organisation, Seminar on Management Training for Computer Utilisation, Bucharest, 1970.

j/ Background paper (Seshagiri).

k/ Communication from M.N. Parlar.

l/ Approximate.

m/ "Diebold annual computer census", Automatic Data Processing Newsletter (New York), 29 November 1971 (data as of June 1971).

Source: The application of computer technology for development ST/ECA/176, UNITED NATIONS, New York, 1973, pp. 29-31.

SOME CHARACTERISTICS OF COMPUTERS OF VARIOUS TYPES

CLASS OF COMPUTER	CHARACTERISTICS	TIME OF PRODUCTION (YEARS)		
		I 1974-75	I. 1976-77	III 1980-85
Mini-computers	Core memory, (words x10^6) Operations per sec. (x10^6) Cost ($ x10^3)	0,032 1 10-20	0,032-0,128 5-10 5-10	0,064-0,512 70-80 3-8
Medium-sized, single-processor computers	Core storage (words x10^6) Operations per sec. (x10^6) Cost ($ x10^3)	0,032-0,512 10-20 60	0,064-2,048 20-30 35-45	0,128-4,1 70-80 25-35
Large multi-processor computers	Core storage (words x10^6) Operations per sec. (x10^6) Cost ($ x10^3)	0,512-4,0 300 260	0,512-8,0 500-600 180-220	4,0-4,0 2000-10000 20-130

THE SYSTEM FRAMEWORK FOR THE PREPARATION OF A REFERENCE HANDBOOK ON MINI-COMPUTERS WITH SPECIFIC COMPATIBLE ORGWARE/SOFTWARE/HARDWARE TO BE USED BY MANAGERS OF INDUSTRIES IN DEVELOPING COUNTRIES. (Under Contract with UNIDO). INTERNATIONAL INSTITUTE FOR APPLIED SYSTEMS ANALYSIS, Laxenburg, April 1977.

(EXHIBIT 4)

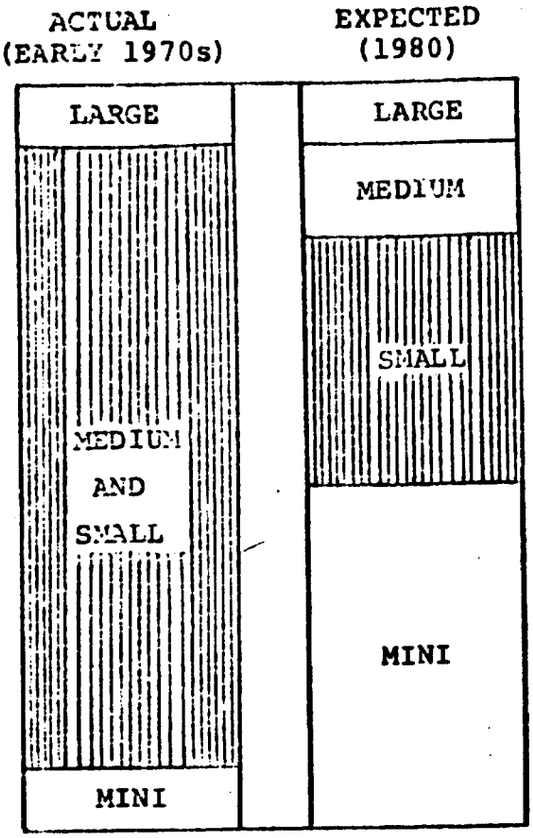
FUTURE COMPUTER CLASSES

COMPUTER CLASSES	MICROCOMPUTER 1977	MICROCOMPUTER 1985	MINICOMPUTER 1977	MINICOMPUTER 1985	MONOCOMPUTER 1977	MONOCOMPUTER 1985	MULTICOMPUTER 1977	MULTICOMPUTER 1985
MAIN MEMORY (bytes)	4-8KB*	32-64KB	32-64KB	0.2-0.5MB**	0.5-2MB	2-4MB	2-16MB	8-64MB

* Kilobytes
** Megabytes

Source: Withington, Frederick G., Beyond 1984: A Technology Forecast, Datamation, 21, 1 (1975), 21 ff.

(EXHIBIT 5)



Source: Butler, R.E., International Cooperation and Regulation for Development, paper presented at the Conference of the International Council for Computer Communication, Stockholm, 1975.

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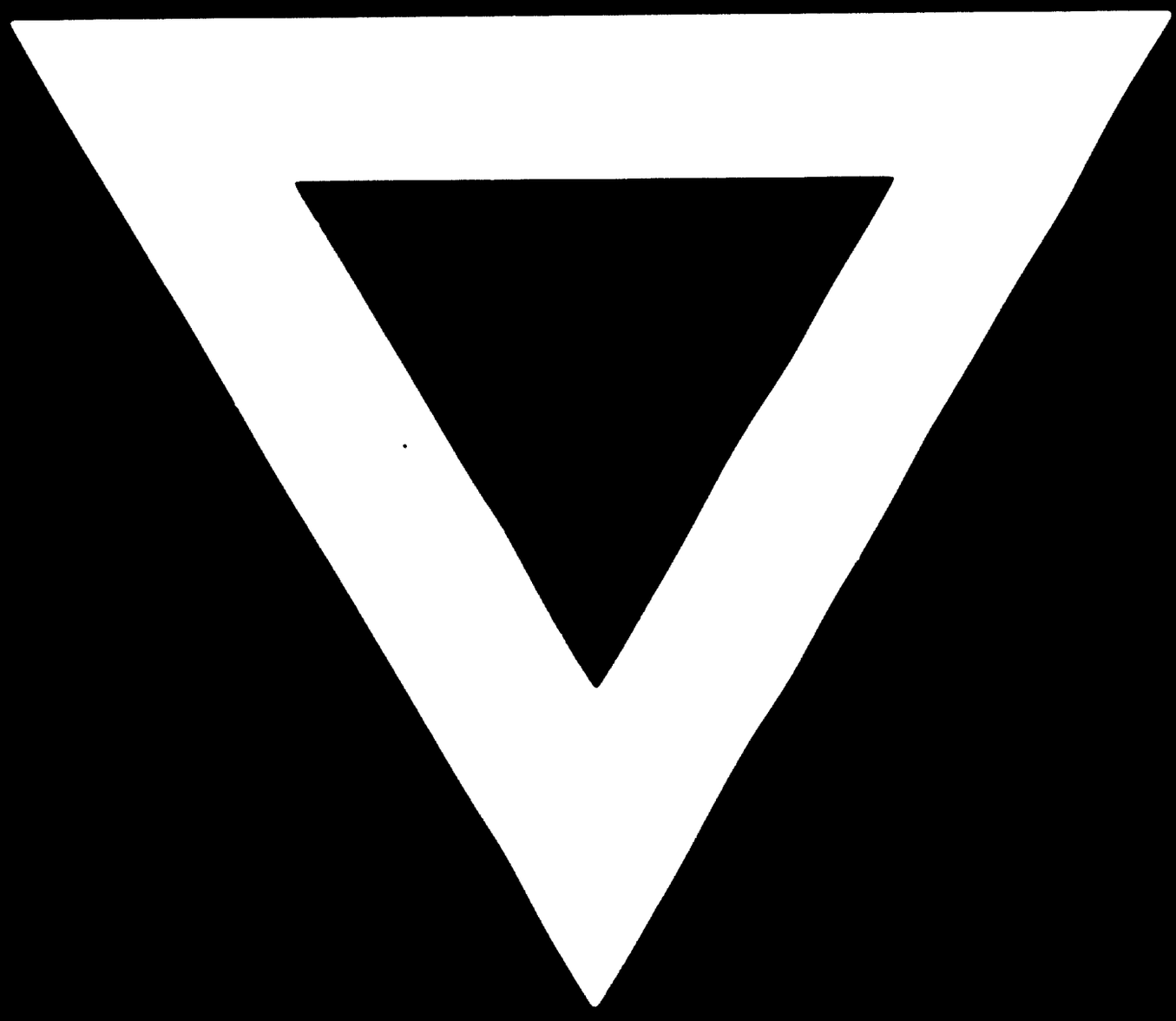

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