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THE ROLE OF COMPUTERS IN DEVELOPING COUNTRIES WITH REFERENCE TO EAST AFRICA*

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ABSTRACT

The role of computers in economic and technological development is examined with particular reference to developing countries. It is stressed that these countries must exploit the potential of computers in their strive to catch-up in the development race. The shortage of qualified EDP personnel is singled out as one of the most critical factors in any unsatisfactory state of computer applications. A computerization policy based on the demands for information by the sophistication of the development process, and supported by a sufficient core of qualified local manpower, is recommended. The situation in East Africa is discussed and recommendations for training and production of telematics equipment are made.

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1. INTRODUCTION

The computer is designed to assist the human brain to accomplish tasks much faster and more accurately by providing extremely fast computational speed, vast storage capabilities and very high computational accuracy. The technology of computers is 47 years old and yet the computer industry is among the first four largest in the World. In terms of computing power, developments in the technology have been exponential, the fastest available computer being 10^6 times as powerful as the first computer completed in 1947.

The fastest computer today can perform over 130 million floating point operations per second [1]. The role of computers in modern society is demonstrated by the fact that current computer workload will require more than 400 billion qualified people working manually and continuously. Even with this number, errors will occur and some tasks will have to be abandoned because they cannot be done by the unaided brain.

The US has always been the greatest manufacturer, supplier and user of computers in the World. Although there are several manufacturing companies(over 200), the market has mostly been monopolized by IBM. There has been a positive correlation between the extent of the utilization of computers and the economic well being of society measured by GNP. There has also been a positive correlation between the number of computers installed and the number of private enterprises: almost all computers in the US and Western Europe are privately owned. On the other hand, governments use computers extensively and are in fact the greatest single user.

Developments in the computer industry have been characterized by massive investments: IBM for example invested US $ 5 billion to develop the system/360 family of computers and in so doing the company ran the risk of going bankrupt had the project failed. It is the investment policy of private enterprise visa-vis that of public institutions which account for the aforementioned differences in computer developments and utilization.

This has negative implications on poor countries which may not risk investment capital for computers.

The cost of computer hardware has been going down continuously owing to developments in the microchip technology [1]. On the other hand, computer software costs are growing fast. This characteristic on the total cost of computing power is a welcome development for poor countries because software engineering, being essentially a mental exercise, is economically within the capabilities of all countries. Computer hardware technology will most likely remain a monopoly of the developed countries for a long time.

The decision to computerize is both economic as well as political. The outcome of computerization must be justified at least in terms of economic returns: the quest for efficiency alone is not sufficient for poor countries unless such efficiency can be translated into economic savings. On the other hand there are several social issues associated with computerization [2], and the political implications necessitate considering the same in making a decision. This paper presents an argument for aggressive well planned and stepwise computerization in developing countries, with particular reference to East Africa.

2. USES OF COMPUTERS

Computer applications can be grouped into five categories. These are

Management applications (MIS and DSS)

Scientific applications (SA)

Operations and Process Control (OPC)

Education (Computer Assisted Learning - CAL)

Computer Graphics and Image Processing (CGIP).

The scope of MIS includes all aspects of data collection, processing, storage and retrieval using electronic computers. In its sophisticated form it involves the creation, use and administration of large data banks using a complex network of large on-line time-sharing computer systems. All the traditional computer applications, such as in accounting, DP and WP for routine administrative activities, are elementary aspects of MIS. On the other hand,Decision Support System (DSS) software is designed to be used interactively by the experienced manager to arrive at better decisions There is an urgent need for developing countries to more aggressively exploit MIS and DSS capabilities in order to reduce serious management deficiencies which are responsible for many of their economic problems.

Whereas management applications invariably involve huge amounts of data input and few elementary manipulations, SA tasks involve relatively small amounts of input data and several complicated computations. The range of SA problems is quite wide: on one extreme are problems requiring a few instructions such as in solving a system of linear equations. On the other extreme are problems encountered in, for example, space exploration (NASA) and which cannot be solved by even the present day supercomputers (the CRAY and the CDC Cyber 205 systems), with their vector-processing capabilities and speeds of a few nano-seconds per floating point operation [1]. Corresponding to this is a wide range of computers available: the decision on what type of hardware and software to acquire is itself a serious problem which requires professional expertise. In most developing countries, including East Africa, this expertise is lacking and the manufacturer representatives, who are essentially marketing personnel, are often used as consultants on all matters relating to the procurement and utilization of computers. Such

consultancy, being inevitably biased, has often resulted in the procurement of second hand and/or obsolete equipment, or of hardware and software which are incompatible with prevailing conditions.

At present the amount and range of SA's in most developing countries is comparatively small and limited to a few scientific institutions. Small and medium computer systems are therefore adequate.

The domain of OPC employs microprocessors and microcomputers, usually forming a vital component in an industrial plant/machinery. They are characteristic of most capital intensive processes whose preference to labour intensive counterparts depends on political, economic and social considerations. However, there are many applications, such as Computer Numerical Control of machine tools (CNC), Robotronics (in hostile environment) and condition monitoring and fault diagnosis, which have no labour intensive substitute. In this respect, computer technology must be part of the process of industrialization, which is vital for any meaningful development, at least in order to adequately exploit the flexibility (programmable characteristic) of the microprocessor/computer accompanying industrial plants.

The applications of electronic devices such as computers in education is the fourth revolution in the history of education, the previous three being the forming of schools, communication through writing and the use of textbooks. Like the other revolutions, it is founded on the requirement to effectively provide education to large groups of people under conditions of limited human (teacher) resources. The fact that on-line computers can be programmed to respond in an interactive (conversational) mode is exploited to provide socratic-type dialogue, with the individual learner as an active respondent. However, compared to other computer applications, CAL is still in its developmental stages. For over two decades CAL research has been mainly in the development of computer-based learning materials and the corresponding hardware and software [3].

In most developing countries, formal educational of any kind is a privilege of only a few people. It would therefore appear ridiculous to talk of CAL in these countries when even the electrical power to drive the

computers is a scarce commodity. It is however important to realise that CAL is as important to, say, the African child as it is to the American child, and any discriminative wide-spread use of CAL by the present-day developed countries will greatly widen the gap between them and the developing countries. The basic problem in developing countries is economic under-development and so it is decisive to know the future implications of remaining passive in the computer revolution all efforts to narrow the economic gap will most likely be negated by passiveness in technological developments. It would appear that the most logical choice is to participate in this revolution at the maximum level allowed by the economy.

CGIP is the application of pictorial computer communication techniques to analyse and synthesise images and pictures of real or imaginary objects. Uses of CGIP include interactive plotting in business, science and technology, cartography, Computer Aided Design (CAD), Simulation and animation, and process control. The technology of CGIP is relatively new and its applications in most developing countries is limited to engineering design and training purposes. This is presumably due to the high costs associated with CGIP equipment and software as well as the low scope of applicability characteristic of technological and economic underdevelopment.

3. INFORMATION, PLANNING AND DEVELOPMENT

The unwritten goal of all developing countries is to develop an industrial and technological infrastructure matching that in other countries of the world, thereby stop being called "developing". In other words, a developing country is constantly striving to "catch-up" in the development race. This means that the average rate of development of a country in the time lapse it will take to catch-up must be greater than that of her competitors.

The basic characteristic of developing countries is poor planning.

Economic and technological underdevelopment are but the most noticeable consequences of poor planning. Figure 1 shows the relationship between the three: sound planning leads to economic and technological development. On the other hand, planning for economic development needs a technological input, and vice versa.

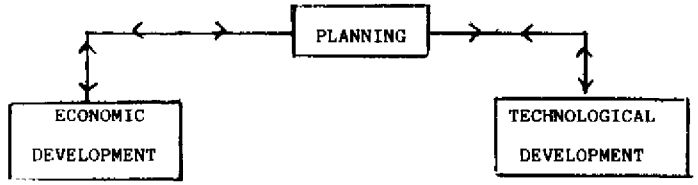

Figure 1: Relationship between planning and economic and technological development.

Other characteristics associated with poor planning are the presence of large reserves of undeveloped resources amidst poverty, non-optimal utilization of energy, shortage of skilled, and abundant availability of unskilled, manpower, and shortage of vital and reliable information required for planning.

In order to obtain required information for planning, sufficient, correct and relevant data must be collected and processed accurately, moreover, the processing speed must be high enough to guarantee timely delivery to the planners. Both the data and the information generated may have to be stored in a form appropriate for future retrieval. All these qualities and functions (underlined), coupled with the large number of variables involved in a typical national planning exercise, point to the need for employing Electronic Data Processing (EDP) methods. The connection between data and planning is shown in Figure 2. It is important to cost correctness, completeness, timeliness and all the other qualities of information in any cost-effective analysis of computerized vs. manual DP system.

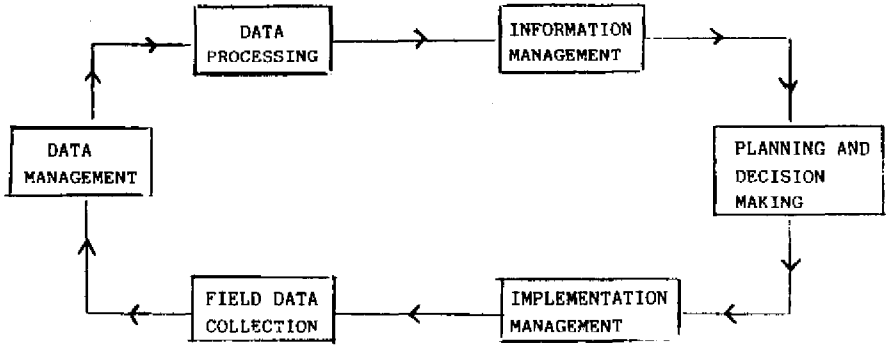

Figure 2: Data Processing (DP) and Planning

The development and exploitation of natural resources, which are vital for developing countries, often pose problems of optimization. There are normally several possible alternatives for a given project and it is often impossible to explore all possibilities without the aid of a computer (simulation). The following extract from reference [1] may illustrate the situation:

> "A certain Oil Gas Company was faced with a decision about the method of development to use for an oil field. Analysis of the field on the CRAY-1 resulted in a decision that was expected to produce about 7% more oil. The estimated extra profit is enough to pay for many CRAY-1 computers."

It is a well known fact that almost all optimization models require computers. Computers can also be used to monitor and predict the productivity of individuals and therefore assist in finding a solution to the manpower deployment problem facing many countries. Social services such as banking and insurance can be greatly improved using computers. Simulation models can be used in training professionals (e.g. managers, doctors) in areas where practical experimentation may be impossible or too expensive. These and many other applications indicate the usefulness of computers in bridging the gap between developed and developing countries.

The requirement to introduce computers in the development process is

an inevitable consequence of the demands for better information by the process as it becomes more sophisticated (see Figure 3). Thus the rate of development is positively correlated with the rate of generation and utilization of required information. It is informative to note that telematics technology (integration of informatics and telecommunications) developed from the recognition of information as a powerful force for development. With more sophistication in the development process, it becomes necessary for computer systems at remote locations to be linked by telecommunication lines so that they can communicate and share work-load as well as information and data.

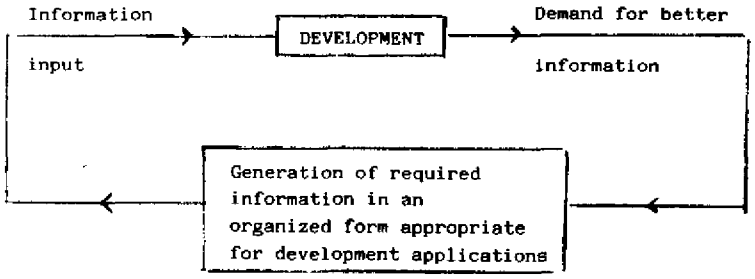

Figure 3: Information and Development

Computer communication across national boundaries (Transborder Data Flow or TDF) is currently an international issue [4]. Developing countries should participate in the on-going debate on TDF as well as in other international activities on information technology, and get prepared to benefit from them, lest they become suppliers of row data, for processing and storage in foreign data banks, and importers of processed information. Unlike the row materials currently being sold, row data is often obtained freely using remote sensors on satellites and as a by-product of multi-national contracts. Thus in addition to financial loses incurred by the host country, the information processed by these multinationals in their home country computers is used to enrich their data banks which may later

be used as instruments of suppression for developing countries. Examples are geological exploration and economic data which, when processed, may provide useful information for negotiating future contracts and for formulating future export-production and marketing policies. Information is an economic commodity as well as power. What is being advocated is not that dealing with multinationals is bad but that developing countries should process their own data to create the necessary information power required in the conduct of negotiations.

4. THE TELEMATIC REVOLUTION

Telematics technology is the third major revolution in human history, the others being the agricultural and the industrial revolutions. It is essentially three revolutions in one, namely a second industrial revolution, an information revolution and a communications revolution. First, the use of micro - and mini-computers has revolutionized traditional methods of production, resulting in new products and increased quality and quantity. Secondly, digital and analogue electronics have made possible the representation of any information in digitized form. Thirdly, new innovations in telecommunications have resulted in machine socialism: computers can communicate and share information and workload.

The impact which this revolution has already made on society could not be anticipated four decades ago when the first computer was made. Computers are now used in almost all areas of human activity and are indispensable in large applications such as in the transportation industry. In officies the computer is replacing the typewriter and file cabinets; in education, computers are becoming indispensable teaching aids, and computer literacy is about to become as important as knowing how to read and write; in providing social services, the computer has found immense applications in areas such as banking (e.g. to process checks, effect electronic fund transfers and provide automatic teller services), transportation (e.g. scheduling and reservations), insurance, hospitals, libraries and shopping

centres; and in corporations, computers handle all data processing tasks such as accounting and personnel management.

With new developments in areas such as VLSI (Very Large Scale Integration) electronics, the use of Josephson junction devices, artificial intelligence and CAD, it is even more difficult to predict the future impact of computers on society. Already the Japanese are working on their fifth generation computer that is expected to bring radical changes in the computing industry. They are out to produce, among other things, intelligent robots and language translation systems. Some authorities predict that in the not too distant future, teleconferencing, remote medical treatment and home shopping and business will be common features made possible by telematics technology. On education it has been predicted that computer technology may compress the present first degree University programme to be attainable at the age of 12 years.

Developing countries must take note of the fact that this revolution is raising the concern of even developed countries like Canada which are pioneers in telematic [4]. A short-sighted consideration of the role of computers in developing countries might lead to a decision to decomputerize. After all it can, and it had been, argued that four decades ago there were virtually no computers and yet the atomic bomb was made and business was conducted profitably. However, for common applications, there are basic reasons for computerization, including to reduce operational costs, produce more timely and accurate information for decision making and to improve services. The proponents of decomputerization fail to appreciate the savings made through improved customer services in areas such as banking where long queues result in wastage of thousands of useful man-hours each day.

Information exchange (TDF), especially among developing countries, is vital for accelerated development and is virtually impossible without telematics technology. The need to belong to the society of man as a scientific being adds to the urgency of taking this technology more seriously. If the developing countries remain passive in the revolution then they will most likely experience a technological shock worse than any before, and

become even more underdeveloped. The present situation is a result of passiveness in the earlier revolutions. Developing countries should exploit fully any innovation which may otherwise increase the political, economic, scientific and technological inequalities. They have the advantage of moving faster by not repeating the mistakes made by the developed countries in arriving where they are today.

5. THE SITUATION IN EAST AFRICA

The most ideal computer mankind will ever be able to produce will be totally useless if there is no qualified manpower to develop and implement the required application software systems on the machine. This fact has been overlooked or underemphasized in several unpublished reports on the relevance of computers in East Africa.

Computers were first installed in East Africa in the early 1960's by ICL which also established a training school in Nairobi in 1963 [5]. In the case of Tanzania, however, the first computer was installed in 1968. By 1972, the role of computers in the development of Tanzania had become an issue, and by 1976 some authorities were talking of phasing out computers. It is needless to say that throughout the period 1968 to 1976 there were very few computer specialists in Tanzania and therefore the "phasing out" philosophy is not a surprise. In his assessment of computer use in Tanzania, Baseley [6] said

> "the biggest stumbling block in discussing the problem and possibilities of computer use is ignorance".

To date, the situation as regards manpower has not changed significantly.

The Tanzanian experience is representative of that in East Africa with minor variations. Kenya has been leading in the number of installations while Uganda has had the fewest. The variations reflect the different policies: in Kenya, unlike the others, the majority of the installations

are owned by private companies.

Computers should be used to relieve man of laborious repetitive computations so that he can use his talents in a more productive and intellectual manner. Both the computer use and the use of the relieved manpower must be stretched to the limits in order to fully appreciate the benefits of computerization: the law of division of labour between man and machine is strictly applicable. It follows that computers are an economic burden in any disorganized and undisciplined society where the motivation for work and the means for enforcing work discipline, are absent or seriously deficient. In such a society the computer will not only be underutilized and misused but the relieved manpower will be wasted or misused for negative productivity. It follows that any assessment of the role of computers in development must include an assessment of the philosophy of work in the developing society. Poor manual systems and mismanagement are manifestations of poor philosophies and any attempt to computerize such systems will fail because of the GIGO (Gabbage in Gabbage out) phenomena.

The literature on computers in Tanzania, for example, shows quite clearly that computers were introduced without adequate preparation (e.g. manpower training) and assessment of both their role and the state of the manual system which were to be computerized: time was needed for organizational maturity. To complicate the situation, user and managerial computer awareness was poor while local competent computer personnel were too few to manage even one installation adequately. Notwithstanding the unfavourable conditions, dependence on foreign procurement consultancy brought computers prematurely to Tanzania. The situation has not changed significantly today although the monopoly previously exercised by ICL has recently been broken by installations of Wang computers.

Most of the computers in East Africa, and particularly in Tanzania, have been and are still being used for traditional clerical replacement tasks such as accounting. In economic terms, this type of usage is alone not sufficient to justify the associated outflow of hard currency. As an example, applications in, say, billing, payroll and general ledger do not generate hard currency and can be done manually: they should constitute only a small

portion of the usage. Applications such as MIS and DSS which cannot be accomplished manually are appropriate because they promote productivity in ways convertible to hard currency earnings.

In summary, the state of EDP in East Africa, as in many other developing countries, has been, and is still, unsatisfactory. This is almost exclusively due to shortage of EDP specialists who are in addition familiar with the local situation. The manpower problem has not been given the seriousness it deserves in any of the available literature: it is mixed up with other administrative, organizational and technical problems for which it is directly or indirectly the cause (see, for example, [6]). The greatest mistake has been to leave a greater part of computer manpower training in private hands, and worse still, the manufacturer. Courses have been organized for durations of as short as two days at exhorbitant costs: anybody who has attended formal training knows how much one can learn in one year, leave alone two days. In any case, while such courses are appropriate in certain situations, the experience of the last two decades leaves no doubt that a more organized system for manpower development is urgently needed. It is the opinion of the author that computers will continue to be misused or underutilized until the manpower problem is solved. Moreover, due to high demands and attractive terms of employment for EDP specialist almost all over the World, the solution lies in training and retaining local experts.

6. CONCLUSIONS AND RECOMMENDATIONS

From the presentation in the previous section it can be concluded that the future of developing countries will be significantly determined by their telematics infrastructure. This includes adequate telecommunications networks, informatics equipments, enough skilled local manpower, and a certain level of computer literacy.

The initial investments, both in terms of materials, financial and human resources, required to set up an appreciable infrastructure, are far beyond the economic capabilities of most developing countries taken individually. This assertion is in view of the revolutionary rate of development of new innovations in telematics technology, implying that time is an important factor, and so developing countries cannot safely take an evolutionary attitude.

The manpower problem has been identified as the most crucial and basic. Figure 4 shows the flow chart for systematically creating on EDP system whereby manpower training precedes procurement of EDP equipment which is in turn determined by the level of development through requirement for better information. In particular, paths 0131 and 0141, corresponding to the manual systems, should mature before paths 0232 and 0242 are entered. In other words, only efficient manual systems should be computerized with the objective of providing required improvements.

There are essentially two basic recommendations, one on training and one on acquisition of equipment. Once the appropriate manpower is available, other problems will naturally be taken up: the secret of development is the combination of natural resources with science and technology.

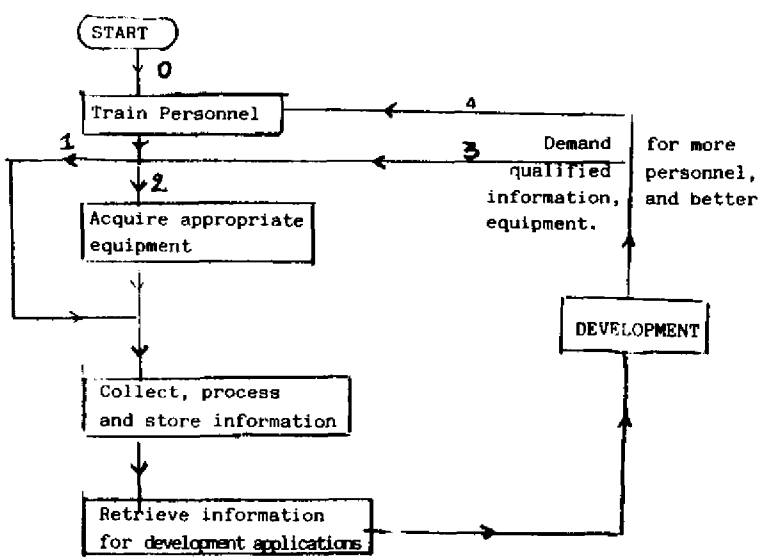

Figure 4: Transition from manual to EDP system

Training

The training of telematics personnel must begin with the popularization and strengthening of mathematics and physics at all levels of education. These two disciplines are core to the success of any future plans with respect to telematics technology. In the case of East Africa, for example, and particularly in Tanzania, mathematics and physics teaching suffer from shortage of teachers, textbooks and other teaching aids. The popularity of the disciplines is eroded further by limited career prospects: areas such as DP which could widen the career opportunities are yet to be sufficiently appreciated. The following recommendations are therefore appropriate:

1. Computer literacy courses should be more aggressively organized for managers and decision makers with a view to raising the level of appreciation of EDP. This should be a permanent feature in order to keep these cadre informed of new developments.
2. The physical sciences curricula for at least secondary schools should include computer courses. This is the case for elementary school curricula in some advanced countries. It should be appreciated that courses like computer programming have the added advantage of training the mind to approach solutions to problems in a systematic and organized manner.
3. All efforts should be made to inculcate interest among scholars particularly at the pre-University level, followed by appropriate expansions to allow more student intake in these disciplines. Mathematicians and Physicists of proven ability who show interest in aspects of telematics should be encouraged and enabled to pursue advanced training in relevant fields anywhere in the World.
4. The computer science curricula at the Universities and other institutions of higher learning should be strengthened. In particular, Universities should offer an undergraduate degree course in computer science, or one with computer science as one of the major subjects. Moreover, all scholars in disciplines likely to lead to managerial or administrative posts should be

required to take EDP courses.

5. Upgrading courses should be organized as a permanent feature for all DP personnel.

The ability to train EDP professionals locally requires the necessary facilities such as computer systems. These should be of the highest quality within the economic limitations. Since the University is the highest institutions of learning, it should be the proper location for the best machine: this will serve the dual purpose of teaching and providing services to customers. Professionals trained with inferior equipment will not be adequately qualified to work with superior machines, and they will lack confidence in handling EDP matters, at least in their initial employments. At the pre-University level, small micro- and mini-computers may be provided for demonstration purposes. With present hardware costs, these are too cheap for the education they provide and are within the capabilities of any developing country. In extreme economic conditions, they may be provided to selected schools with strong bias for mathematics and physics.

Acquisition of telematics equipment.

As a short term measure, equipment should continue to be imported as demanded and paid for by sophistication of the development process. However, in the long run, developing countries should aim at producing their own equipment . In order to achieve this within a time limit which is compatible with the rate of change of telematics technology, a regional approach is essential (this applies to any other sophisticated and expensive technology). Already regional collaborations exist in other fields such as management sciences (e.g. ESAMI), and the lack of one in telematics can only be due to illiteracy coupled with conservative attitudes to maintain the status quo. In this connection, the following proposal is made:

6. A regional telematics Centre should be established with the long term aim of producing equipment , including computer hardware and software.

According to Figure 4, this centre should start operating only after training the required manpower. The experiences of countries like Brazil and India should guide the development of such a centre.

This proposal is contrary to several documented opinions that developing countries should not embark on computer hardware manufacturing (see, for example [7]). It is the contention of the author that such an opinion is ill-founded, being based on the current state of semi-conductor and electronics technologies in the developed countries, and the weak economic and technological base of developing countries. It is worth noting that the above technologies are hardly 20 years old! Moreover, when it comes to, say, purchasing military weapons nobody cares to remind the developing countries that they are economically poor. It is to be expected that computer manufacturers in developed countries would wish to continue monopolizing this technology and as such encourage advising developing countries not to think of manufacturing their own equipment. To invest is to risk and develop at least in terms of increased mental power to tackle future problems; not to invest is to underdevelop both mentally and economically as well as risking the freedom for self determination.

The dangers of perpetually depending on foreign manufacturers for the supply of informatics equipment and software are so serious, politically and otherwise, that urgent remedial action is required. It is worth noting that some countries like China and North Korea realized this option much earlier and now they are self-reliant. It is however needless to say that progress in telematics technology depends heavily on progress in other associated technologies.

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