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ABSTRACT

At its twenty-third session, the General Assembly adopted resolution 2458(XXIII) requesting the Secretary-General to prepare a report giving special consideration to the situation of the developing countries with regard to: (1) the results already obtained and the needs and prospects for the use of electronic computers in accelerating the process of economic and social development; (2) the various forms which international action may take to intensify cooperation in the field of computers and (3) the role the United Nations can play in promoting international cooperation in that field with emphasis on questions concerning the transfer of technology, the training of personnel, and technical equipment. The report is presented in two parts: Part One discusses programs for developing countries and Part Two deals with caveats, barriers and incentives with respect to computer technology for development. The principal conclusions and recommendations drawn from this report are included. (Author/WH)

DEPARTMENT OF ECONOMIC AND SOCIAL AFFAIRS

the application of computer technology for development

UNITED NATIONS
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INTRODUCTION

General

1. At its twenty-third session, the General Assembly adopted resolution 2458(XXIII) requesting the Secretary-General to prepare a report giving special consideration to the situation of the developing countries with regard to:

(*a*) The results already obtained and the needs and prospects for the use of electronic computers in accelerating the process of economic and social development;

(*b*) The various forms which international action may take to intensify co-operation in the field of computers;

(*c*) The role which the United Nations can play in promoting international co-operation in that field, with emphasis on questions concerning the transfer of technology, the training of personnel and technical equipment.

2. A number of activities were undertaken in connexion with the preparation of this report. The Secretary-General sent a letter and questionnaire to Governments of Member States inviting them to provide him with relevant information in connexion with the above-mentioned resolution (see annex IV). Replies were received from fifty-one Governments. Organizations in the United Nations family were invited to co-operate by responding to a letter seeking their views and experience. This was followed up by visits by consultants to the Headquarters of each interested organization for discussions with their staff. Other relevant organizations in the field of computer technology were also approached and invited to provide information and their views. A number of the important international professional organizations were invited to put forward their comments and views and they co-operated closely with the Secretary-General in the preparation of this report.

3. Pursuant to the resolution the Advisory Committee on the Application of Science and Technology to Development (ACAST) assisted the Secretary-General, and established an *Ad Hoc* Working Group on Computer Technology. During the eleventh session of the Advisory Committee, this *Ad Hoc* Working Group met and made some preliminary comments and observations. In order to supplement the materials, information and suggestions that were presented from all these sources, the Secretary-General commissioned a number of specialists to prepare background papers.

4. From 24 to 27 February 1970, an *Ad Hoc* Panel of Experts was convened by the Secretary-General. The list of members of the Panel and participants is contained in annex III. The report of the Panel

of Experts was widely circulated for review and comments to organizations in the United Nations family, to professional computer organizations and to other interested bodies and individual specialists.

5. The Advisory Committee on the Application of Science and Technology to Development accepted the invitation of the Government of Romania to hold the meeting of its *Ad Hoc* Working Group on Computer Technology in Bucharest on 13 and 14 April 1970 and authorized the Working Group to communicate its views and comments to the Secretary-General on behalf of the full Committee. At that meeting, the ACAST Working Group formulated its views on the draft report which had been prepared by the Panel of Experts. It was also informed of and took into account the comments and observations received on the report of the Panel. The report adopted by the ACAST Working Group is contained in annex II.

6. The present report comprises two main parts. Part One discusses programmes for developing countries while Part Two deals with caveats, barriers and incentives with respect to computer technology for development.

7. In operative paragraph 1 (*a*) of resolution 2458 (XXIII), the Secretary-General was asked to present the results already obtained with respect to the use of electronic computers in accelerating the process of economic and social development. Unfortunately, the responses received from Governments contained insufficient data to provide a clear description or assessment of computer installations or usage in the developing countries. Some useful data were obtained and have been used extensively in the preparation of the present report. The other aspects of the situation specified in the resolution have been dealt with fully in the report. This report should be regarded as a first endeavour to take a general view of the application of computer technology for the benefit of the developing countries; as such, it has been able to point out some of the main elements involved and formulate a number of principal conclusions and recommendations.

8. During the Second United Nations Development Decade, the developing countries will need to call more fully on relevant technology to accelerate their development; computer technology is one important element in determining the rate of technological change. The continuing growth of computer technology and its application in the industrialized countries will be a general feature of the 1970s. Increasingly, it is being recognized that in itself the computer is not a panacea and that all the difficulties and consequences of using computer technology need to be considered. A long-term commitment will be required by the individual Governments of developing countries, which may in turn contribute to lessening the gap between the developed and the developing countries in the application of computer technology. It is expected that the Second United Nations Development Decade will be a period during which the developing countries will be able more fully to utilize computer technology, under sound and realistic conditions, to improve the rate of their desired economic and social change.

Brief description of computers

9. A computer is a device to process information; it has a means of accepting information (input), a means of storing information (memory), a means of processing the information (central processing unit), and an output device. The processor performs arithmetical or logical operations on the data, and the memory stores both input data and intermediate results. The computer memory also stores the information which specifies the sequence of operations to be performed (the stored program[1] or machine language program).

HARDWARE

10. The physical parts of a computing system are collectively called computer hardware.

11. The major components of a computer system are:

(*a*) Input equipment: card readers, punched tape readers, keyboards, document readers;

(*b*) Central processor: the unit which carries out the logical and arithmetical operations;

(*c*) Memory: devices for storing both data and instructions on how to process the data; magnetic cores, magnetic disks or magnetic tapes are examples;

(*d*) Output equipment: line printers, plotters or display devices.

12. Card readers are most widely used for input, but document readers are coming in to use as their reliability increases. A number of companies are developing equipment which enables data to go directly from keyboard to magnetic tape.

13. Central processors vary in capability and in speed; the larger processors are the most economical.

14. Most high speed memories are made with magnetic cores; a few computers have extra high speed "scratch-pad" memories made of thin-film magnetic materials. Intermediate speed memories use magnetic disks or drums, and magnetic tapes serve as slower speed memories. Access time, the time it takes to transfer an item or group of items from its location in storage to where it is needed, ranges from microseconds (millionths of a second) to hundredths of seconds for disk and drums and to minutes for random access to information on magnetic tape. The price for storing an alphabetic character varies with speed, from $0.25 for core storage to perhaps $0.0001 for storage on magnetic tape.

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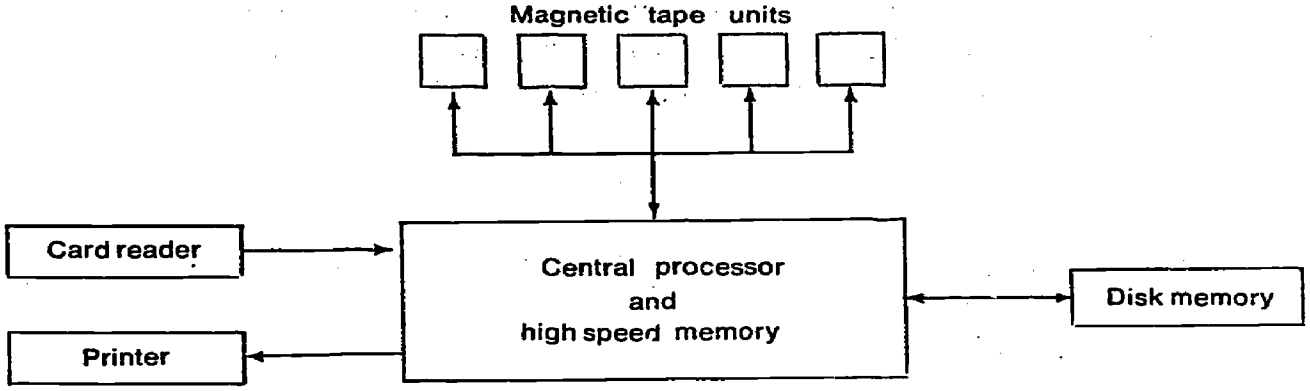
[1] "Program" and "programme" are two alternative spellings for the concept of "a plan to be followed". In this report the spelling "program" indicates a set of instructions and data specifying a computational or data processing plan. For other plans, the spelling "programme" is used—for example, an educational programme.

15. A typical line printer prints a line 132 characters long and at rates of 1,100 lines per minute. Manufacturers are beginning to offer display devices that show text and can do curve plotting.

16. Figure I shows the organization of a typical computer system.

Figure I. Organization of a computer system



17. Systems for administrative and business applications must be capable of handling large files and large volumes of input and output in which the data may be numerical or alphabetical. The terms automatic data processing (ADP) and electronic data processing (EDP) are used to describe such operations. A more complete discussion of computer hardware is given in annex I.

SOFTWARE

18. Before a computer may be used a program must be established in its memory. The program is a set of instructions specifying a sequence of arithmetical and logical operations to be applied to a given set of data (a plan to be followed). When the instructions refer directly to the hardware components of the computer they are converted simply into electrical signals which activate the physical devices. Such a list of instructions and associated data is referred to as a machine language program. Machine language programming is tedious and may give rise to error. Therefore, with the first commercial deliveries (see annex I, para. 5), a symbolic assembly language was developed and a translating program was written: this was a computer program which when executed caused the computer to accept statements in the assembly language and generated machine language commands. This permitted the user to refer to quantities by symbolic names. Along with assembly languages came the technique of developing programs in sections (called subroutines) in such a way that they could be used with other programs, and libraries of subroutines could be collected and distributed.

19. The operating system was a highly significant software development. This is a resident program which allows the computer to accept and process one job after another without requiring operator

action between jobs. There is no waste of time between jobs, an especially important factor when there are many small jobs each requiring only a few seconds to run. Even in large installations working on large problems, numerous short runs are required to "debug" subroutines, that is, to check them for errors. When the pieces are correct, the whole program is assembled and tested on small sets of data. A good operating system can double the throughput (number of jobs run per hour) of a computer system.

20. Systems were developed that would accept a job stream, line up the jobs and select them to be run according to priority. Short "debugging" runs to find errors can then be put ahead of long production problems.

21. High performance systems have several input devices and printers, permitting several job streams at a time. Multiple input/output channels can be established at remote locations to make a remote job entry system.

COMPUTER LANGUAGES

22. Symbolic assembly languages were followed by problem-oriented or procedure-oriented languages. The first of these was Fortran (formula translator) which accepted statements of a mathematical type. This was followed by Algol (algorithmic language) and by Cobol (common business oriented language).

23. The standardization aspects of these languages are of interest. Fortran and PL/1, another computer language, were *de facto* standards established by one computer manufacturer; Algol resulted from professional society co-operative efforts; Cobol was sponsored by the Government of the United States of America.

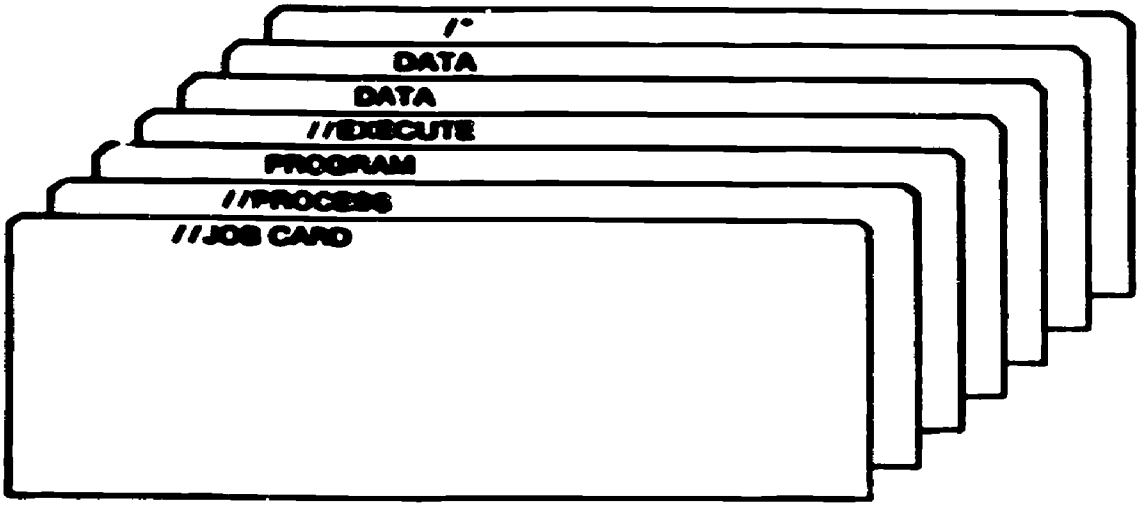
24. In another class, there are special purpose languages. SIMSCRIPT, SIMULA and GPSS are designed for specifying machine tool control. IPL-V, LISP, and SNOBOL are string processing languages for symbol manipulation.

25. Since computer hardware is costly, the first operating systems were designed to keep the hardware busy even at the price of making users wait. A more recent mode of computer operation is time-sharing, an arrangement where one computer serves many users, each at his own terminal. The computer serves each user in turn in such a way as to keep him occupied between turns. Reliable performance of time-sharing systems depends, among other things, upon the quality of the communication lines between the terminals and the computer. Additional descriptions of computers and their uses are given in annex I.

A COMPUTER JOB

26. The functions of software can be illustrated by examining how a computer processes a job submitted to it in the batch mode. For purposes of discussion it will be assumed that the problem is to be read into the computer from cards. For a typical operating system the deck might have the following structure:

Figure II. Structure of a job deck



//JOB CARD	identifies the user.
//PROCESS	specifies the process involved. For example, it may specify that the following cards are in Fortran and that the Fortran translator should be applied to them.
PROGRAM	contains the program. The number of such cards may vary.
//EXECUTE	indicates, for example, that the program should be run after translation.
DATA	contains input data, if needed. The number of such cards may vary.
/*	denotes end of program.

27. The operating system looks for the job card. If the user is on the approved list it continues; otherwise the cards are passed through the reader with no processing and an appropriate message is printed. If the next card says "execute Fortran" the Fortran translator is loaded into the core memory and begins to process the cards of the program. If an error is found, the translation terminates and the rest of the cards are passed through the reader. According to the quality of the Fortran translator, a more or less lucid error message appears on the printer.

28. If the translation is successful the operating system looks at the next control card. If the instruction is "execute", the user's program, the result of the translation from Fortran, is loaded into the core memory and execution starts. If the program calls for data, data cards are read in and the execution of the program continues. Either the program terminates as planned when the end of program card is read, or some unplanned event occurs.

PRINCIPAL CONCLUSIONS AND RECOMMENDATIONS

29. From the information provided in response to the Secretary-General's questionnaire and from the analysis in this report, a number of principal conclusions and recommendations may be drawn. These will require appropriate action by Governments in both the developed and developing countries, by the United Nations and organizations in the United Nations family, by national and international organizations and institutes, by industry both public and private and by national and international professional and user organizations in the field of computer science and technology and in related areas.

Conclusion I:

Education and training for the application of computers to accelerate the process of economic and social development must receive first priority.

Therefore, it is recommended that, in the developing countries:

Recommendation 1—Appropriate centres at the national and regional levels be established or strengthened;

Recommendation 2—Education and training be supported at all levels, ranging through operators, programmers, computer scientists, computer systems analysts, managers and policy-makers as well as the general public;

Recommendation 3—Means be found for creating materials and developing techniques for teaching the effective use of computers and these efforts be encouraged;

Recommendation 4—Better means for exchange of technical information be established.

Conclusion II:

Each developing country needs a broad national policy, consistent with its national goals, on the application of computer technology.

Therefore, it is recommended that each developing country:

Recommendation 5—Formulate a plan containing realistic goals, listed in order of priority, so that orderly short-term and long-term development may take place;

Recommendation 6—Allocate sufficient resources to implement such a plan.

Conclusion III:

International co-operation needs to be increased in activities relating to the application of computer technology to development.

Therefore:

Recommendation 7—The Secretary-General believes that the General Assembly may wish to consider the proposal made by the *Ad Hoc* Panel of Experts and supported by the ACAST Working Group for the establishment of an international advisory board on the application of computer technology for development which could report annually to the Secretary-General who would transmit the report to the Economic and Social Council and the General Assembly. Two broad types of function might be envisaged for such a board:

(*a*) To promote the application of computer technology for development through international co-operative efforts in association with the United Nations family of organizations;

(*b*) To provide, upon request, independent and objective advice to assist developing countries in their decisions on the use of computer technology for their development;

It is also recommended that:

Recommendation 8—Governments of developing countries be encouraged to request the assistance of appropriate organizations in the United Nations family in connexion with efforts related to Recommendations 1-5;

Recommendation 9—Organizations and institutions in developed countries be encouraged to establish "twinning" relationships with organizations in the developing countries and that United Nations programmes support such action;

Recommendation 10—The United Nations family of organizations call more fully on the international professional organizations in their technical assistance and information dissemination activities;

Recommendation 11—Efforts by user groups, manufacturers and the professional community to enhance the compatibility of both hardware and software be encouraged.

Conclusion IV:

Computer technology will increase in importance in the developing countries during the Second United Nations Development Decade and its diffusion and sound application can make a significant contribution in accelerating the rate of their economic and social development.

30. Therefore, it is important that in the developing countries:

(*a*) The analysis and systematization that occur when computerization takes place be recognized in itself as a most significant contribution to improving management decision-making and resource allocation;

(*b*) Attention be given to the need to improve the quality of collected data;

(*c*) The commonality of computer techniques in many disciplines be recognized;

(*d*) The benefits of purchase *versus* rental of computer equipment be carefully studied (In some developing countries, a national leasing company may be appropriate, while in other parts of the world a regional approach to the lease/purchase problem may be desirable.);

(*e*) Trade barriers including customs regulations impeding the international movement of equipment, magnetic tapes and cards be minimized;

(*f*) Exchange of software and data under appropriate conditions of protection be facilitated and encouraged.

Part One

PROGRAMMES FOR DEVELOPING COUNTRIES

I. COMPUTERS IN DEVELOPING COUNTRIES

31. Technology has an essential role to play in reducing the disparities that exist between the developing and the developed countries. Computers are especially important in this context, because 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.

Development and transfer of technology

32. Technology is the knowledge of the industrial arts; a technological change is any change which affects a product or the process of producing it. In February 1963, as a result of the Economic and Social Council's recognition of the crucial role of science and technology in development, the United Nations convened a major conference on the application of science and technology for the benefit of less developed areas.[2] Many of the arguments and conclusions of that conference are relevant to this report. Certain general topics discussed there, such as education and training, methods of achieving international co-operation, organization and planning for development, and specific points such as the desirability of installing older equipment in the less developed countries are important in the context of computer technology. It is not surprising that the precepts which hold for the transfer of technology in general also hold for computer technology in particular; this theme will recur many times in the present report. Since 1963, individual economists and organizations for studying the economies of countries have continued to focus attention on technology, technological change and technological forecasting.[3] Technology is not the only key to reducing the disparities between the developing and the developed countries,[4] but technological progress is essential.

Computers and technology

33. Although in many respects the transfer of computer technology is like the transfer of any other technology, computers have a

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[2] *Science and Technology for Development* (United Nations publication, Sales No.: 63.I.21-28). A summary of this conference was presented in the Report of the Secretary-General to the United Nations Economic and Social Council at its twenty-sixth session.

[3] See E. Mansfield, *Economics of Technical Change* (New York, W. W. Norton, 1968); Organisation for Economic Co-operation and Development, *Gaps in Technology: Electronic Computers* (Paris, OECD publications 1969) and E. Jantsch, *Technological Forecasting* (Paris, OECD publications, 1967).

[4] International Bank for Reconstruction and Development, *Partners in Development: Report of the Commission on International Development* (New York, Praeger, 1969)—emphasizes the urgent measures which will also have to be taken with regard to aid, education, research, trade and population control.

special position. They are the result of one of the most remarkable growths the world has ever witnessed. It is just two decades since the very first electronic computers began to operate, and yet in this short span there have been three full generations of machine evolution. Computers were first used for science and research, and then were rapidly adapted to business and government administration. Today they are used everywhere; in the physical, social and life sciences, in engineering and manufacturing and in the private and public sectors.

34. Perhaps the most important aspect of computers is that in the course of introducing them to carry out a task, people are brought to reassess the whole way in which the task should be done. In fact, computers often lead to a re-evaluation of why the task is being done. This examination of ends and means is fully as important as the introduction of the computer itself. The world has come to recognize that computers can in themselves be one of the principal instruments for the transfer of technology.

35. Significant as the penetration of computers into industry and technology has already been in North America and in Europe, there is no sign of slowdown in the installation of new equipment or in the widening of the range of applications. But in developing countries, as with all too many aspects of technology, computer use is still slight.

36. Even where computers have been introduced there is often underutilization of the equipment because, for example, there are not enough people with training and experience to apply the new methods. Concerted action for the transfer of computer technology to developing countries is of top priority.

Current installations of computers in developing countries

37. One of the purposes of the questionnaire circulated by the Secretary-General to Governments of Member States was to obtain an idea of the number of computers in developing countries, and their use. Altogether fifty-one countries replied to the questionnaire (see annex V): ten in the Americas, seventeen in Europe, twelve in Africa and twelve in Asia and the Far East. As noted by the ACAST Working Group (annex II, para. 18 (*c*)), this large number of replies demonstrates the importance that Member States attach to computer technology. However, the data provided in the questionnaire replies were not adequate nor were the answers sufficiently detailed to give a representative or clear description of the extent to which computers are installed or being used in developing countries. Although some conclusions may be drawn from the available data, much more information on computer installations and applications in the developing countries will be needed if a detailed and meaningful picture of the results and needs for the use of electronic computers in accelerating the process of economic and social development is to be achieved. The ACAST Working Group (annex II, para. 18 (*b*)) supported this view as well as noting the need for more information. Detailed and periodic surveys of the

computer industry and technology in the industrially advanced countries are available, but the results of these are not applicable to the developing countries.

38. Of the Governments that responded to the Secretary-General's questionnaire, three indicated that they had no computers, five that there was one computer in their country and eight that there was more than one computer, while the others did not provide aggregate numbers. Occasionally the distribution of computers between the public and the private sector was given: table 1 lists these figures. By way of comparison with the developed countries, in 1969 Canada had 259 computers in the public sector and 1,669 in the private sector; Japan had 154 and 5,447, respectively.

TABLE 1. SOME EXAMPLES OF DISTRIBUTION OF COMPUTERS IN THE PUBLIC AND PRIVATE SECTORS IN DEVELOPING COUNTRIES, 1969

Country	*Public sector*	*Private sector*	*Total*
India	69	42	111
Chile	18	15	33
Nigeria	7	3	10
Trinidad and Tobago	7	7	14
Iraq	1	5	6
Thailand	6	7	13
Republic of Korea	10	4	14

SOURCE: Information based on replies of Governments of Member States to the Secretary-General's questionnaire.

Applications of computers in developing countries

39. The broad range of computer applications which are important to social and economic development are outlined in annex I, paragraphs 26 to 70. Briefly, these cover the following major activities, within which many subordinate activities can be identified: (*a*) government planning and administration; (*b*) collection of statistics on production and resources; (*c*) management of national industries; (*d*) public health administration; (*e*) preparation of economic indices; (*f*) education and research; (*g*) demographic tabulation, analysis, projection.

40. It is apparent that all these are potentially of interest to developing countries. According to the incomplete information given in the replies of Governments of Member States to the Secretary-General's questionnaire, the applications most commonly found in developing countries are to demography, censuses, and government administration and accounting. Fifty-four different areas of application, not all distinct,

were mentioned by sixteen of the countries. The following areas were mentioned with the indicated frequencies:

Statistical computations	10
Transportation	8
Research computations	7
Accounting	6
Financial computations	6

41. These applications are similar to those first made when computers were introduced into the public sector in the industrially advanced countries. Usually they are automatic data processing (ADP) versions of government tasks which are of major importance. Sometimes the conversion to ADP is undertaken early because it is justifiable and may be readily implemented, for example, where there are good programs available from the manufacturer, people with considerable experience in the application or data in a form easily made machine-readable. Although the simplest applications are not necessarily the best ones to convert to ADP first, they do provide an opportunity for a country to obtain experience.

42. With regard to the ways in which computers are actually used in developing countries, it is possible to point to cases where the approach is as sophisticated and the results as striking as any that can be found in an industrialized country. In general, however, determining where computers can be used to maximum effect in developing countries is a matter of great difficulty and great importance. It depends in part on which sector of the economy it is desirable to emphasize, on national priorities and on the political, social and economic implications of the results. It also depends on certain preconditions, the most important of which is the presence of experienced people. An analysis of the replies to the Secretary-General's questionnaire reveals that the clearest need in the developing countries is for training and education in the field of computers, so that applications important to development can be undertaken. This need is exposed in almost every one of the replies received from the developing countries. In section II of the present report the types of training and education which are needed are considered in detail. After education and training, the need for better access to computing facilities was emphasized. The types of facilities and services which are required in the developing countries are examined in section III.

43. Additional needs include the existence of good data bases and information systems as outlined in annex I, paragraphs 30 to 37. These systems do not necessarily have to be computer-based, but they must be reliable. Simultaneously, it is necessary to develop related disciplines where computers are used—in management science, statistics and operational research for example. These prerequisites and priorities are discussed in greater detail in section VII.

II. EDUCATION AND TRAINING FOR COMPUTER TECHNOLOGY

44. The scale of development described in the previous section demands education and training at various levels, ranging through that of the policy-maker, the manager of the computer centre and the specialist. Above all there must be people at the highest level of government who understand the possibilities and limitations of computers for development and can make decisions concerning them.[5]

Education of decision-makers, managers and computer systems analysts

45. Those who make decisions about the allocation of resources in developing countries are usually sensitive to the political, economic and cultural forces at work within their country and knowledgeable about a whole range of management techniques. It is essential to make those responsible for planning and decision-making aware of the sound, economic possibilities of the computer. Decision-makers are usually overworked; they must nevertheless be encouraged to learn what can be done with a computing system by attending orientation seminars, visiting computer centres, and generally keeping abreast of developments in this field. Otherwise they will be subject to the pressures of local computer salesmen who paint optimistic pictures of what computers can do and fail to tell of the pitfalls and deficiencies. Consequently the costs for setting up a computer operation often turn out to be substantially greater than anticipated and more time is needed for the installation to become productive. Another source of information for the decision-maker is a counterpart in a neighbouring country with whom to compare decisions. This is not always successful as mistakes as well as successful moves may be imitated. In the parts of the world where seminars and courses designed for decision-makers are not available, the United Nations family of organizations or its agencies have an important task in filling this need.

46. Management training programmes include courses on economics, labour-management relations, operations research and systems analysis. Computer systems analysts are concerned with the structure and mechanism of organizations. A basic method in computer systems analysis is to identify the type and nature of information needed by an organization, the origin and recipient of the information, the responsibilities of, and action to be taken by, the recipient of the information and the channels to be used in the flow of information.

[5] See also the comment of the ACAST Working Group in annex II, paragraph 18 (*a*) and (*b*).

47. Since computers are so important in modern information systems, training programmes for both managers and systems analysts should include the opportunity of actually working for a time in a computer centre, as well as attending basic courses on such subjects as flow charting, data preparation, file management and report generation. Of particular interest is the increasing use of computer-based management games where students are introduced to a computer simulation which requires them to compete against others in making decisions and allocating resources. These subjects are being incorporated into the curricula of the management and business data processing courses offered in the industrially advanced countries and the need for them has been clearly recognized in courses offered by the United Nations family of organizations in the developing countries (see section IV). One problem is that unless managers have attended these courses before their computers are installed, the latter will probably be underutilized for a time; on the other hand, the presence of computers is necessary for the courses to be effective.

Training of automatic data processing (ADP) managers and supervisors

48. An ADP manager must understand his computing system and deal with employees, users and vendors of equipment. The only adequate training for the job is years of experience in a computing centre.

49. An experienced manager for a computer centre is hard to find, especially for a developing country acquiring its first computer. The most competent person available should be selected and sent to an appropriate centre to complete his training even before the decision to install a computer is made. Since in practice this seldom happens, the country is often obliged to seek managerial help through a technical assistance programme.

Training of systems programmers and applications programmers

50. Computing systems depend on software related to operating systems, user languages and translators, library programmes and programmes for special tasks. The system programmer must understand how these components fit together: how to use languages and subsystems, correct errors which may be present in a system which has been long in use, install new software capabilities provided by the manufacturer and be able to tell users how to bring their programmes up to date. He must also advise the director of the computer installation about the purchase of equipment and software. Few formal courses for training systems programmers have been developed and so far there has been no alternative to having a trainee spend at least a year in a well run computer centre working with experienced people. If possible he should first have spent one or two years as an applications programmer, and should continue his training through participation in

user group meetings and perhaps even courses sponsored by the manufacturer. Because of the long lead time required to train systems programmers, most installations begin functioning with people who are not adequately trained.

51. Though there are straightforward and well understood procedures for training computer specialists in most categories, computer applications range over so many subjects that no one individual can be expected to be a general applications programmer. A data analyst needs to know which statistical methods are valid. A physical scientist may wish to solve very complex mathematical problems involving differential equations or integral equations and will need to know which algorithms or procedures will yield reliable answers. In other areas of application, such as payroll, the mathematical processes may be simple, but the complexity of choices may be such that it is almost impossible to define the procedures sufficiently clearly to run them on a computer. The applications programmer may be requested to design file systems. He frequently finds himself doing the whole system design. According to the area in which he is working he will find different programming languages such as Fortran, Cobol, Algol or report generating languages, more suitable than others.

52. An applications programmer needs to be highly trained in his own field; instead of a professional programmer being trained to become an applications programmer, it is preferable for the professional in some particular discipline to be given training in programming and so become the applications programmer for that area. The limitations of this method of training should be recognized. Until the person involved becomes proficient in programming, he should be encouraged to review the systems he designs with those who have had extensive experience. This is especially important when creating systems with large data bases, since these are difficult to change once they come into existence. A programming expert, even without detailed knowledge in the field of application, may suggest data structures and programming techniques which can simplify processing and significantly reduce costs.

Training of engineers, technicians and operators

53. Maintenance engineers and technicians need different training from that of computer operators, programmers and users. Their background should be in electrical engineering, mechanical engineering, logical design and communications, and the usual practice is to start with graduates from engineering or technical schools in these areas and supplement their training with courses on computer hardware. When the computer is rented, the prime responsibility for maintenance lies with the manufacturer. When it is purchased there is usually an option to have maintenance supplied by the manufacturer.

54. The choice of continuing contract maintenance or undertaking it locally depends on many factors and there is no obviously best decision for all countries. The arguments for taking over maintenance

are: (*a*) the foreign exchange advantage; (*b*) the forced development of an electronic engineering capability; (*c*) the establishment of a solid base for future development in computer technology. Romania, for example, has chosen this course. They have established a national organization to carry out this function for all computers in the country.

55. The disadvantages of undertaking maintenance locally are: (*a*) the cost of maintaining an adequate supply of spare parts; (*b*) the need for import licences to obtain parts and the foreign exchange problems involved; (*c*) the problems of training maintenance staff; (*d*) the difficulties of acquiring information about current diagnostic procedures used by the vendor; (*e*) access to information about expected failures and failure characteristics of the equipment.

56. Those working with computers for process control and other production techniques will also require an engineering or technical background, preferably in the field of engineering in which the computer is being used—chemical, power or mechanical engineering, for example. Here also training programmes should be arranged with the manufacturers, supplemented by training at installations where equipment is being used for similar purposes.

57. Trainees learning to operate computers do not need an extensive education; they need practical experience in working with computers. In addition to operators, people are needed for data handling and supervision, and for handling files in both machine-readable and conventional forms. A country must have an installed computer to train such workers locally. However, if there are computer facilities in the region it should be possible to send people to them for on-the-job training. The alternative is to depend upon the manufacturer who offers training programmes using his hardware. Eventually such training will probably be given in technical schools. Frequently computer activity in a developing country starts with a commercial installation. Although there are difficulties—private companies are sometimes reluctant to have outsiders using their computers—a developing country should explore the possibilities of training on such computers. Consideration might also be given by private companies in the developing countries, wherever circumstances are appropriate, to the idea of offering their facilities for these purposes.

Curricula and professional evaluation

58. Even in the industrially advanced countries most universities have not provided the professional training for the tasks outlined above. University programmes in computer science concentrate on the mathematical and theorical aspects of computers required for research, including numerical analysis, automata theory, the theory of formal languages and logical design. Courses on programming languages and operating systems are useful to systems and applications programmers. Training for the skills mentioned earlier has usually been given on the job, in schools operated by the manufacturers, in courses sponsored

by the professional societies and, to an increasing degree, in junior colleges and schools. Those universities in developing countries that are building up educational programmes in computing should realize that courses in management science, data processing and systems programming are highly relevant to the needs of the country.

59. One result of teaching these more applied subjects outside the traditional academic disciplines is that formal curricula, teaching materials and well recognized methods of professional evaluation have been slow to evolve. Efforts towards this are now taking place and the United Nations family of organizations can make a valuable contribution to them. Developing countries and their universities need encouragement and support for their recognition of the new technical and professional categories which are being established. In this way young people in the developing countries would be drawn to enter careers in these important fields.

Education and training abroad

60. For many years developing countries have been sending their best students and professional people in the field of computer technology abroad for specialized education and training. Some go to universities, some to governmental agencies and some obtain experience in the private sector. Problems can arise with regard to training abroad. The typical student who is away for one or two years may lose touch with the conditions in his home country and may have difficulty working with or acquiring the confidence of his fellow nationals upon return. There may be a lack of trust if he has been in a foreign political environment, or simply an estrangement due to the existence of different viewpoints. Although it is difficult to plan far enough ahead, it is helpful if the country has well formulated plans and programmes for these students when they return home. In all cases follow-up work should be done with regard to the person who has received training abroad, to evaluate the programme in which he participated and derive the maximum benefit from his experience.

61. An additional difficulty connected with education abroad is the "brain drain", with the attendant loss to a country if the student elects not to return because of opportunities offered him in the foreign country. It has been reported recently[6] that in the United States for every three engineers who have graduated from United States schools a fourth is provided by immigration. Of those from abroad, one in ten comes from India, one in four from other countries of the Far East and forty per cent from western Europe.

62. Where there are national or regional centres to provide training and practical experience, the student is never far from his home environment and many of the problems described above are not present or may be minimized.

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[6] See *Engineer* (March-April 1970), p. 10. See also report of the United States National Science Foundation entitled *American Science Manpower, 1968* (Washington, D.C., December 1969), document No. NSF 69-38.

63. Although there may be regions where it is necessary to create new centres, most countries have existing institutions—universities, technical schools and government-supported facilities—which could undertake either national or regional programmes. In some cases it will be necessary to install or upgrade the computing facilities, but it will usually be preferable to build on an existing structure than to create a new one which may be isolated from the other teaching and operational activities to which it should relate. For this reason it is proposed that the technical assistance programmes described in the next two sections be concentrated, in the main, in existing national and regional institutions.

Educational consultants

64. Another approach to education in the field of computers has been to invite outstanding professional people to set up and participate in educational programmes in the developing nations. An example is the development of the Indian Institute of Technology at Kanpur in India, where from twenty to twenty-five American visitors (each serving terms of from one to two years) constantly augmented the faculty during the first decade of its development. This kind of programme is not without its problems. Professional persons find it difficult to be away from their work for more than one year, and one year is hardly enough to establish a continuing programme. Nevertheless, many university faculty members have participated, because this type of programme can be co-ordinated with sabbatical leave. In some cases, visits of short periods have been successful but all too often the activity dies out and the value of the visit is lost. It has been suggested that the first visit should last at least a year and be followed by several short visits to sustain activities.

65. In order to obtain consultants in fields such as data processing, where people are not usually available from a university under a sabbatical leave arrangement, it may be necessary to employ professional consulting firms. When an expert goes to a developing country as an individual, he may be at a disadvantage with regard to his professional career on his return. But when a professional consultant goes, he is carrying out an assigned task and on return will go on to a new assignment. In this connexion it might be suggested that organizations of the United Nations family should use more professional consultants, particularly for subjects outside the normal interests of the academic community. In proposing this it is necessary to caution against consultants who offer standard solutions applicable in highly industrialized countries but not in developing countries. Short-term visits by experts must therefore be planned carefully with experts in residence and with nationals in the developing countries, so as to draw upon all the useful sources of experience, in both the developed and developing countries. Attention should be called to orientation courses such as those sponsored by the Ford Foundation in India.

These are of substantial help in introducing the visiting expert to his new environment.

Special teaching materials

66. There is a chronic shortage of competent teachers of computing in developing countries. A great effort must be made to provide special teaching facilities and materials to augment the capacity of the teachers and to achieve better distribution of those high quality materials related to the teaching of computing which already exist. Any new teaching materials and techniques must be examined closely as to their educational effectiveness in relation to costs, and alternatives that may be available or could be developed must be considered. Prerequisites of these new materials and techniques, such as opportunities for training teachers in their use, must be present, and the limited experience with these materials under certain conditions in the developing countries should be considered.

67. Among the techniques which have been used successfully are:

"Packaged" teaching materials, such as film strips, slides, video-tapes, films, "programmed-learning" textbooks (possibly accompanied by tape cassettes) and programme packages to be used on time-sharing systems; all the potentialities of audio-visual presentation, preferably with the additional features of "programmed learning" and conversational learning can be exploited. The creation of teaching materials of this sort requires a great deal of manpower, especially in the production and improvement of the contents. However, if the material is used by very many students, there will be an over-all saving.

Television broadcasting: a series of televised lectures on computer programming is a promising means of mass education. Such a series may be incorporated into the curriculum of a programme like "University of the air", wherever these institutions are organized. Here again, tutorials and follow-up work in the form of exercises are desirable.

68. It is important to supplement all the specialized techniques described here with opportunities for personal assistance, and for the submission of practical exercises on computers, as well as with follow-up action. In many cases the follow-up work may be difficult. Even universities equipped with an adequate computer may have difficulty in handling the exercises submitted by a very large number of students. One solution is to use mark-sensed cards or optical character recognition (OCR). By the former method, students mark cards with special pencils and the marks are later read mechanically; by the latter, the markings are read by an optical reader. Processing systems based on these types of input are possible in both a university environment and with programmes offered to the public at large. However, optical character recognition equipment has been developed more recently and is less reliable than other computing equipment. Decisions as to its use require careful control of the quality of input documents.

69. UNESCO should be encouraged to maintain current information about teaching materials and to see that the information is dis-

seminated widely in the professional literature. Although teaching materials have their place there is no substitute for the actual solution of realistic problems on computer.

Specialized training and education

70. In view of the competitive aspects of computer hardware and system development by manufacturers, developing countries will find it particularly difficult to initiate specialized training and education and to build up a group of people with competence in these subjects.

71. For those developing countries in the more advanced levels of computer activity it may be feasible to design and build devices using imported integrated circuits and to develop software systems. In these areas there is substantial technical competence in the universities of the industrially advanced countries and there already exists a policy which facilitates the flow of information. For example, many universities have been designing peripheral devices for their computers and most of the existing time-sharing systems were designed in universities.

III. COMPUTER FACILITIES AND SERVICES

72. This section examines the type of computing facilities which should be available to developing countries, beginning with a discussion of national and regional facilities. Later the equipment needs and services of a national (or regional) computer facility are detailed. Particular configurations or suppliers are not specified, for the choice of these will depend on the companies operating in the area and on the types of equipment available.

National and regional computer facilities

73. The recognition, implicit in General Assembly resolution 2458 (XXIII), that developing countries need computing facilities for social and economic development, and educational and training programmes to use the facilities, was confirmed by many Governments in their responses to the Secretary-General's questionnaire. It is impracticable to entertain the idea of a single, large computing facility sponsored by the United Nations for all the needs of the developing countries. On the other hand, a minimum national computing system represents a substantial investment in hardware, facilities and staff. Although it is a significant step to make the initial installations (see paras. 37-38), many of the developing countries have installed one or even several computers for governmental functions. But small developing nations may not be able to allocate the necessary resources unless assistance is given them in an appropriate way.

74. This leads to a consideration of regional centres and activities.[7] The extent to which United Nations programmes should be based on a regional approach has been much debated. There is always the danger that a regional activity will not function because of primarily political forces dividing the countries of the region. Even when these are not present it may be difficult to establish a region. With respect to computing for example, developing countries with well established computing centres may feel that they will gain from a regional activity. They may wish to educate and train their staff at advanced educational institutions in the developed countries. The choice of whether to participate in a regional activity will have to be determined by each country for itself. For many countries there will be incentives. Even if they are willing to commit financial resources for national facilities, they are unlikely to find the professional staff necessary to operate the facilities effectively. For Africa alone it has been estimated that at least thirty national computing facilities are required. To suggest that the establish-

[7] This question of regional and national activities was discussed extensively by the ACAST Working Group, see annex II, paragraphs 7 to 9.

ment of all these centres in the immediate future should be an initial goal would be unrealistic from the viewpoint of both finance and personnel. Regional computing centres or regional programmes sponsored by the United Nations employing the facilities of national centres can be used as a transitory stage for initial training by countries without computers. Furthermore a regional activity could provide a means of upgrading the level of competence of a national computer activity. Since the technology at a regional centre can be at a higher level of sophistication, it will be easier to attract international experts as visitors and resident staff. There are operational examples of activities on a regional basis in such fields as meteorology and international air traffic. In West Africa, the Airways Corporation, the Examinations Council and the Medical Research Council are cases of effective co-operation. Regional computing activities should be encouraged and supported wherever a group of Governments indicate their wish for co-operation on this basis.

75. If regional centres are decided on, there is the question of how they should be managed and operated. It is proposed in section VI that they be associated with the regional economic commission. A close relationship could strengthen both, for their functions can be complementary.

76. A regional centre may have its own staff and equipment or it may have its own staff and use equipment belonging to other international or to national activities: or again, even the services of staff could be arranged on a contract basis. Generally, it is proposed that the teaching programmes be carried on by visiting staff. In this way the regional centre can vary what it offers to meet the growing demands of the region.

77. With regard to facilities, there is the possibility that one manufacturer or company might be invited to install a facility which would be operated on a service bureau basis. Finally there is the possibility that some agency, such as a consultant group or a university would be invited to install and manage a facility under contract for a number of years.

National advisory bureaux on computing

78. The requirements for computing in government administration are so numerous and varied, and arise in so many functional areas that most developed countries have found it necessary to set up advisory committees, agencies or bureaux for computing. The responsibilities of these groups vary widely, depending on whether the agency is expected to formulate policies and guiding principles for the acquisition of new facilities, serve as an advisory board for co-ordinating facilities and ensuring compatibility, actually carry out service bureau operations for governmental departments or act as a training bureau. Advisory and policy committees exist in Australia, Belgium, Canada, Finland, France, Israel, Norway, Sweden, Switzerland, the Netherlands, the United Kingdom, the United States, the Federal Republic of Germany

and in many other countries. These committees are usually responsible to the treasury or financial department of their respective Governments or exist within an office of organization and management. In many cases they have been set up only within the last two or three years. In some countries there are separate advisory bureaux for the different levels of government. In the Netherlands, for example, there are three automatic data processing committees, one for each of the three levels of government—central, provincial and municipal—and in Israel there is also a special committee for advising municipalities on computer applications.

79. Developing countries often need a source of advice on broad policies related to computers, and to the establishment and management of national computing centres and government bureaux. Regional activities supported by the United Nations through technical assistance programmes are one source of such aid (see paras. 107-108). The professional societies have indicated their willingness to help developing countries (see paras. 142-147) and the Intergovernmental Council for Administrative Data Processing (ICA), an informal body of representatives from centralized government computing installations, is prepared to help (see annex IX).

National computing bureaux

80. Annex I, paragraphs 38 to 42, describes how in the developing countries, as well as those which are industrially more advanced, the basic tasks of government are increasingly being carried out with the help of computers. A frequent approach is to set up a centralized government computing bureau to carry out these computing tasks for a number of government departments. Such bureaux have been set up in many countries, including Australia, Canada, Denmark, Finland, Israel and Switzerland. These bureaux may provide services only for Governments, or they may, as in the case of Chile, undertake work for the private sector as well.

81. As computers take over more tasks in a country, the need for greater computing capacity arises and the problem arises of whether to provide this by acquiring additional computers or by enlarging the capacity of existing installations. This problem is a variant of one which Governments recurrently face: whether to centralize or decentralize their facilities.

82. In favour of centralized government service bureaux there are the following arguments:

(*a*) Costs are lower for a single large computer than for several small machines. (It was noted in annex I, paragraph 21 that doubling the cost of an installation yields approximately four times the productive capacity);

(*b*) Operating and overhead costs, planning, space and salaries, for example, are proportionately less for centralized facilities;

(*c*) It is easier to maintain level, balanced work-loads in a large multi-purpose installation;

(*d*) Better use can be made of a single pool of trained manpower;

(*e*) It is easier to build towards integrated information systems (see annex I.B.2).

In favour of decentralized computer facilities the following aspects may be suggested:

(*a*) Greater independence of tasks and better opportunities to apply priorities and build up specialized operations;

(*b*) Less delay and lower costs for data transmission;

(*c*) Greater protection against breakdown of machines;

(*d*) Work done closer to where the results are needed.

83. The advantages and disadvantages of each system are such that it is impossible to say that either policy is preferable in all cases. Those factors which determine government policy concerning centralization *versus* decentralization in general, namely geographical considerations, cultural differences and variations in the availability of manpower, will also be important for computers. In countries where communications are well developed it is becoming possible to achieve both the economies of centralization and the advantages of decentralization by linking remote facilities, but this option is seldom open to developing countries as yet.

84. The above discussion concentrates on the service bureau type of computer centre. Attention should be called to the research computing centre. An example, supported by the United Nations Development Programme (UNDP) is that of the Computing Research Centre in Bratislava, Czechoslovakia. This Centre has established liaison with the University of Oslo and, more recently, with the University of Texas where similar equipment is installed and which are able to act as a source of visiting staff and of computer programs.

Computer installations

85. Computer systems range through large and intermediate to small systems (see table 2). Recently a number of companies have been offering "mini-computers". These are satisfactory for certain areas of scientific or engineering computation and can be very useful in teaching, especially for a university or country where computer technology is in the initial stage. Since they have no significant capability for data handling and printing, they cannot be used for the data processing and administrative applications which must be possible where computers are to be used for development.

TABLE 2. EQUIPMENT AND CAPABILITY OF COMPUTER SYSTEMS OF VARIOUS SIZES

	System		
	Small	*Intermediate*	*Large*
Input	Card reader 80-200 CPM[a]	Card reader 1,000 CPM[a]	Several card readers 1,000 CPM[a] each
High speed memory ...	8,000-32,000 characters	64,000-256,000 characters	More than 256,000 characters
Disk memory .	0-1,000,000 characters (bytes)	1,000,000-30,000,000 characters	More than 30,000,000 characters
Magnetic tapes	0 or 1 unit	2 to 4 units	More than 4 units
Printers	200-600 LPM[b]	600-1,000 LPM[b]	2 or more at 1,000 LPM[b]
Communication capability ..	Possible	Yes	Yes

[a] CPM = cards per minute.
[b] LPM = lines per minute.

86. Currently, a small data processing system costs about $100,000 and includes a line printer, a card reader and at least one magnetic tape or disk. The cost of the intermediate system ranges from $500,000 to $1 million. It has faster card readers and line printers, more memory (core, disks, and magnetic tape) and a faster central processor. Large-scale systems cost more than a million dollars. Such installations will only be of interest at the operational or advanced stages. The relation between the performance and the size of a computer is discussed briefly in annex I, paragraphs 19 to 22.

87. A computer should have the capacity to process the initial work-load in one shift. Because of the relatively high capital investment, computers are operated during evenings, nights and weekends when necessary; up to four shifts are possible[8] if weekends are included. One of the striking differences between installations in developing countries and those in industrially advanced countries is that the former are often underutilized while the latter are often operating near capacity. This is because the technological growth rate is always very slow at first.[9]

Total cost of a computer centre

88. In too many cases computer centres have been set up without adequate operating budgets. No provision has been made for programming advisers or for key-punch operators or other persons to help in

[8] Because of the requirements for such factors as maintenance, system changes and fault correction it is very difficult to achieve even as much as three shifts of productive operation.

[9] International Bank for Reconstruction and Development, *Partners in Development: Report of the Commission on International Development* (New York, Praeger, 1969), viii (5).

the preparation of the data, always an important part of the work of a government computing facility.

89. The main costs associated with a computer centre may be listed as follows:

Investment costs:

- Feasibility study
- Construction or modification of a building, including installation of air conditioning, power service, false floor for computer cables, storage for cards, magnetic tapes, work space for users etc.
- Purchase of computer, furniture etc.
- Purchase of computer software
- Shipping and installation costs
- Initial complement of maintenance parts
- Taxes (custom duties)
- Data conversion
- Initial training
- Any appropriate capital costs (depreciation, amortization etc.)
- Contingencies

Operating costs:

- Personnel costs:
  - Director, manager, personal assistant, typing and clerical help
  - Systems and application programmers
  - Operating and consulting staff
  - Key-punch staff
  - Maintenance staff
  - Janitorial staff
  - Education and training of staff
- Supplies and recurring expenses:
  - Electric power and water (also for air conditioning)
  - Paper, cards, magnetic tape and disks, and spare parts
  - Rental costs for leased equipment
  - Publication and mailing costs
  - Costs for library materials (journals, texts, computer programs etc.).

90. Even "free" software has implicit costs. The centre has to assign staff time to communicate with the supplier, see that the program runs properly on the local hardware, teach users about the programs and be able to adapt them to the local configuration. A computer centre must be prepared to put much of its resources into software and into service aids for its users. A computer centre even of modest size needs several systems programmers to keep the system up to date by installing new systems, languages, updates, releases and so on.

91. In commercial installations the budget for personnel and supplies can be twice the hardware costs. In educational installations the budget is less than this, because the applications programmers are faculty members and students, not, properly speaking, staff of the computing centre. Any centre with a large service bureau will operate in the

same way, but even there the annual costs for salaries, supplies and services will at least equal the hardware costs. In developing countries the ratio of hardware to staff costs will be higher than it is in industrially advanced countries. A significant budget will be needed for program advisers, for publishing a newsletter for users, for messenger services and the like.

92. The hardware vendor may contract to provide maintenance, although some installations in developing nations choose to do their own maintenance. In any case it will be necessary to maintain a supply of spare parts, and to know the vendor's techniques for fault detection.

Financing of computers

93. Computer manufacturers offer their equipment both for purchase and for rent, and computers are rented perhaps more often than any other type of capital equipment. There are good arguments both for purchase and for renting.

94. A comparison of costs shows that, for most types of equipment, in about four and a half to five years the amount paid out in rental will equal the purchase and maintenance costs. Thus if it is expected that the equipment will be used longer than five years, it would be preferable to purchase it. Moreover, with a purchased machine the hourly cost of operation decreases significantly as use extends into shifts beyond the first, since the capital costs have already been paid and only the marginal operating costs have to be met.[10]

95. In favour of renting as opposed to purchasing the machinery is the fact that computer technology has been changing so rapidly that machines have quickly become obsolete. Even if they do not become obsolete, in many situations the growth in their use is very rapid (a doubling every two and a half to three years is common) and if the pace quickens further, a country may find that it is outgrowing its computer installation and is faced with an expensive upgrading of a purchased machine.

96. Against the above arguments for rent instead of purchase there are the counter-arguments that third generation hardware, together with the associated software, is likely to last longer than earlier models; and that it takes two or three years even to achieve efficient operation, and replacement times of less than five years are not economical. These reasons, among others, led the Government of the United States to adopt a general policy of increasing the proportion of purchased machines in the United States.

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[10] The reduction in the hourly operating costs for second and third shifts is not as great as is sometimes argued. Besides additional costs for power, air-conditioning, supplies and operating staff, there are costs for maintenance and wear on mechanical equipment which are probably proportional to the hours of use. Moreover greater use means greater requirements for user services, and a larger variety of system demands. Nevertheless it remains true that the marginal cost of computer time, in common with that of most production processes, decreases as the system becomes more heavily loaded.

97. In industrially advanced countries another alternative has emerged whereby leasing companies, acting as a third party, buy a computer from a manufacturer and rent it at rates lower than those quoted by the manufacturer. They are able to do this because they undertake to place elsewhere equipment which has become too small for a particular user,[11] and since the original manufacturer provides the maintenance, there is no loss in the quality of service. Some countries may find it advantageous to form a national leasing company, whereas in other areas of the world a regional approach may be desirable.

98. Altogether, the complexities of financing computers are such that it would seem highly desirable to have a place where developing countries could obtain advice on these matters.[12] This is especially necessary since the cost benefits of computers will be different in developing countries, where the labour markets differ from those of industrially advanced countries (see section VII). To have the full range of opportunities, it would also be desirable to find some way of having leasing options extended to developing countries, which so far have rarely, if ever, had this choice.

99. It is often suggested that developing countries install older, second generation computers, but there are arguments against this. First, the equipment is already obsolete when it is removed from service in the developed country, and, therefore, the centres using it will not have the latest capabilities. Secondly, the serviceability of older computers is much less than that of new hardware. Sometimes it has been so poor that maintenance has cost more than the price of new modern equipment and in some cases, spare parts may no longer be available. Thirdly, consulting help may not be available, because people are no longer familiar with the old software. Finally, since in the long run most of the money spent on a computing centre will be for salaries and software, and since the value of the software for older equipment is much less, due to its reduced life expectancy, the real savings will be much lower than the apparent savings.

100. A case for installing older equipment can be made, especially if the cost is low enough, say one third to half of the original purchase price. Transistored "second generation" equipment may continue to be reliable over an extended period, and older machines may come with a very useful collection of routines. However, many developing countries are not prepared to accept the suggestion that equipment no longer considered to be adequate for an industrially advanced country is good enough for them. The ACAST Working Group noted that the arguments against older equipment are generally convincing; there may, however, be particular circumstances in some countries where an exception is in order (see annex V, paras. 14-15). It is clearly necessary for any institution which is considering installing older equipment to examine all aspects of the proposal carefully.

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[11] Furthermore, the manufacturer has other clear choices for funds which are invested in a rented machine and this adds to the rental.

[12] The need for such advice to be made generally available was emphasized by the ACAST Working Group (annex II, para. 15).

Dissemination of computer information

101. As is the case with every branch of technology, information about computers is being generated at an accelerating rate, and there are problems involved in making it available to developing countries. There should be at least one national centre with a good computer library in each country; further, each computing centre will need literature about its own equipment and about applications which are locally important.

102. The literature on computers has an archival component (periodicals, research journals, review publications and the like), and a current awareness component (publications which list the contents of research journals, reports and evaluations of new equipment etc.). In addition there is information which might be classified as ephemera (notices of meetings, conference programmes, notices of software packages, announcements for books, courses and training programmes and so on). Developing countries certainly need a good selection of the archival material about computers, just as they do about other aspects of technology. Methods of financing such acquisitions should be explored, for example, through the United Nations Educational, Scientific and Cultural Organization (UNESCO) and the professional societies. The current awareness material is also valuable, and here the acquisition problems are even greater, for they are usually offered on subscription for rates which can be prohibitively high. A possible solution which would make at least the ephemera available might be to convert this material to microform, that is to print it on microfiches or microfilm; it would then be possible to mail the equivalent of a hundred pages or more of printed material at a rate comparable to that for a postcard. The information contained in the ephemera will be useful to people in developing countries, for it provides an awareness of what is going on in the discipline, makes it possible to order conference reports and instructional materials as soon as these become available, and in general can impart a sense of participation in current activities. Since there are no copyright problems with such material, and there will be no costs for selection and classification (as the material would not be retained more than a few weeks), costs should be low. This type of distribution might be undertaken, for example, by a university in a developed country which is already circulating the material as part of its own library operation.

"Twinning" and bilateral links[18]

103. The field office of a computer manufacturer often does not have good communication with the central office. It is difficult for a computer centre in a developing country to learn about or acquire

[18] For a general discussion of this subject, see United Nations Educational, Scientific and Cultural Organization, *Bilateral Institutional Links in Science and Technology*, "Science policy studies and documents", No. 13; also document E/AC.52/L.82.

software packages. One solution already mentioned in this report is to set up a "twinning" relationship or a bilateral link with a similar installation in a developed country: that installation could undertake, *inter alia*, to collect and send information and software packages to the institution in the developing country. For this system to be most effective the "twins" should have equipment made by the same manufacturer and similar responsibilities within their respective countries for such functions as operations and teaching. In view of the problems of foreign exchange, it may be argued that the costs of the "twinning" services should be absorbed by the budget of the centre in the developed country; but to ensure that the materials sent are always useful, and to encourage an economically viable service it may be better to budget the costs in the developing country. However, a viable arrangement requires extra resources for the institution in the developed country, as altruistic services tend to lapse.

104. Among the reasons why "twinning" is attractive is that it provides a means of personal concern and involvement for people in both developing and developed countries and may be a means of bringing institutions with similar equipment, problems or experience closer together.

IV. THE ACTIVITIES OF THE UNITED NATIONS FAMILY OF ORGANIZATIONS IN THE APPLICATION OF COMPUTER TECHNOLOGY FOR DEVELOPMENT

105. In this section are described the various activities which have for many years been undertaken in the United Nations family of organizations with respect to the application of computer technology for development. These activities involve two substantive divisions of the United Nations, the United Nations Industrial Development Organization (UNIDO), the International Labour Organisation (ILO), the United Nations Educational, Scientific and Cultural Organization (UNESCO), the World Health Organization (WHO) and the World Meteorological Organization (WMO), in addition to the United Nations Development Programme (UNDP) and the International Bank for Reconstruction and Development (IBRD), who are providing support for a number of projects with a computer component. United Nations Institute for Training and Research (UNITAR), Food and Agriculture Organization of the United Nations (FAO), International Telecommunications Union (ITU), and International Atomic Energy Agency (IAEA) also have an interest in the field of computer technology from the point of view of their particular areas of activity.

106. Almost all the organizations of the United Nations systems, including the regional economic commissions, use computers for internal administrative purposes or to fulfil their statutory obligations; in some cases the use is extensive. The benefits arising out of these applications can serve developing as well as industrially advanced countries. Many United Nations and other international organizations are also mechanizing the collection of the data needed for their operation. Many of the organizations of the United Nations family have computer facilities of significant power; among these are the installations at United Nations Headquarters in New York in the International Computing Centre, those of the ILO and WHO in Geneva and of UNESCO in Paris. In most cases there is a willingness to do computing work for developing countries. Many of the organizations have plans for expansion. Such plans inevitably raise questions as to the best way of avoiding duplication of costly investments, a problem which, as already noted, also arises with the expansion of computing facilities in national governmental agencies. The plans of the United Nations family of organizations in this connexion are currently being reviewed and it would be beyond the terms of reference of this report to comment on them.

United Nations

107. Within the United Nations Secretariat two substantive divisions, the Statistical Office and the Public Administration Division co-operate to provide advice on the effective use of computers, support experts and conduct training programmes. Some forty-two man-years of expert advice in this field have been provided to twenty countries over the last twenty years, 90 per cent of this assistance having been provided in the last ten. In addition, over five man-years of regional and interregional adviser services have been provided, mostly involving short-term missions. Persons from the developing countries have been trained through fellowships and orientation services, and since 1961 over fifty fellowships have been granted to students from twenty countries. *Orientation Course in Mechanized Data Processing*,[14] one of several publications since 1964, has been translated into French and Spanish and used widely by public administration institutes co-operating with the United Nations. The assistance (provided by the United Nations) has been directed to the public sector as a whole.

108. In addition to the efforts described above, the Statistical Office has been using computers for the collection and standardization of economic statistics. Prior to 1966, the use of computers was on a contractual basis with service organizations. In November 1965, computers were installed at the United Nations Headquarters in New York and a new section of the Statistical Office was formed: the International Computing Centre. Through the use of these computers, the Statistical Office has been able to establish and operate data banks in such fields as external trade statistics, national accounts statistics, demographic statistics, and industrial commodity production statistics and make them available for economic analysis, projections and planning to other divisions and offices within the United Nations, to the specialized agencies and to Governments and other institutions. The International Computing Centre has also engaged in on-the-job training of fellows in the management of data processing installations and the use of computers for statistical data processing. To date, this work has been experimental in nature and small in scope but, as time and resources permit, it is expected that greater effort can be devoted to this type of training.

United Nations Educational, Scientific and Cultural Organization

109. United Nations Educational, Scientific and Cultural Organization is carrying on a broad range of activities in the field of computer sciences, in co-operation with universities in the developing and industrially advanced countries.

In brief, these activities encompass:

Science: the training of personnel, promotion of international co-operation, study of computers as research tools in science policy, hydrology, oceanography and similar disciplines;

[14] United Nations publication, Sales No.: 66.II.H.3.

Education: the use of computers for educational administration, planning and instruction;

Communication: documentation research and training, library automation, computer models for education, scientific and technical manpower;

Social sciences, human sciences and culture: the use of computers for social science research and documentation.

110. The proposed UNESCO budget programme for 1971/72 contains a recommendation that the Director-General be authorized to continue to promote research in the basic sciences, in particular with respect to computer sciences.

International Labour Organisation

111. For over seventeen years the ILO has, with UNDP support, assisted in setting up management development and productivity centres to provide training in management, consultancy and computer technology; this has in four cases involved the creation of electronic data processing units.

112. In response to numerous requests from other centres to develop computer training divisions, the ILO recently initiated a new programme; "Computer training for management". Studies by the ILO in developing countries revealed the following problems: the need for improved management practices to accelerate industrial growth; insufficient knowledge of the proper use of computers; a proliferation of computer installations, many of which are not used to their full potential; a scarcity of management systems analysts to link management to computers. To resolve these problems the ILO proposes to train managers in the use of computer-based management information systems (MIS) to aid decision-making, and to train systems analysts to develop such systems.

113. On the basis of past experience, the ILO seeks in its new programme to reduce the time and effort involved in developing MIS, by designing general purpose systems and related documentation which can be readily adapted to individual enterprises in many countries. International experts would guide national counterparts in training and in the applications of MIS. Before the arrival of experts on projects, national staff would receive training at a central institute. This would reduce the amount of guidance required from experts, and permit the projects to develop MIS applications more rapidly.

World Meteorological Organization

114. In response to General Assembly resolutions 1721 (XVI) and 1802 (XVII), the World Meteorological Organization has established and is now carrying out its World Weather Watch programme —a global plan for the application of modern scientific and technological developments designed to enable all countries to derive full economic benefits from improved meteorological services. This programme comprises a global data processing system and a global telecom-

munication system, both of which include the use of computers by world, regional and national centres and telecommunication hubs.

115. Assistance for developing countries in obtaining computer facilities in support of the World Weather Watch is available through UNDP and the Voluntary Assistance Programme of WMO. The support to the Regional Meteorological Telecommunication Hubs at New Delhi, India and Prague, Czechoslovakia are examples of assistance under the latter programme. At its headquarters in Geneva, WMO is processing information needed for the operation of the international programme established by it. It prepares its information by computer and also provides operational information required for the World Weather Watch on digital carriers for ready use by the individual countries using their computing facilities.

World Health Organization

116. Since 1964 the following activities have been undertaken by the World Health Organization:

Conference on the application of ADP systems in health administration, organized by the WHO Regional Office for Europe (Copenhagen, 17 to 21 November 1964);

Symposium on the use of electronic computers in health statistics and medical research, organized by the WHO Regional Office for Europe (Stockholm, 6 to 10 July 1966);

Seminar on the public health uses of electronic computers, organized by the WHO Regional Office for Europe (London, June 1968);

Working Group on the Regional Office's activities in the field of medical computing, organized by the WHO Regional Office for Europe (Bratislava, Czechoslovakia, 24 to 26 February 1970);

Advisory Committee on computers in health programmes, organized by the WHO Regional Office for the Americas (Buenos Aires, 13 to 17 April 1970); The establishment, in collaboration with UNDP, of the Central Institute of Public Health, Sofia, Bulgaria;

Course on electronic data processing in health services, organized by the WHO Regional Office for the Eastern Mediterranean (WHO headquarters, Geneva, 25 May to 3 June 1970);

Expert Committee on statistical indicators for the planning and evaluation of public health programmes (WHO headquarters, Geneva, 2 to 8 December 1970).

117. In addition, in 1967, WHO established the Division of Research in Epidemiology and Communications Science with special responsibilities in the application of computer science to health development.

118. The World Health Organization thus contributes to the training of personnel from developing countries in the use of computers and computational techniques in such areas as epidemiology, international health statistics, medical literature, medical research and public health administration.

United Nations Industrial Development Organization

119. United Nations Industrial Development Organization deals with industrial development at both the macro-level and the micro-level. Computers are mainly being used in industrialization surveys for industrial development planning and programming, programme and project implementation and control and information systems as well as project operation.

120. As regards training in computer application in developing countries, the field of project implementation may provide an illustration. UNIDO gears the training to the application of network analysis techniques for the scheduling, monitoring and control of the implementation of industrial projects including techniques for resource allocation.

121. Computer application in other fields is under study by UNIDO.

United Nations Development Programme

122. From the inception of the United Nations Development Programme Special Fund in 1959 up to March 1970, financial assistance has been approved for twenty projects under which a provision is made for computer applications. The total UNDP allocation for these projects has amounted to more than twenty-three million dollars with the following elements directly related to computer operations:

	US dollars
Expert services in the field of computer applications (software)	3,430,000
Training (mainly for fellowships) in computer-based data processing	726,000
Computer equipment (hardware)	4,200,000
TOTAL	8,356,000

123. Of these twenty approved projects, six are in the field of flood control and water resources, six are management training centres, five are computing centres, one is a hydrometeorological institute, one is in the field of public health and one in natural resources. Their geographical distribution is as follows: Europe, nine: Asia and the Far East, five (including one regional); Africa, four (including two regional), the Middle East, one and the Americas, one. Six of these projects are executed by ILO, five by UNESCO, four by the United Nations, two by FAO and WMO respectively and one by WHO.

124. In addition to the above support, UNDP is also providing on request the services of computer specialists under the Technical Assistance component of the Programme.

Contacts with professional computer organizations

125. It may be noted that in establishing and conducting training programmes the United Nations family of organizations has had very little contact with the national and international professional organiza-

tions in the computer field, where a large body of expertise resides. For example, announcements about the courses in professional journals have been infrequent and the societies have rarely been called on for help in setting up courses or finding persons to aid in teaching them. Although there have been some contacts with educational institutions, these have not been extensive. One result is that curricula have not benefited from constant review by those actively engaged in the profession. Another is that the search for persons qualified to teach courses is probably not carried on over a sufficiently wide base. Chapter eight of *A Study of the Capacity of the United Nations Development System (DP/5)* refers to the problems of recruiting staff for the United Nations; advertising in the journals of professional computer organizations would help when instructors and other staff are needed for computer training programmes. Section VI of the present report contains a recommendation concerning co-operation with the professional bodies.

V. OTHER INTERNATIONAL EFFORTS

Governments, educational in itutions and foundations

126. A vital component of foreign aid in the field of computer technology is the support of research and educational institutes in developing countries by Governments and foundations. Often the aid takes the form of contracts to universities from industrially advanced countries to conduct educational programmes in developing countries. Also common are contracts to build computer models and simulations of important sections of the economy in developing countries.

127. In India, there are five institutes of technology, supported respectively by the United Nations, the Federal Republic of Germany, the Union of Soviet Socialist Republics, the United Kingdom and the United States. In all cases the support is for the institute as a whole; sometimes included are funds for computer facilities or computer projects. For example the Ford Foundation support for the engineering programme in Santiago, Chile, included funds for the computer centre, and the support of the same Foundation for the agricultural programme in India included subsidies for establishing computer centres both in the Government and in universities. The Rockefeller Foundation has sent computer experts to the University of Ibadan in Nigeria.

128. Universities in the industrialized countries are obvious candidates for "twinning" (see paras. 103-104) with universities in the developing countries and this type of pairing has been in effect for some time. Aid may take the form of the loan of academic staff, planning of curricula, or provision of teaching materials or research guidance. It should be noted that universities will not be the most appropriate choice for pairing with national or regional centres of the type discussed earlier, where there must be an emphasis on data processing, and computing for government administration.

129. Even a large university can have difficulty in finding enough staff to carry out the extensive programme which should be mounted if the institution in the developing country is to reach a threshold beyond which it can carry on for itself. To overcome this difficulty in the establishment of the Indian Institute of Technology at Kanpur, a nine university consortium, financed by the United States Agency for International Development (AID) was set up. Over a period of years these universities sent some twenty-five professors to Kanpur each year.

130. The Kanpur computer, a medium-sized machine with punch card input-output, a line printer, and three magnetic tape units, was delivered in July 1963. At that time, three visiting experts in computing were already in India. One of these acted as the director of the

computer centre; another acted as systems programmer in developing, modifying and updating the software; the third concentrated on the academic programme. The three set up short courses aimed at introducing persons from university, government and the private sector to computing. At present, the computer centre is operating successfully. It is an essential part of the academic programme and also carries on administrative computing. It is completely staffed by Indian nationals.

131. The need to strengthen research and educational institutions in developing countries was emphasized repeatedly in the replies of Governments to the Secretary-General's questionnaire. It can be strongly argued that in furthering research emphasis must be placed on those aspects of the work which contribute to the transfer of technology rather than on research for its own sake. One way of marking this emphasis is to support those computer centres and computer applications which are important for development.

132. Possible sources of support for furthering computer technology in the developing countries may be forthcoming from Canada, through the International Research Development Centre, from Japan through the Japan Computer Usage Development Institute, from Israel and from France.

Intergovernmental Bureau for Informatics—International Computation Centre (IBI-ICC)[15]

133. The IBI-ICC was created as an international computer centre under the auspices of UNESCO in pursuance of a series of resolutions dating back to October 1946, but it did not actually come into being until November 1961 when ten States members of UNESCO ratified the International Convention bringing it into operation. The member States provide funds according to a scale of assessments proportional to the contribution paid by each to UNESCO. The organizational structure consists of a General Assembly, an Executive Council, and a scientific and administrative staff with a Director at its head. It is located in the Viale della Civiltà del Lavoro, Rome. The General Assembly which meets every two years, consists of a representative of each contributing member State and a representative of UNESCO. The Executive Council which ordinarily meets twice a year, consists of six members elected by the General Assembly and a representative of UNESCO. The Director is appointed by the General Assembly for a four-year term which may be renewed.

134. The IBI-ICC was conceived at a time when many people felt that high speed computers would be large and expensive and that joint action by many countries was needed to acquire and operate a facility which would serve developed and developing countries alike. This kind of co-operation has of course been necessary with regard to high energy accelerators in physics, and the Centre d'Etudes et de Recherches Nucléaires (CERN) facility in Geneva is an outstandingly

[15] See also annex II, paragraph 10.

successful example of international co-operation in that field. But computer technology has evolved differently. The cost of computers is not comparable with that of large accelerators and—what is equally important—computers soon became necessary not only for research, but also for performing efficient operations in a great many activities. The result was the establishment of a market for computers of many sizes and it became possible, and necessary, to have not one but a number of computers in every country.

135. The IBI-ICC was slow to react to the change. It expended a great deal of effort in its early days on acquiring and operating a computer facility which in the end proved to be only of marginal value to its members. Although the initial contacts, through UNESCO, with the international computing fraternity were profitable, there was difficulty in maintaining them. The International Federation for Information Processing (IFIP) grew up independently and absorbed many of the tasks of providing an international clearing house for computer information and of sponsoring international conferences. Membership in IBI-ICC did not grow at the expected rate, leaving it chronically short of funds, and this was both a cause of and compounded by staffing problems.

136. In 1969, the Fourth General Assembly of the International Computation Centre modified the objectives of the Centre so as to make it an intergovernmental bureau for information processing rather than computation, and in accordance with this modification the name of the organization was changed to the "Intergovernmental Bureau for Informatics". This organization is now undertaking to promote the use of information processing at governmental levels through a variety of means, which include sponsoring and conducting education programmes in developing countries in the language of the region. It is also offering to provide a permanent address and secretariat services for international professional bodies and other organizations concerned with information processing.

Private sector contributions

137. Developing countries are bound to have difficulty in deciding how to react to offers of help from companies in the private sector. The record shows that many private companies are prepared to make highly desirable long-term investments of capital in the education of nationals. The importance of the initiative of the private sector in the growth and application of computer technology merits particular recognition, a point also mentioned by the ACAST Working Group (see annex II, paras. 11-12). The Group further stressed the developing countries' need for an authoritative source of independent, disinterested advice in dealing with the private sector.

138. In the computer field, manufacturers send technical and sales personnel abroad on training programmes and courses, often for appreciable periods of time. The computer market, in which one company exercises considerable influence in the world, is highly competitive, and

it is natural for developing countries to take advantage of offers which fall within normal marketing practice, for example, technical assistance in the form of visiting experts. Some companies are prepared to go beyond this by bringing in experts, or arranging for tours (usually by decision-makers) of computer sites even when there is no immediate prospect of a sale. Computer manufacturers contribute to the evolution of the technology by encouraging their employees to participate actively in professional societies. This contribution is not disinterested, but it is valuable. In Latin America it is often the custom for professors to have only part-time appointments in universities; they also are employed by consultant, engineering and manufacturing companies. This connexion between the universities and companies in the private sector has resulted in a vigorous computing industry, not surprisingly with a heavy emphasis on business data processing.

139. Paragraphs 198 to 201 of section IX of the present report suggest ways in which computer (and software) manufacturers might make contributions to developing countries by relaxing the restrictions on the distribution of software. The large educational discounts for computers, which were available to universities in industrially advanced countries for a long time, have without question been an important factor in the widespread penetration of computers into the educational world. The discounts have been reduced to the point where they are no longer significant, but in industrially advanced countries computers are now firmly established in universities so that the effects of the policy change will probably not be severe. Computers are not yet as prevalent in the educational institutions of the developing countries. The reduction of educational discounts and the withdrawal of special arrangements for acquiring computers have not yet been applied as completely there and it is hoped that manufacturers will continue to recognize the case for maintaining these concessions.

140. Help should be expected not only from the computer manufacturing companies in the private sector but also from consulting and software companies and from companies which use computing equipment. These companies have also contributed to the growth of their national computer societies, for example by allowing their technically qualified people to participate in them; this is important because those organizations need members from all relevant sectors of the computer industry.

141. The initiative of the private sector is an important factor in the growth and application of the computer technology. Under conditions that are equally attractive to Governments of the developing countries and to companies in the private sector, the expertise and goodwill of the private sector can be brought to bear on the problems of development.

Professional organizations

142. Both national and international professional organizations may be available for providing technical assistance in bilateral and

multilateral programmes. National professional computer organizations with members from among computer and software suppliers, from among government and commercial users and the educational community render valuable service to the computer technology. The organizations maintain a large network of special interest groups, task forces and committees whose members possess considerable expertise. Government bodies and organizations in the United Nations family do not draw upon them as often as they might. Clearly it is not proper to ask a professional body to carry out a task which might conflict with its own interests; but a professional body can recommend individuals who can advise on the selection of equipment or give an opinion about a consulting organization.

143. There are many other tasks they can do effectively. In several countries the national professional bodies conduct censuses on the number of persons engaged in the computer industry, and on current salary scales. Very often these surveys yield the most accurate statistics there are on the computer industry. These statistics are of obvious help in planning government policy. All national organizations have the education of their members as a goal, and they sponsor courses, hold technical and educational sessions, bring in visitors and conduct visiting lectureship programmes. Their most important contributions, however, are the scientific and technical journals which appear in many countries and in several languages. This computer literature has been of central importance in the emergence of computer science (*informatique*) as a discipline and a profession.

144. National professional groups may be a good source of advice concerning government legislation related to computers. It is particularly relevant to this report that some national organizations in industrially advanced countries have begun to take an interest in helping developing countries. The American Federation of Information Processing Societies, for example, has recently funded a computer internship programme.

145. The international professional organizations have the same aims as the national ones, with international co-operation as an additional objective. The International Federation for Information Processing (IFIP) and the International Federation of Automatic Control (IFAC) (see annexes VII and VIII) have undertaken to assist developing countries. The Intergovernmental Council for Administrative Data Processing (ICA) (see annex IX) is also concerned with helping the developing countries.

146. Among the tasks which international professional organizations could perform are the following:

(*a*) Nomination of representatives to serve on the international and regional advisory boards. This is potentially the most important service they could render; if the representatives are energetic in their participation they will soon become involved in such activities as seminars, advice to Governments on organizing facilities, fellowship programmes and "twinning";

(*b*) Provision of financial help to make technical publications available to members of developing countries, under appropriate conditions;

(*c*) Maintenance of an active roster of experts available for consultant services, short visits or extended stays. This list should be brought up to date at least once a year;

(*d*) Arrangement of sessions of interest to developing countries in the international symposia, and sponsorship of persons from those countries to attend the sessions;

(*e*) Arrangement for some conferences and technical meetings to be held in the developing countries;

(*f*) Support for the translation of texts and important books on computer technology into different languages.

147. The involvement of some professional organizations in the preparation of the present report may be taken as an indication of their responsiveness to the above.

VI. AN INTERNATIONAL ADVISORY BOARD ON COMPUTER TECHNOLOGY FOR DEVELOPMENT

148. Even in those parts of the world where the greatest number of computers are installed, the rate of growth and application of computer technology shows no sign of slowing down. There is a strong desire on the part of the developing countries to increase their participation in this rapidly developing technology so as to assist their development in an economically feasible manner. Considerations concerning the types of policies and programmes for the application of computer technology in the developing countries themselves are discussed elsewhere in this report. At the international level, the Panel of Experts and the ACAST Working Group concluded that an instrument is needed to stimulate the realistic and sound development, application and adaptation of computer technology with particular reference to the conditions found in the developing countries. Such an instrument would take into consideration the work already being done in the United Nations family of organizations and elsewhere. Much experience has already been gained and there are many lessons that may be learned from this experience in both the developed and the developing countries; it can be drawn on still more intensively and the duplication of efforts can be minimized wherever possible.

149. For the achievement of above objectives the following activities may be suggested:

(*a*) Promoting international co-operation in computer activities related to development;

(*b*) Formulating strategies to accelerate the process of development through the application of computer technology;

(*c*) Recommending policies with regard to the application of computers for development for the United Nations family of organizations and for the developing countries;

(*d*) Providing the developing countries with methods for obtaining assistance in all aspects of information processing and computer technology, and reviewing proposals, if requested;

(*e*) Co-ordinating, for United Nations supported activities, programmes and projects on computer technology for development;

(*f*) Sponsoring, promoting and supporting activities of the United Nations and the United Nations family of organizations as well as those of national and other interested organizations related to computers for development;

(*g*) Advising on computer activities supported by the United Nations and its family of organizations, as requested;

(*h*) Involving the major international professional organizations as well as the principal international user bodies concerned with computer technology.

150. To achieve these tasks, the Secretary-General believes that the General Assembly may wish to consider the proposal made by the *Ad Hoc* Panel of Experts and supported by the ACAST Working Group[16] for the establishment of an international advisory board on the application of computer technology for development. Such a board could report annually to the Secretary-General who would submit the report for consideration by the Economic and Social Council and the General Assembly. Two broad types of function might be envisaged for this board:

(*a*) To promote the application of computer technology for development through international co-operative efforts in association with the United Nations family of organizations;

(*b*) To provide, upon request, independent and objective advice to assist the developing countries in their decisions on the use of computer technology for their development.

151. It might be envisaged that the board be appointed by the Secretary-General for a period of three years and meet twice a year. In view of the important role played by UNDP in supporting activities in this field, the Secretary-General would consult with UNDP in this matter. The membership of the board might be envisaged as consisting of twelve experts appointed in their individual capacity by the Secretary-General in consultation with UNDP; representatives of major international professional organizations such as IFIP and IFAC and other particularly user-oriented bodies deemed appropriate by the Secretary-General and UNDP; and representatives of organizations in the United Nations family, including IBRD.

152. In the view of the Panel of Experts and the ACAST Working Group the board must have strong connexions with the international professional computing community through its representatives from such bodies as IFIP and IFAC.

153. The presence on the proposed board of persons of independent judgement, not influenced by existing jurisdictional or political considerations should be of great value. It could be a most important means of ensuring that any policies evolved within the United Nations regarding computing for development are realistic and practical, and also that persons who are appointed as directors, visitors or consultants have the international standing and professional competence to carry out the tasks expected of them. It could be hoped that any proposal for large-scale support by the United Nations of a computing activity would not fail to have the benefit of review and assessment by this international board if it were established.

154. The involvement of the organizations of the United Nations family in this proposed board will be conducive to concerted efforts and

[16] See annex II, paragraphs 1 to 6.

make it possible to draw up the experience of these organizations in their particular spheres of competence.

155. Although there are already persons responsible for some of the functions outlined above in the United Nations system of organizations, United Nations supported institutions or international professional organizations, the scope and importance of the board's activities would make it necessary for it to have its own secretariat of sufficient size to provide services for the board, to facilitate the direct advisory service activities in which the board would be involved and to ensure that it would be fully interrelated with the requirements of the UNDP secretariat. The secretariat would not need to be large, as it would be able to call on outside consultants and make full use of the relevant facilities and expertise of the specialized agencies and the substantive divisions of the United Nations Secretariat. It is envisaged that the secretariat would not need to build up a large operational structure nor should it have a computer facility, for it would be able, as required, to call upon needed resources from facilities within the United Nations system or from other organizations.

156. The ACAST Working Group in its report mentioned its own involvement in an examination of the machinery in the United Nations family for dealing with the application of science and technology for development and stated that the proposed international advisory board and its supporting secretariat reflected the Advisory Committee's opinion that the United Nations machinery must be adapted to the needs of the changing technology and be able to provide the central policy role and the leadership which that changing technology demanded. The Committee considered this to be particularly true if the developing countries were to feel that there was a central point for efforts to encourage the realistic application of the newer technology to their development (see annex II, paras. 1-6).

157. Consideration has been given to meeting regional needs and Governments within a region may wish to consider the desirability of establishing a regional counterpart to the proposed international advisory board on computer technology for development, which should be associated with the corresponding regional economic commission. These regional boards should have representation from the region as well as some members cross appointed from the proposed International Board. The professional bodies and the United Nations organizations should also be represented.

VII. STRATEGIES AND EXPECTATIONS

158. Previous sections of the present report have concentrated on computers in their own right. But the computer technology is only one aspect of the technological activity of a country and in planning its growth it is necessary to relate it to other technological factors and to general national goals and programmes. In this section some of these relationships are examined.

Levels of computer activity

159. As a preliminary step to studying how the growth of computer usage can be encouraged to keep pace with and promote general technological growth, it may be helpful to classify countries according to their use of computers. For this purpose, a four level classification has been drawn up as follows. The ACAST Working Group expressed the opinion that this concept of levels would be useful (see annex II, para. 17).

Level	*Characteristics*
Initial	There are no operational computers in the country. A few nationals have had contact with computing. The only local sources of information are computer salesmen.
Basic	There is some understanding of computers in government (and private) decision centres. A few computer installations are to be found. There are some nationals involved in computer operations. There is some education and training in computer technology in the country. Computers are used in basic government operations.
Operational	There is extensive understanding of computers in government (and private) decision centres. Among the numerous computer installations there are some very large machines. There are centres for education and training in computer technology and some are of excellent quality. They offer degree programmes in computer or information science. There is design and production of software and some manufacture of hardware. Computers are affecting many disciplines, particularly science, engineering and medicine.
Advanced	Most government and administrative work is carried out by computers. There are well established professional activities and national meetings on computers. There is a complete range of quality education and training programmes. The number of computers, of all sizes, is increasing rapidly. Time-sharing, teleprocessing and remote job entry are common. There is design and production of both hardware and software. Many technologies have been changed or are in the course of being changed. New applications of computers are found regularly. There is strong participation in and contribution to international activities.

160. It will, of course, be obvious that the dividing lines between classes are not well defined and a country may be on one level with respect to certain characteristics and on another with respect to others.

161. At the first or initial level there is little computer activity and particular emphasis will be placed on methods of assisting countries in this category.

162. At the second or basic level there are nationals in the country who have been trained abroad and understand the problems of establishing a computer service. Often the first computing centres in a country are established and managed by foreign corporations who give training abroad or on the job. The pay may be above the local average scale, with the result that there will be little transfer of trained people to other installations. Such computer centres do not contribute to the capability of the country in the same way that national or university centres do.

163. The third level is operational. For countries in this category there are numerous well-run computer centres and many people who can give objective advice. At this stage the country is not dependent on the advice of salesmen; the source of information has moved to educational institutions and national or governmental computer sites.

164. The last category is advanced. Here many types of computers are widely used in industry, government and educational institutions. Technical meetings are held frequently and publication of computer information is extensive.

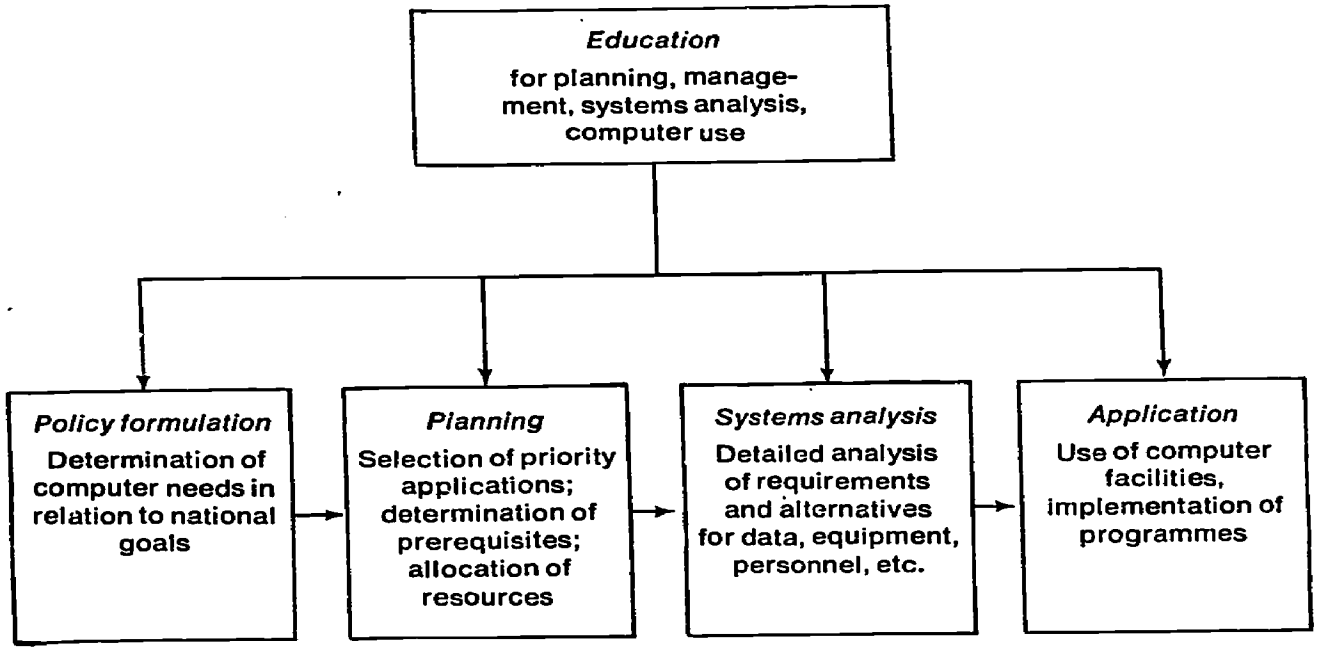
Upgrading the level of computer technology

165. What should countries do to move from one level in computer technology to another—from initial to basic, basic to operational, and operational to advanced? Clearly for countries at the initial level a national computer centre is needed as soon as possible and, until one is available, good access to a regional facility is essential.

166. The first emphasis should however not be placed on the computer itself. It must be on formulating a broad national policy where the role that the computer technology is expected to play in achieving national goals is made clear. From this policy will follow detailed planning, such as the selection of priority applications for computers. Such applications may be to the population census, or to some part of the governmental financial system. In general, applications which can make the maximum contribution to raising the socio-economic level of the country should be sought. The planning will have to include a determination of prerequisites, such as better information, which must be met if the application is to be carried out, and allocation of necessary resources. After priority applications are selected there will have to be detailed systems analyses in which specific requirements are defined, alternatives are investigated and needs for personnel and equipment set forth. As seen in figure III, education will be a prerequisite of every stage of the sequence which leads to the actual implementation of a

computer application important to national development. When a developing country has been able to execute this sequence, even once, for itself, it will be beyond the initial level of computer use.

Figure III. Sequence for applying computers to development



167. To move to the operational stage, the procedure described above will have to be carried out many times and in many sectors. During some of the repetitions it will undoubtedly be necessary to acquire new computer facilities. But computers should be acquired only as needed; they must not be installed on the basis of a vague notion that they will turn out to be necessary. Initially, developing countries will need advice on how to assess their needs, for which they may wish to turn to the proposed international advisory board and the sources described in section VI.

168. To go from the operational to the advanced level is much more difficult. Widespread educational and training facilities for computing are needed. There must be good educational programmes in applied mathematics, computer science, electronic engineering, management science and similar disciplines. The technology must also be supported by other elements of the technical and scientific infrastructure. There must be a reliable communications system so that remote job-entry and time-sharing computer systems can grow. There must be a viable electronics industry to make it possible to design computer components if not whole computer systems.

169. The action required to move from one level of computer techonology to the next may be tabulated as follows. At each transition the actions are additional to those taken previously.

Transition	*Action*
	Decision-makers and planners must participate in explanatory courses on the background and potentialities of computers. Prospective computing managerial and operating staff must work at regional or nearby national centre, attend conferences, seminars and so on. Advice should be obtained on priority computing applications, hardware selection and the like.
Initial to basic	Small to medium-sized computer(s) should be installed for public administration work. Using available computer facilities, training or educational programmes should be undertaken. A national computer policy should be formulated, consistent with over-all goals. Segments of information system should be chosen for computer implementation. A national training and educational programme should be built up, including the establishment of computer science courses at universities.
Basic to operational	Advanced programmes should be initiated by sending some persons abroad for advanced training, seminars, participation in institutional conferences etc. A computer communication system must be built up. Action is necessary to ensure presence of large computers in the country. Selected software development, for example, applications for nationally important industries, should be encouraged. Professional society activity, including publication, also to be encouraged.
Operational to advanced	Government information systems must be integrated. Elements of hardware fabrications which might be useful should be selected. Computer related disciplines, such as management science and operation research, should be built up. Research should be sponsored and encouraged in computer areas which expertise has developed and to adapt computers to special needs. There must be vigorous national societies in the fields of information processing and automatic control. All these will have to be built up patiently with planning and with help from the industrially advanced countries.

"Leap-frogging": skipping a level of development

170. In bringing a technology into a developing country it is desirable to import the best practices, so that the country can "leap-frog" over earlier stages and gain the advantages of the most modern techniques. To some extent this is possible with computers. It has already been recommended (see paras. 93-100) that developing countries acquire, whenever possible, third generation computers because of their increased reliability, decreased operating costs and more versatile software.

171. There are, however, components of the computer technology which should not be adopted until a great deal of experience has been gained and the most careful preparations have been made for them. At this point it may be useful to review those developments in computers which this report has indicated should not be emphasized initially:

(*a*) The manufacture of computers and their components is becoming a more and more highly automated process. Marketing of computer products is highly competitive and has to be carried out on a world-wide basis. With regard to hardware, the research and investments connected with its production will generally go beyond the present and foreseable capabilities of most developing countries, unless they act on a regional basis or belong to the category which has advanced technological facilities;

(*b*) Time-sharing is extremely attractive to users impatient with batch processing delays, and to those who wish access to computers from their own premises. However, not only are the computer costs higher[17] in this mode, but—even more important—time-sharing systems require a reliable, inexpensive communications network. This is lacking in many developing countries. Until it is available time-sharing should be deferred;

(*c*) As indicated in annex I, paragraph 43 to 50 there are certain types of application which are receiving attention in the industrially advanced countries, but which have not yet reached their potential. Included in these are computer-assisted instruction, on-line management information systems and library automation. These will undoubtedly come into their own. But they are proving difficult to implement even in the industrially advanced countries. Developing countries should not undertake them unless they have special knowledge or skills which are pertinent.

172. Many of the applications of computers will have to be realised in stages. In accounting, it may not be necessary to pass through a manual accounting stage, a unit record stage (involving punched cards, printers, sorters and the like, but no computers) and finally an electronic data processing stage. But it is difficult to conceive of an accounting application being introduced as a completely automated

[17] These high machine costs can be offset by lower costs for programmer's time.

process, without a prior operation in which the essential elements of the system have been thoroughly tested without the computer. In general, the systems analysis which precedes a computerized application should be based upon, but not copied from, an operational procedure.

173. The widespread use of computers is too dependent on education, always a slow process, to happen quickly. But computers, and the integrated information system which comes with them, will enable developing countries to plan on a national scale, according to national priorities. And they will be able to do this in ways which even the industrially advanced countries are only now beginning to learn. In this respect computers will make "leap-frogging" possible.