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12 OCTOBER 1989
ENGLISH

ASSISTANCE TO KING ABDULAZIZ CITY FOR SCIENCE AND TECHNOLOGY (KACST) FOR THE ESTABLISHMENT OF A NATIONAL SOFTWARE DEVELOPMENT CENTRE

UC/SAU/89/060

KINGDOM OF SAUDI ARABIA

Technical Report: Preparatory Study for the Establishment of a Saudi National Software Development Centre

Prepared for the Government of the Kingdom of Saudi Arabia
by the United Nations Industrial Development Organization

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Based on the work of R.H. Anderson, Computer Industry Expert

United Nations Industrial Development Organization

Vienna

TABLE OF CONTENTS

I. EXECUTIVE SUMMARY

Computers are used throughout the Kingdom of Saudi Arabia for administrative and financial processing, data base systems, modeling and simulation for planning, real-time process control, communicating to organizations external to Saudi Arabia, and a variety of scientific and other business applications. For these systems, software development is a vital, ongoing process that requires a large number of highly trained and skilled Saudi personnel, as well as many expensive expatriates with special skills. The question addressed by this report is: Are the tools and methodologies to develop software that are being used within the Kingdom effective and efficient ones, or could this time-consuming process be done better? To answer this question, the King Abduzaziz City for Science and Technology (KACST) asked that the U.N. Industrial Development Organization (UNIDO) undertake a study of software development within the Kingdom, and provide conclusions and recommendations addressing the question. During May 24 through June 22, 1989, Dr. Robert H. Anderson, a U.S. computer expert and consultant, conducted a study mission to Saudi Arabia as a consultant to UNIDO. Dr. Anderson studied training in software development being conducted by the Institute of Public Administration, the National Computer Centre, and private sector companies. He visited key universities and organizations that are users of computer technology. Dr. Anderson prepared a draft report of his findings which was subjected to review by members of KACST and other Saudi government organizations, universities, representatives of UNDP and UNIDO, and by three internationally recognized computer experts. This report contains the findings and recommendations resulting from this study mission and incorporates the recommendations and conclusions of the review meeting.

Important factors to be considered in considering the state of software development within the Kingdom are global trends in computer technology; they strongly affect future options and opportunities. Among the key trends that will affect the Kingdom are: (1) powerful personal computers and graphic workstations bringing computing power and highly interactive systems to individual software developers and users at very reasonable cost; and (2) standardization of many key software and hardware systems, such as MS-DOS and UNIX as standard operating systems, the Postscript page formatting language, Ethernet, TCP/IP, and X.25 as networking standards at various levels. These standards allow computing to be purchased in smaller increments as needed, various manufacturers' equipment to coexist on local networks, highly interactive computing power to be put in the hands of an individual software developer or user, and computers throughout the Kingdom and the world to exchange information with each other. For these and similar reasons, the tools and techniques available for effective software development are changing, and the types of systems being developed are also changing.

This study has concluded that there are a number of problems involving the effective use of computers within the Kingdom that need to be addressed. The key problems are:

(1) Existing computer facilities (primarily mainframe computers) are not being used effectively. Over 8 billion Saudi riyals have been spent on computing facilities in the Kingdom, with a similar amount invested in software and programming for these machines.

(2) There is a need for greater self-sufficiency in computing and software development within the Kingdom.

(3) The speed of software development must be dramatically increased.

(4) Although existing computer facilities must be used more effectively, when new computing facilities are purchased, greater attention should be given to the growing power of workstations and personal computers.

(5) There does not currently exist a national plan for computing within the Kingdom; this plan should clearly delineate the roles and responsibilities of Universities, the Government sector, and the private sector.

This study considered three possible solution strategies in addressing these problems:

- Strengthen existing institutions (such as the NCC and IPA) or
- Develop a national computing plan, then use that plan to assign specific activities to existing institutions, or
- Create a National Software Development Centre as a center of excellence and focal point in selecting and introducing new software development methodologies.

For a variety of reasons discussed in the body of this study, we have concluded that, in addition to current training activities underway, there should be some facility or center(s) within the Kingdom concentrating on building practical computing skills and software development techniques of high quality for the future. Specifically, we make the following recommendations:

Recommendation 1: A Saudi National Software Development Centre should be established.

Recommendation 2: The key areas of concentration for the proposed National Software Development Centre are:

2.1. Effective use of modern personal computers, graphic workstations, and networking to bring the benefits of computing to all types and sizes of organizations within both private enterprise and the public sector.

2.2. Use of modern computing tools and techniques for software development:
- *Relational database systems and query capabilities*
- *Languages tailored for the development of simulations and models, and the use of computer-aided design (CAD) models for engineering and architecture*
- *Computer-assisted software engineering (CASE) tools*
- *Communication and networking products, including the use of networking standards such as EDIFACT and X.25*
- *Office automation systems*
- *Authoring systems tools for the development of educational systems which should be tailored to the Arabic language and the special needs of Saudi Arabia*
- *Standard operating systems that are manufacturer-independent (e.g., UNIX)*
- *Software development project management, design, and documentation tools.*

2.3. Arabization of key software packages deemed to be important for widespread use within the Kingdom.

2.4. International exchanges and agreements with international organizations, both for information interchange and to obtain licensing agreements allowing access to source code for Arabization of existing software products.

2.5. Acting as a coordination point between private industry, educational institutions, and government ministries on such topics as:
- *Development of a national plan for computing within Saudi Arabia, including setting of priorities for introduction of new tools and techniques*
- *Establishing standards for software documentation and the use of the Arabic language in computing (e.g., on keyboards, displays, printouts, programming languages.*

It should be noted in the above recommendations that emphasis is on the use of smaller computers that are becoming highly cost-effective, and on a specific set of software tools available commercially (e.g., for building relational database systems, or computer-assisted software engineering (CASE) tools) whose use can make the development of certain information systems at least 10 times more efficient than using traditional tools and techniques. To achieve these goals, specific objectives are proposed:

Recommendation 3: Specific objectives of the proposed Centre, in order to increase the skills of existing human resources within the Kingdom, should be:

3.1. To develop specific needed software packages within the Kingdom, or Arabize existing packages that may be available in other languages, to meet important needs. This software development should explicitly address the need to increase the effective utilization of existing computing facilities (primarily mainframes).

3.2. To develop a "core" of high-trained Saudi nationals to lead Centre projects in areas and disciplines mentioned under item 2 within Recommendation 2.

3.3. Using that core Centre staff, to introduce a variety of qualified personnel from both private industry and government to these tools and techniques, through hands-on development projects, consulting activities, and seminars and workshops.

3.4. To establish proper physical and computational facilities allowing modern computing techniques to be investigated and used by both Centre staff and participants in Centre activities.

3.5. To provide a center of excellence to which both private industry and government can turn for consulting and advisory services regarding the best computing tools and techniques.

3.6 To continuously monitor the fast-changing computer field in leading industrialized countries, and select and choose to highlight in Centre activities those tools and techniques that are most promising and important.

3.7. To acquaint a wide segment of Saudi software developers and users with the tools and techniques developed and promoted by the Centre.

Perhaps the most important objective in the above list is to conduct a set of software development projects using the best tools and techniques, and allow participants from government and the private sector to participate in these software development projects in order to have "hands-on" experience in the use of these new tools and techniques. In this manner, excellent software can be created as a result of the projects, with the side benefit of increasing the skills of the participants who can then take these skills back to their respective organizations. The next recommendation lists seven specific activities to be undertaken to achieve the stated objectives:

Recommendation 4: The main activities of the proposed Centre allowing it to achieve the above objectives should be:

4.1. Carry out "hands-on" software development projects, allowing 8 to 10 participants on each project to conduct a major software development project using the tools and techniques recommended by the Centre.

4.2. Use international experts in software development to train a core staff in tools and techniques, then use these international experts to assist in consulting activities, software development projects, workshops, etc.

4.3. Conduct seminars or workshops to acquaint groups of from 10 to 20 participants in new software development ideas and techniques.

4.4. Provide consultancy services to both private industry and Governmental Institutions and Organizations.

4.5. Conduct workshops and conferences, and publish papers and conference proceedings to publicize Centre findings, recommendations and results for broad dissemination.

4.6. Develop active links to international and other external organizations, such as software development companies, to permit exchange of technology and the arrangement of licensing agreements that provide access to needed source code, documentation, etc.

4.7. Procure necessary equipment and physical facilities for the operation of a center of excellence in modern software development techniques.

The proposed Centre is designed to work actively with both government institutions and the private sector. In particular, it should be able to accept consulting assignments from both sectors as a means of obtaining specific software development projects, and be able to enter into contractual relationships with organizations throughout the world to obtain needed software licenses (e.g., if needed in certain cases to permit Arabization of existing software tools) and to license use of software products created by the Centre.

In considering software development projects to be undertaken by the Centre, special consideration should be given to key sectors of the Kingdom for which these methodologies are particularly appropriate: (1) Educational programmes and curricula for secondary and primary schools in the Kingdom, which have special requirements not met by much of the commercially available western educational software; (2) The Saudi banking system, in which the use of personal computers and workstations is spreading; and (3) Medical applications and research.

For the Centre to operate effectively as center of excellence able to assist both government and the private sector, the following policies are strongly encouraged as part of its operating charter:

Recommendation 5: Because of the strategic importance of the proposed Centre, and in accordance with the regulations of the Kingdom, the following policies should be strongly considered for the Centre.

5.1. The Centre should enter into contracts with the private sector for development work, to provide consulting services, license private companies to use and distribute Centre-developed software products, etc.

5.2. The Centre should consider the participation of women in developing its programme, for example by having one of its "hands-on" software development projects be remotely located and supervised by women.

5.3. Because the Center's activities are deliberately ones that are quite new to the Kingdom, the Centre should not attempt initially to obtain certification of its activities by the Civil Service Bureau. This policy could be subject to review after the activities of the Centre become well-known and the excellence of its programme is established.

5.4. The Centre should consider charging a fee to participants and organizations for its services.

5.5. An arrangement should be made whereby the Centre is allowed to use earnings thus received, to be used to upgrade computing and other facilities so that it can remain at the relevant state-of-the-art in computing technology for the benefit of the Kingdom.

Finally, because of: (1) the proposed Center's ties to both the government and the private sector; (2) the charter of KACST to promote the flow of information between government and the private sector; and (3) the facilities and personnel of KACST knowledgeable in modern computing techniques, we propose the institutional affiliation of the Centre:

Recommendation 6: The proposed Centre should be administratively located within the King Abdulaziz City for Science and Technology (KACST).

The facilities and infrastructure already existing at KACST are described more fully in Section III of this report, below.

This study proposes that the Centre have a Director and an Administrative Manager, and a Board of Advisors to help guide its program and policies, with these advisors drawn from the key institutions in the three major sectors of the Kingdom: Government, Universities, and the private sector. These advisors should represent both providers of, and users of, computing technology. In addition, it is proposed that a panel of international computer experts be convened periodically to guide the technologies used and pioneered by the Centre. It is estimated that, if the Centre were to share some common facilities with other KACST institutes (such as a common library and shared mainframe computer), it would require approximately 900 square meters of space. If reasonable charges were made to participants for Centre activities, it is estimated that after several years of initial investment, primarily in capital equipment for computing, the Centre in succeeding years should receive approximately $1.2 million in yearly income, and have operating expenses approximately $230,000 greater than this income. The total initial investment during the first four years not covered by income is estimated to be approximately $ 1.83 million. (This amount does not include rent or other cost of physical facility space.) The proposed budget for the Centre includes a contribution by the United Nations Development Programme office in Riyadh of a total of $700,000 U.S. dollars during the first four years of its operation. The above calculations, however, are not nearly as important as the benefits to the Kingdom in ease and speed of software development, increased knowledge among Saudi computing professionals about modern methods and techniques, and more self-sufficiency within the Kingdom in the development of simulations, models, financial planning systems, database management systems, and similar important applications.

II. INTRODUCTION

Computers are vital to the Kingdom of Saudi Arabia. Operation of the Kingdom's airports, oil refineries, water desalinization plants, government ministries, as well as thousands of private companies depend on effective computing systems. Although true for many countries, this statement is especially true for Saudi Arabia, due to the shortage of highly trained Saudi personnel to run these facilities, so that the operation of many facilities depends on automated systems and expensive and temporary expatriate personnel.

Although there are many individual industries, processes and businesses within the Kingdom, most of the computer applications fall within several general categories:

- *Administrative and financial processing*, to process payrolls, create financial records and budgets, etc. These systems must be tailored to unique requirements within the Kingdom, such as specific pay grades and scales, and formats in which budgets must be submitted. Most of these administrative programs are currently written in the COBOL language for large ministries or departments, although administrative records may be kept for smaller businesses using commercially available packages such as Lotus 1-2-3 or dBase III or IV for personal computers;

- *Data base systems*, in which large numbers of records are stored, queried to locate specific items of information, and from which are produced statistical summaries and reports; examples are databases kept by the Ministry of the Interior regarding all visas issued, work permits for expatriates, and identity cards for Saudi citizens. These databases are often accessed by statistical analysis programs such as the SAS system to produce summary data, graphs, analyses and reports;

- *Models and simulations*, used for planning purposes (e.g., within the Ministry of Planning), and for scientific analyses (e.g., within the oil industry to model processing plant operation, or to model the underground seepage of oil or water). One particular category of modeling involves computer-aided design (CAD) used by civil engineering firms, architects, and manufacturing firms. These CAD models in manufacturing may be linked to factory machines for computer-aided manufacturing (CAM). Most models being used are either purchased commercially for specialized purposes such as oil refinery modeling, or else programmed in the Fortran language;

- *Real-time process control*, most often found in process industries such as oil refining and water desalinization, in which the computer program reacts to inputs received from sensors and directly controls the operation of valves and other variables;

- *Communication programs*, linking computers within the Kingdom both to each other and to remote computers worldwide through telecommunication facilities.

To meet all these needs and other more specialized ones, such as scientific ones like image processing and map production, the Kingdom requires people -- preferably Saudi citizens -- trained in software development. Indeed, software development is of great strategic importance to the Kingdom. This report presents findings regarding the state of software development within the Kingdom, and makes specific recommendations that would lead to more efficient, advanced software development techniques becoming widely used. These tools and techniques could allow software systems to be created in 1/10 the time now required for many systems.

The computing field is essentially unique because it continues to change so rapidly. A later section of this report discusses global trends in computing technology, but it should be noted here that more and more powerful personal computers and workstations are bringing useful computing at very modest cost to businesses and organizations of every size, and the spread of small computers has created a "commodity industry" in which thousands of highly useful, and sometimes very specialized,

software packages are available "off the shelf" very inexpensively, due to the mass market in which they can be sold. All of this creates substantial opportunities to use computing for organizations of all sizes within Saudi Arabia, although the Kingdom also has unique requirements to which general-purpose software packages must be tailored. In particular, the operation of many programs (e.g., their display screens and reports) should be converted to Arabic, and good documentation should be available in Arabic. The question is: Are computers, and modern software tools and techniques, being used effectively within Saudi Arabia, or should more be done to spread modern and effective computing techniques to private and government organizations?

This report is the result of an initiative begun at a meeting in November 1988 between representatives of the United Nations Industrial Development Organization (UNIDO), Dr. Abdullah Al-Kadhi, Mr. Mohammed Ali Al-Tasan and other senior officials of the King Abdulaziz City for Science and Technology (KACST). At this meeting, the state of computing within the Kingdom -- particularly on personal computers and workstations available to all organizations -- was discussed. It was felt that an initiative might be needed to increase knowledge of modern computing tools and techniques, but that a preliminary study of the need for such an initiative should be conducted first. As a result, it was decided that a project study be performed regarding the concept of a Saudi National Software Development Centre to be associated with KACST. The concept was favorably received by KACST, and a UNIDO project study was requested by them.

During May 24 through June 22, 1989, Dr. Robert H. Anderson, a U.S. computer expert and consultant, acting as a consultant to UNIDO, conducted the study mission to Saudi Arabia. Dr. Anderson conducted meetings with three major entities during his study: (1) representatives of government ministries that either use computers, or conduct training courses in computing; (2) major universities that teach computer science and engineering courses; and (3) private (and "semigovernment") companies that sell computers and/or offer training courses in various computer programs or disciplines, or are users of computers. A schedule of the meetings conducted by Dr. Anderson is given in Annex A. Some of the key institutions visited by Dr. Anderson in his study include:

- The National Computer Centre (NCC) within the Ministry of Finance
- The Institute for Public Administration (IPA)
- The National Information Centre within the Ministry of Interior
- Ministries of Planning, Social Insurance, Education
- King Saud University (computer center and computer science department)
- King Fahd University of Petroleum & Minerals, Dhahran
- Private and semi-government companies such as Aramco, SABIC, Saudi-American Bank, al Alamiah, Jeraisy Computer Services, and distributors for Amdahl, DEC and IBM computer products
- The Council of Saudi Chambers of Commerce & Industry.

A draft report containing the findings and recommendations resulting from this study mission was transmitted to KACST in August, 1989, and a review meeting was held at KACST facilities in Riyadh during September 11-13, 1989 to discuss those findings. In addition to representatives of KACST, other educational and government institutions within the Kingdom, UNDP, and UNIDO, the meeting also included three internationally recognized computer experts acting as reviewers. The attendees and schedule for this review meeting are contained in Annex B. This final report of the study mission incorporates the guidance and recommendations received at the review meeting.

III. THE KING ABDULAZIZ CITY FOR SCIENCE AND TECHNOLOGY (KACST)

Before discussing study findings and recommendations, it is useful to present information on the role and structure of KACST, to show the strong ties between this initiative and KACST's objectives, facilities, and functions.

KACST bylaws were issued by Royal Decree No. M/8, dated Rabi.-II 19, 1406. The Objectives of KACST are:

- To formulate the national policy for science and technology development, and to draw up the strategy and plan for its implementation;
- To conduct applied scientific research programs to promote further the Kingdom's development;
- To assist the private sector in the research and development of agricultural and industrial products;
- To support joint research programs between KACST and international scientific institutions;
- To award scholarships to develop necessary skills of individuals and to award grants to institutions to undertake applied research work;
- To coordinate with government agencies, scientific organizations and research centers in the Kingdom.

The organizational structure of KACST is shown in Figures 1a and 1b on the following two pages. Additional information about the structure and programs of KACST is contained in Annex C. Of particular relevance to this present study is KACST's Directorate of Information Systems & Technical Services. Some of the facilities and services of this Directorate are:

- *Information Retrieval Services.* KACST has access, through online search, to its own databases and over 500 foreign databases (such as Dialog, Lexis, Nexis), providing the latest science and technology information to the Kingdom. KACST can supply hardcopy printout of source articles from its own library, from Kingdom information centers, or from foreign vendors.

- *Databases.* KACST maintains databases such as: On-going research projects; English-language bibliography; Arabic-language bibliography; Manpower; Union List of Periodicals; Current Awareness; and KACST funded projects.

- *Computer Centre.* KACST has an IBM 4361 computer installed, and has developed information retrieval software allowing researchers to make a free-text search within the different databases.

- *Terminological Data Bank.* A multi-lingual databank is being developed for scientific and technical terminology, with correspondences given for words in Arabic, English, German and French.

- *GULFNET.* KACST is the main node on a data network linking various computer sites within Gulf countries, thereby allowing these countries to submit information retrieval requests, exchange electronic mail, and receive documents and information. KACST is also linked to BITNET and through it to the EARN network (in Europe), Internet and UUCPnet, allowing exchange of electronic mail and files with other institutions throughout the world.

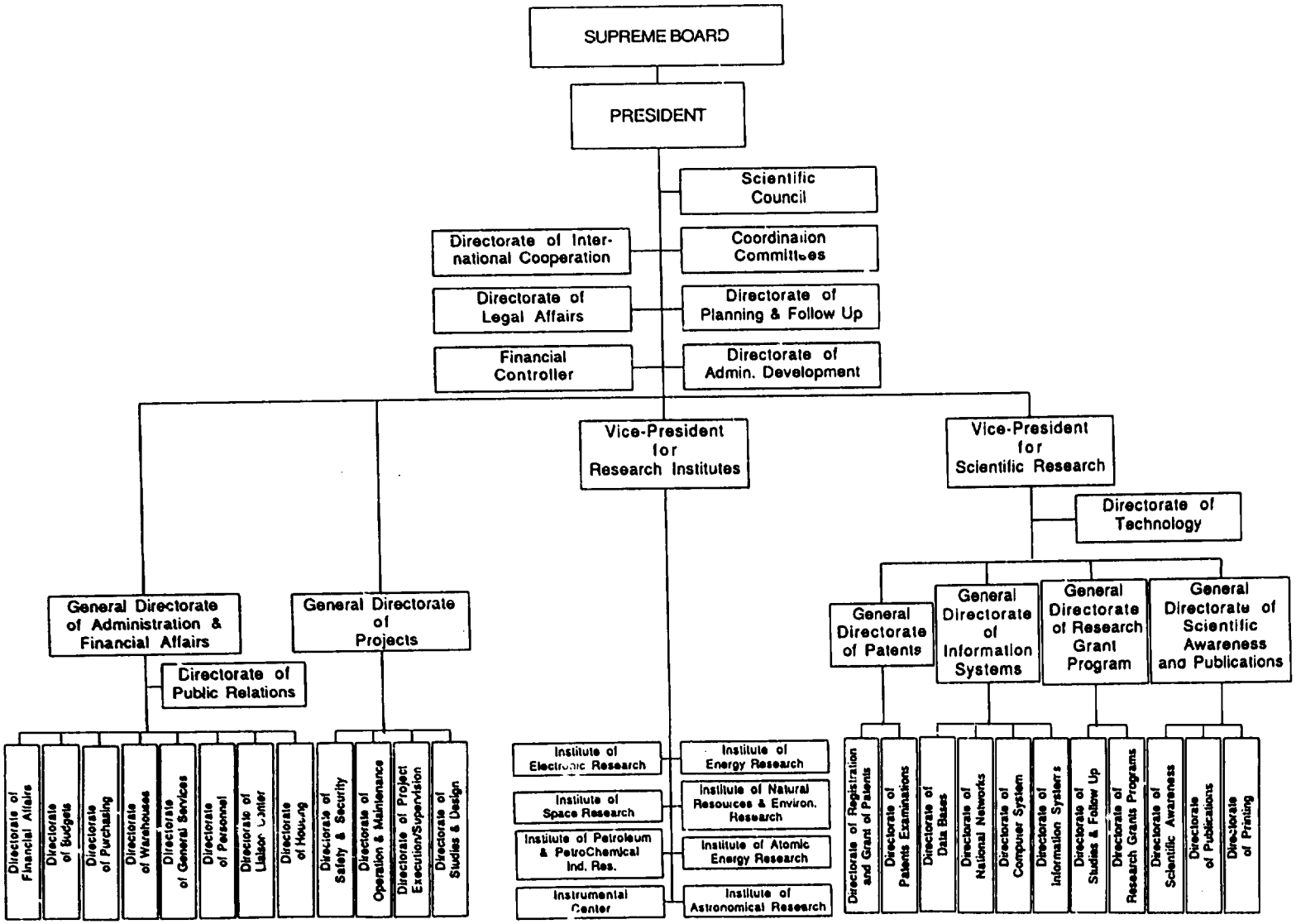


Figure 1a: KING ABDULAZIZ CITY FOR SCIENCE AND TECHNOLOGY ORGANIZATION CHART

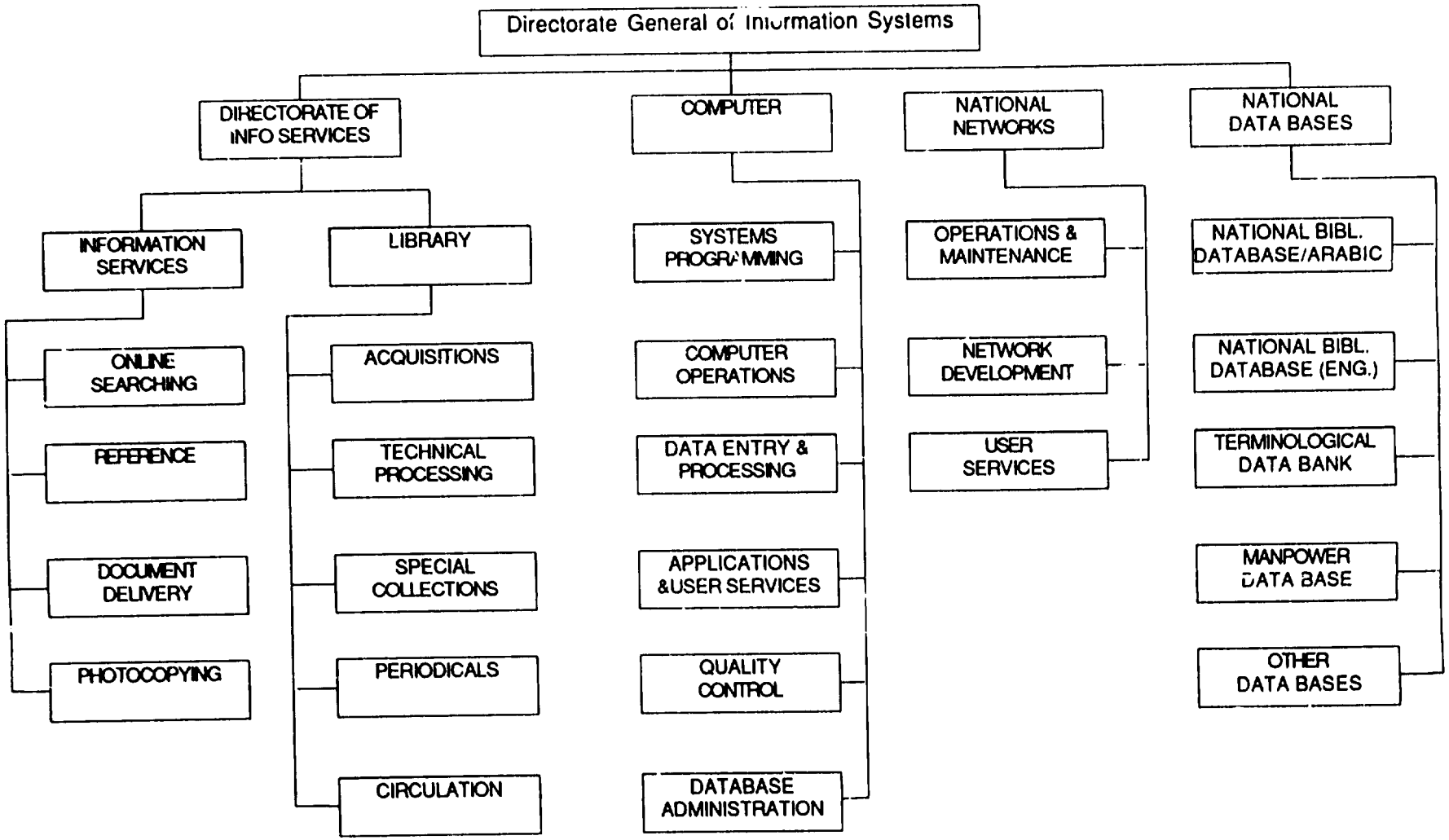


Figure 1b: KING ABDULAZIZ CITY FOR SCIENCE AND TECHNOLOGY ORGANIZATION CHART FOR DIRECTORATE GENERAL OF INFORMATION SYSTEMS

In addition, it is important to note that KACST currently sponsors 15 of its employees studying computer science abroad. Within the next several years, these well-educated employees will return to the Kingdom, half with Ph.D. degrees and half with Masters degrees. These students, having the latest knowledge, will form a very valuable resource within KACST in helping lead the Kingdom in modern software development equipment and techniques.

From its charter and this list of activities, it can be seen that KACST has an infrastructure that would allow a National Software Development Centre to be in electronic contact with the world, and to share some key facilities (such as the IBM mainframe and electronic network linkages) to greatly reduce the capitalization and investment required for the initiation of the proposed Centre.

The charter of KACST explicitly encourages it to:

- Develop ties with companies in the private sector, and
-Assist in the development of private sector companies.

A major role of KACST is seen as being a bridge between the Saudi government, universities, and private sector companies -- by which useful research results from government or university laboratories become translated into practical systems, products and tools for private industry, and the needs of the private sector become known to the government and universities. Clearly, software development tools and methodologies is one key area in which such close two-way communication with the private sector is needed, given the continuing rapid changes in computing hardware and software.

The question then becomes: What is the status of software development and training in the Kingdom, and is a new Centre to spur more advanced computing tools and techniques needed?

IV. THE CURRENT STATUS OF COMPUTER SOFTWARE DEVELOPMENT AND TRAINING WITHIN THE KINGDOM OF SAUDI ARABIA

To assess the quality of software development within the Kingdom, it is useful to ask first: How are software developers now trained? Which languages and skills do they learn? What tools and techniques do they have available? And as a result of this training, what tools and techniques are now being used within the Kingdom to develop needed software?

Computer training and education (and the related activities of Arabization of software programs and documentation, and development of some new software packages required to meet the Kingdom's specific needs) is conducted in five major ways:

- By government ministries (such as NCC and IPA)
- By private and "semigovernment" sector companies
- Through education programs at universities,
- By sending students abroad for specific study and training programs, and
- Training seminars held in conjunction with the Saudi National Computer Conference, and other occasional seminars and training programs.

We discuss each in turn.

A. GOVERNMENT MINISTRY COMPUTER TRAINING PROGRAMS

Major computer training programs within the government, for government personnel, are conducted by the Institute for Public Administration and the Ministry of Finance's National Computer Centre. In particular, the IPA is authorized by the government to be the official training establishment, giving courses and certificates of completion that are honored within the government for advancement.

'. *Institute for Public Administration (IPA).* The IPA offers basic training in several computer topics, such as computer operator skills, programming in COBOL, Fortran, and data entry. They also teach more general courses in systems analysis and programming. They offer a variety of levels, ranging from a two-year diploma, through a one-year operator training course, to a six-week "Introduction to Computing" course. They are currently in the process of developing 23 new short courses, some of them related to (IBM-compatible) personal computers, such as dBase III and word processing. All computer training at IPA in specific systems and languages relates either to IBM-compatible mainframes or IBM-compatible PCs, due to the preponderance of these systems in government ministries.

Most courses are taught in a combination of English and Arabic, with most of the reference materials in English. IPA does not do Arabization of software packages, relying totally on teaching about "off the shelf" existing computer products.

IPA has a staff of approximately 12 application programmers, who develop systems needed internally within IPA (e.g., for tracking students and courses) and maintaining existing software. They have an Amdahl (IBM-compatible) mainframe, and a Data General minicomputer within their computer center.

In general, IPA teaches basic topics that are needed by the personnel of a variety of government ministries in developing staff to handle their current problems. Their training is well respected by the rest of the government. All IPA training programs are provided free to government personnel.

2. *National Computer Centre (NCC)* within the Ministry of Finance. The NCC provides both computer courses and consulting regarding computer applications to other government ministries.

About 41 other agencies are linked to the NCC via leased telephone lines. They conduct about 48 different classes, with the average class size about 12 people. In total, they handle about 500 trainees per year. Again, all these training services are provided free of charge.

Annex D contains a recent list of the courses being taught by the NCC. Again, they are in the basic topics (COBOL, Fortran, IBM operating systems). Most of the courses are taught in English, but some are in Arabic.

The NCC doesn't do Arabization of existing software packages, but provides consultation to others who are doing so.

The NCC has developed an "individual training plan" for individuals, which sets out a sequence of courses needed by an individual to achieve his goals, then tracks progress through those courses. Unlike the IPA, the NCC does occasionally train non-Saudis. There is more demand for their courses than they can fill.

For more advanced topics, the NCC is considering using instructors from private sector local companies, if they have the relevant expertise.

The NCC courses are not presently certificated by the IPA, but discussions on this topic are on-going, and the NCC hopes to achieve certification for at least some of its courses in the near future. There is some frustration regarding this issue, as they have well-qualified instructors (including some expatriates provided as part of the Statistical and Data Processing Project (STADAP) of the U.S. Saudi Arabian Joint Commission on Economic Cooperation) and a well-provisioned classroom with a TV projector for computer displays, TV and audio recording and playback devices, personal computers for students, etc., including the availability of a TV broadcast link for remote teaching of women.

A considerable number of the "courses" available from the NCC are videotapes to be viewed by the student. These are professional videotapes prepared by companies in the U.S. and Europe, and meet high standards on a variety of topics, although viewing a videotape course is not the same thing as a "hands-on" course using real computers and software systems, and instructors.

3. *King Fahd University of Petroleum & Minerals (KFUPM), Dhahran.* A third source of computer training for external institutions within the Kingdom is KFUPM. Both its College of Computer Sciences and Engineering, and its Data Processing Centre offer short courses on a variety of computer topics. Some of the courses presented during the 1988-89 academic year are listed in Annex E. These courses tend to be more advanced than those of the other two institutions (e.g., Structured Systems Analysis and Specifications; SAS/Graph). There is clearly a depth of understanding regarding current computer trends, tools, and developments here (and at other universities) that is an important resource for spreading advanced computer knowledge within the Kingdom, given the right incentives and circumstances. University education and training in computer topics is discussed more fully under "Computer Education At Universities," below.

B. PRIVATE SECTOR COMPANIES

Computer training provided by private sector companies tends to be of two types: (1) training in specific products for which they are a licensed distributor, and (2) short-courses offered to the general population. Much of the training in the first category is bundled in with contracts to provide hardware or software packages, allowing government ministries and others to obtain training as part of a general procurement. (Indeed, this bundling of adequate training for Saudis as part of major purchases is required by the government.) However, a complaint often heard during this study was that some major computer companies do not provide adequate, continuing in-Kingdom training and education for major

software products (such as new operating system releases, or major database products), necessitating out-of-Kingdom trips to obtain needed knowledge.

The short-course private training given by private companies most often covers the same materials as IPA and NCC: introduction to personal computers, programming in BASIC or COBOL, introduction to word processing, data entry, etc. In fact a large number of people within the Kingdom are being introduced to "computer literacy" this way; for example, one company alone, al-Alamiah, has over 6,000 attendees per year in its various courses.

All of this private-sector training provides some measure of increased computer literacy within the Kingdom, but essentially none of the courses given prepares a generation of Saudis in modern programming and computer use techniques.

C. COMPUTER EDUCATION AT UNIVERSITIES

In general, the universities have high-quality faculty that are very knowledgeable about the computing trends and tools this report stresses. This faculty forms a valuable pool of talent which the proposed Centre could draw upon. Some current government regulations do not encourage external consulting activities -- especially to other government institutions -- by faculty. However, KACST should actively work toward developing close ties with key faculty members who could act as project leaders, seminar leaders, etc. for the proposed Centre.

D. COMPUTER TRAINING ABROAD

Many institutions, particularly the NCC, keep an active file of computer training courses offered abroad. The Civil Service Bureau has an approved list of such courses for which it offers accreditation, meaning that successful passage of that course can be used as part of the justification for achieving a particular government rank, position, or salary. During the past several years of budget tightness, trips abroad for training have been curtailed significantly; several major government ministries stated that they had sent no one abroad during the past 12 months.

Nevertheless, a considerable amount of money is spent by government ministries and private companies each year on out-of-Kingdom training courses, even excluding the sending of students for Masters or Ph.D. degrees at western universities. (Consider one example from the Civil Service Bureau: Its committee on out-of-Kingdom training approves about 75 persons per year for computer training (not education) for trips exceeding two weeks. (Shorter trips do not require committee approval.) If the average stay for these persons is 30 days at 600 SR/day, plus hotel and meals at $100/day, average tuition of $2000 and average airfare of $1500, this training alone accounts for $847,500 per year -- and the figures used in these calculations are very conservative.) Add shorter trips, and the many trips abroad made by private companies and other institutions not needing Civil Service Bureau imprimature, and the expenditures for computer training abroad become substantial.

One justification for considering the establishment of a world-class advanced computer training center in the Kingdom is the saving of a significant fraction of the money currently being spent to acquire training abroad. It must be acknowledged, however, that a considerable portion of this out-of-Kingdom training falls in two categories that the proposed Centre only indirectly addresses: (1) training in very specific systems, such as a new release of an operating system or database system; and (2) general education, such as obtaining a Masters or Ph.D. degree in computer science or engineering. We emphasize, however, that saving some training moeny is *not* the principal justification for the proposed Centre. Much more important is the quality and speed that should be achieved in developing software within the Kingdom, the flexibility and understandability of the resulting software, and the

importance of more self-sufficiency within the Kingdom in its ability to develop modern, effective software systems.

E. SEMINARS, CONFERENCES, AND OTHER ACTIVITIES

The growing and active Saudi computing community sponsors a yearly National Computer Conference in Saudi Arabia, which draws many Gulf participants in computing. These conferences often are accompanied by training seminars in a variety of current computing topics, providing useful upgrading of knowledge and skills within the Kingdom. There is also a recently-established Saudi Computer Society that is undertaking various projects; in particular, it has formed a computer training committee to investigate and help stimulate effective training on computing topics. All of these activities provide much-needed coordination and communication among computing professionals in the Gulf region. These institutions could provide important assistance and guidance in establishing continuity and resources for forward-looking computer training in the Kingdom.

F. SUMMARY ON THE STATE OF COMPUTER TRAINING IN THE KINGDOM

We find that, with the exception of a few short-courses or special one-time seminars at KFUPM or in private industry, essentially all of the computer training being given within the Kingdom is very low-level, concentrating on nearly-obsolete tools and technology. (This statement is explicitly about training, and is not meant to apply to computer science education in the universities.) This status is likely to continue, because there is a continuing demand for such training, as more Saudi citizens first become acquainted with computers.

The low level of this current computer training has implications for the Kingdom, which we discuss at the end of the following section, which provides an overview of international trends in computing.

V. GLOBAL TRENDS IN COMPUTER TECHNOLOGY

(Note: Some of the data and figures in this section are taken from the recently published report, "Global Trends in Computer Technology and Their Impact on Export Control", by the U.S. National Research Council, 1988.)

Trends in computer technology can be discussed in three major categories: hardware, software, and networking.

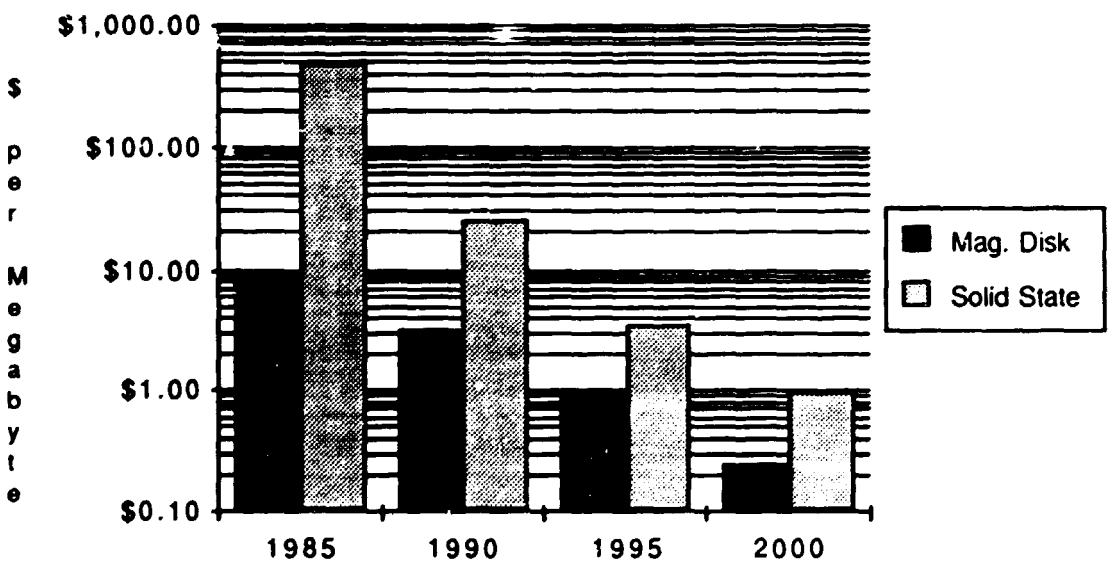
A. HARDWARE

Computers are normally described as being in one of five different classes:

Class	Price range	Examples
Supercomputer	above $5 million	Cray, Connection Machine
Mainframe	from $500,000 to $5 million	IBM 3090, 3080
Minicomputer	from $50,000 to $500,000	DEC 8800, HP 3000
Workstation	from $7,000 to $50,000	Sun 3/60, DEC MicroVAX
Personal Computer	below $7,000	IBM PC, Apple Macintosh

As is well known, the cost of all forms of computers have been dropping drastically for many years, while the performance has been increasing, and those trends will continue. As one example, the storage cost for data (in U.S. dollars per megabyte (= millions of 8-bit bytes of data) projected for the period 1985 - 2000 is shown in Figure 2.

Figure 2: STORAGE COST TRENDS, 1985-2000

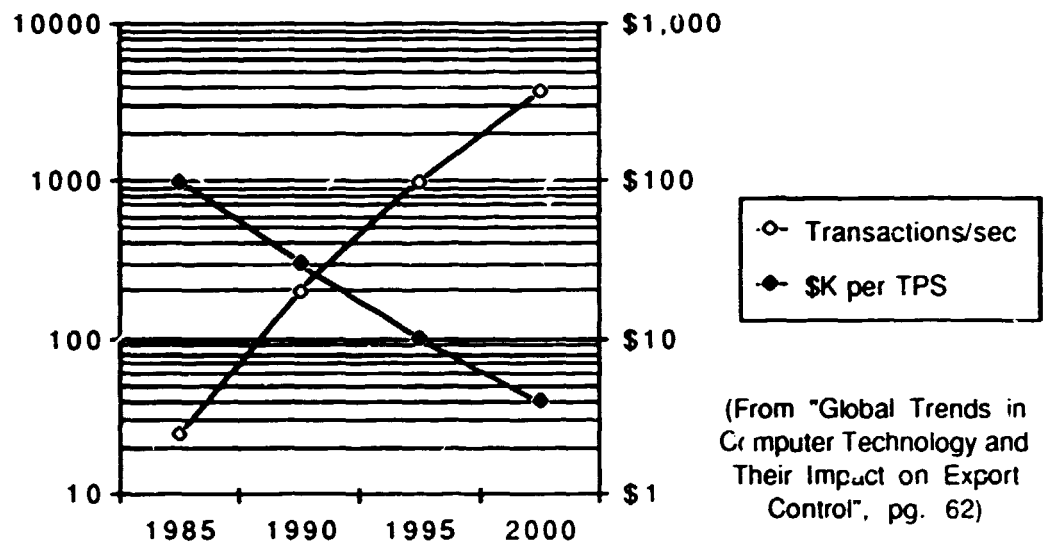


(from "Global Trends in Computer Technology and Their Impact on Export Control", pg. 24)

This figure shows the cost of magnetic disk storage dropping from $10 per megabyte to $0.20 over that period, an amazing drop to 1/50 of the former cost. Breakthroughs in magneto-optical technology might even improve on these figures.

One additional example: Many complete computer hardware+software systems are used primarily as data base management systems, processing thousands of transactions per second (TPS). The plots in Figure 3 show the dramatic increase in speed projected over the 1985 - 2000 time period (from 15 TPS to 3000 TPS, while at the same time the cost in thousand dollars per TPS falls from $100 to approximately $3.

Figure 3: SPEED AND COST OF DATABASE SYSTEMS



(From "Global Trends in Computer Technology and Their Impact on Export Control", pg. 62)

Note that these trends mean several possible things, within the Kingdom as well as elsewhere: (1) for the same amount of money, it will be possible to obtain much more computing; or (2) to achieve some needed level of computing, it will be possible to get it for much less money. In practice, this means that smaller businesses and government departments might obtain satisfactory computing (for a database or management information system) from a minicomputer or even a small network of workstations, rather than needing an expensive mainframe. Indeed, today's upper-range personal computer (e.g., based on the Intel 80386 or comparable Motorola CPU chip, with hard disk and high-resolution display) can provide computing comparable to a minicomputer installation of 5 to 8 years ago, very adequate for many substantial computing tasks. Lower-range personal computers can provide word processing capabilities, personal filing systems, etc. that can greatly aid in performing office tasks.

B. SOFTWARE

As computing spreads throughout the world and to various levels of the economy, software has become a commodity. It can be bought "off-the-shelf" to do a wide variety of tasks: word processing, spreadsheet calculations, a database "shell" into which data can be entered directly, graphing and plotting programs, etc. This commoditization of the software market has been accompanied by the emergence of standard interfaces at many levels:

- MS-DOS and UNIX as standard operating system interfaces
- the X Window System as a standard user interface for workstations
- Postscript as a standard page formatting language
- Ethernet and TCP/IP as standard network protocols, with corporate proprietary protocols such as IBM's SNA and Apple's Appletalk forming *de facto* standards in some organizations

These standards allow software developers to create "commodity" products (e.g., that work under UNIX System V, or MS-DOS) which are independent of a particular manufacturer's system, and therefore sell to a much wider market. By selling millions of copies instead of hundreds or thousands, the price per copy drops tremendously.

The main trend in software has been away from programming thousands of lines of code in order to create a useful system; rather, it is now possible to:

- use a "fourth-generation language (4GL)" to create an application more quickly, because it provides many standard features at a higher level than does COBOL or Fortran; similarly, there are now non-procedural languages for programming (like the spreadsheet paradigm, or Apple's HyperCard environment) that put programming power into the hands of even non-programmers;

- use a relational database system (RDBMS) to create a flexible database that can evolve as needs change, without major reprogramming; most database systems are now including an interface to the SQL language (developed by IBM) as a standard query language for accessing their contents;

- use specialized languages for simulation and modeling (e.g., SIMSCRIPT, GPSS and SIMULA) to implement models more quickly, that are easier to change and to understand;

- use computer-aided design (CAD) programs for civil and mechanical engineering, architecture, and many of other engineering tasks. The resulting drawings are vastly easier to update, can be transmitted electronically while retaining their structural interrelationships, and can be used to produce a variety of views and specialized drawings from one master design;

- use computer-aided software engineering (CASE) environments for software development, providing many integrated, interactive tools for programming that greatly reduce the time required to develop a software system; many of these tools also aid the user in creating "object-oriented programs" that are more modular and understandable than traditional programs;

- use "expert system" tools to create a software system that makes recommendations or acts as a human expert would, based on rules of behavior that have been acquired from that expert.

Many of the above software tools and techniques are becoming available primarily on powerful personal computers (e.g., with an Intel 80386 or Motorola 68030 or higher) or on workstations (e.g., such as Sun/3 or /4 systems, or DEC MicroVAX or equivalent Hewlett-Packard, Data General, and Prime products). A major trend is the growing use of the UNIX System V operating system on workstations, providing a standard interface for which software can be developed. These workstations have high-quality graphic interfaces allowing multiple "windows" of information to be displayed, and providing an "immediate" feedback to operator commands.

C. NETWORKING

There is a major international trend in computer networking to use a set of standards called ISO OSI (International Standards Organization's Open Systems Interconnection). It consists of seven

separate layers, each interfaced with its immediate neighbors. The first layers (physical, datalink, and networking) describe the physical signals transmitted, low-level grouping of data bits into more meaningful packets, and protocols for establishing and relinquishing a link. (The X.25 international networking standard being implemented by the PTT within the Kingdom is at this lower level.) The intermediate layers (transport, session) describe standards for the conduct of a session, in which a connection is made, data is passed and its integrity verified, then the session ended. The top layers (presentation, application) are reserved for standards for describing the user-computer interface and intercommunication among application programs. There is no space in this report to explain the role of each layer; it is only important to realize that it is becoming easier to connect dissimilar machines, in separate places, to each other using such standards.

There is also a trend toward high-bandwidth local-area networks (LANs), usually using the Ethernet protocol developed by Xerox Corporation, to link workstations together, and tie them into a larger computer (e.g., a mainframe or specialized "file server") that acts as an archive and repository of data. This permits each individual workstation to have a minimum of local file storage, keeping cost per workstation down. Most computer scientists see networks tying together varying sizes and specialties of machines as the future "standard system architecture." Network operating systems now in use and under development (such as Sun Microsystems' Network File System) already allow a user on one machine to directly access files on another machine within the network as if they were located on his local machine (assuming he has permission to do so), or to run processes on other machines. In these environments, the total computing power of the network becomes available to a user, yet it is more reliable than single mainframes (because individual machines can go down and come up without affecting other users), and more cost-effective (because computing power can be added in small increments as needed), yet it provides greater immediacy of interaction for users (because graphic displays on workstations are directly tied to the workstation's memory, without an intervening communication link).

D. SUMMARY OF INTERNATIONAL TRENDS, AND THEIR RELEVANCE IN SAUDI ARABIA

The major trends in computing are toward: (1) standard interfaces, permitting software "commodities" to be developed that are widely applicable to many individual manufacturers' machines; (2) powerful personal computers and workstations with sufficient power to run many useful applications (such as database management systems with tens of thousands of records); and (3) efficient, standard networks tying dissimilar pieces of computing equipment together.

These trends all provide users of computers much greater freedom in choosing their equipment, because they are freed from dependence on a single manufacturer, and they can buy as much computing power as they need in increments, for example by adding workstations into a local area network as needed.

However, the Kingdom of Saudi Arabia is not in a good position to take advantage of many of these international computing trends. Most of its computing, especially in government ministries, is performed on IBM or IBM-compatible mainframes, with some growing use of low-level IBM PC or IBM-compatible "clone" personal computers for some office tasks. Most of the programming is done in older languages such as COBOL and Fortran. The powerful tools becoming available on modern workstations and personal computers (e.g., for programming environments, for modeling and simulation, for computer-aided design, for interactive relational database management systems) are being designed to meet the new standards mentioned above: X Windows or Display Postscript interface, UNIX System V, Ethernet network protocol -- not necessarily for an IBM mainframe environment.

The IBM mainframe "standard" (including IBM compatibles such as Amdahl and NEC) has been useful to the Kingdom for the past 7 to 10 years, because it has allowed standardized training on operating systems, file systems, etc. However, at the same time it has created the following problems:

- These existing mainframe computers are not being used efficiently, because software development for them is complex and time-consuming, and existing mainframe tools for software development are not advanced;

- Some of the more advanced topics in handling complex IBM mainframe systems are not taught within the Kingdom, requiring expensive travel to the U.S. or Britain to obtain training;

- Some courses that are needed are only available from IBM or a few other vendors, at high cost; much of the Kingdom's computer resources are "locked in" to a few vendors, creating near-monopoly conditions without price or functional competition;

- Mainframe computers are expensive in personnel and equipment; they need operators, programmers, managers, raised floors and very controlled environments (power and air conditioning);

- It is not easy to add increments of computing power to a mainframe without major upgrades or replacing the whole machine;

- Some of the new computing tools and techniques require workstation or advanced PC environments, and are not available on mainframes;

- Mainframes are very expensive in dollars per MIPS (millions of instructions per second) compared with other alternatives.

For all of these reasons, it is time for some steps to be taken to allow the Kingdom to move into the next generation of software development techniques. Using modern CASE, RDBMS, CAD, MIS and other software tools, it will be possible to develop software applications much more efficiently, with less people and less time, than heretofore. It is important that *these new tools and methodologies, although used on highly interactive workstations, can be used to develop software for mainframe computers, and therefore to increase the utilization of existing mainframes.* To put these statements into their most dramatic form:

> Every line of COBOL code written within the Kingdom, from now on, is code that is difficult to debug, difficult to maintain, difficult to document, and difficult to change as needs change. And it need not be that way; there are better alternatives.

We do not argue that change should occur instantaneously; indeed, it will take years to provide new languages and tools to programmers and managers of computer centers. However, we believe the process should be started with some first steps, now; only in that way can the Kingdom evolve its computing into more efficient forms, and begin to utilize existing computers much better, within the next 10 years.

The following section presents specific conclusions and recommendations regarding how these first steps should be taken.

VI. CONCLUSIONS AND RECOMMENDATIONS REGARDING THE NEED FOR A SAUDI NATIONAL SOFTWARE DEVELOPMENT CENTER

When the status of computer usage and software development in the Kingdom of Saudi Arabia is compared with current trends in international computer development, it becomes apparent that software development is of major strategic importance to the Kingdom, and that there are a number of problems involving the effective use of computers that need to be addressed. The key problems are:

(1) Existing computer facilities (primarily mainframe computers) are not being used effectively. Over 8 billion Saudi riyals have been spent on computing facilities in the Kingdom, with a similar amount invested in software and programming for these machines. This tremendous existing investment must be more effectively utilized through much more efficient software development than is currently being done;

(2) There is a need for greater self-sufficiency in computing and software development within the Kingdom. Because computer systems are critical to the operation of most sectors of the Kingdom, more self-sufficiency in software development is of strategic importance to the Kingdom;

(3) The speed of software development must be dramatically increased. It is too often the case that in the year or two it takes to develop a software system, both the requirements and the computing technology change before the job is completed, making the resulting system less relevant than it should be. New software methodologies mentioned elsewhere in this report now make dramatic increases in software development efficiency possible;

(4) Although existing computer facilities must be used more effectively (as described in (1), above), when new computing facilities are purchased, greater attention should be given to the growing power of workstations and personal computers, so that modern software systems developed by major international software publishers explicitly for this hardware can be used, and investment in new computing can be made in smaller, more modular increments and tailored to the specific requirements of the project(s);

(5) There does not currently exist a national plan for computing within the Kingdom; this plan should clearly delineate the roles and responsibilities of Universities, the Government sector, and the private sector, regarding training, software development, education, policies regarding methodologies, tools, techniques to be adopted, standards, documentation, etc.

This study considered three possible solution strategies in addressing these problems:

- Strengthen existing institutions (such as the NCC and IPA), or
- Develop a national computing plan, then use that plan to assign specific activities to existing institutions, or
- Create a National Software Development Centre as a center of excellence and focal point in selecting and introducing new software development methodologies.

It was felt that existing institutions are concentrating on *training* large numbers of citizens in various basic computing technologies, which is absorbing their attention and resources. What is needed is a different kind of activity, concentrating on introducing new methodologies of high quality to selected persons -- a "planting of seeds" so that these new techniques can take root within various organizations throughout the Kingdom. Furthermore, these new methodologies cannot be introduced simply by lecture-style classrooms, but they must be actively worked on in "hands-on" projects for participants to obtain sufficient experience and familiarity.

It was also concluded that development of a national computing plan could be started in parallel with the establishment of a Centre devoted to software development, and that the concept of the Centre should not be delayed until such a plan is available. If and when a plan becomes available, it might alter or extend the terms of reference for the Centre, but will not affect the strategic importance of the Centre for Saudi Arabia. A national computing plan is not a substitute for the Centre, and the Centre is not a substitute for the plan.

This study has therefore concluded that, in addition to current training activities underway, there should be some facility or center(s) within the Kingdom concentrating on building practical computing skills and software development techniques for the future. Specifically, we make the following recommendations:

Recommendation 1: A Saudi National Software Development Centre should be established.

In general, the goal of this Centre is to concentrate on developing both skills and specific software systems that are expected to be important to the Kingdom's computing requirements within five to 10 years. The Centre should concentrate on increasing the *speed and quality* of software development, and not conduct large-scale training activities. The Centre should also act in coordination and support of existing institutions. The systems it develops and the skills it imparts to Centre participants should be equivalent to the best professional institutes in the U.S. and Europe. In addition, it should:

- Concentrate on proven, available computer techniques that can reduce the time and resources for programming new applications by many times, or that provide new capabilities and insights not presently available;

- Work with private enterprise, government ministries, and universities to provide these facilities and training, and not compete with any of these institutions;

- Decide which new existing tools and techniques are of particular importance to the Kingdom, and work to make those tools available within the Kingdom; at times, this might involve active developmental work on Arabizing existing software, or developing specialized software to meet these needs;

- Enter into special contractual relationships with private companies (e.g., to establish business relationships with software firms, in order to Arabize their products, or to license software it has developed for commercial use).

More specifically, the discussion of trends in global computing, when compared with the current state of Saudi computing, leads to a specific recommendation regarding areas in which the Centre should concentrate its resources and attention:

Recommendation 2: The key areas of concentration for the proposed National Software Development Centre are:

2.1. Effective use of modern personal computers, graphic workstations, and networking to bring the benefits of computing to all types and sizes of organizations within both private enterprise and the public sector.

2.2. Use of modern computing tools and techniques for software development:
- *Relational database systems and query capabilities*
- *Languages tailored for the implementation of simulations and models, and the use of computer-aided design (CAD) models for engineering and architecture*

- *Computer-assisted software engineering (CASE) tools*
- *Communication and networking products, including the use of networking standards such as EDIFACT and X.25*
- *Office automation systems*
- *Authoring systems tools for the development of educational systems which should be tailored to the Arabic language and the special needs of Saudi Arabia*
- *Standard operating systems that are manufacturer-independent (e.g., UNIX)*
- *Software development project management, design, and documentation tools.*

2.3. Arabization of key software packages deemed to be important for widespread use within the Kingdom.

2.4. International exchanges and agreements with international organizations, both for information interchange and to obtain licensing agreements allowing access to source code for Arabization of existing software products.

2.5. Acting as a coordination point between private industry, educational institutions, and government ministries on such topics as:

- *Development of a national plan for computing within Saudi Arabia, including setting of priorities for introduction of new tools and techniques*
- *Establishing standards for software documentation and the use of the Arabic language in computing (e.g., on keyboards, displays, printouts, programming languages.*

To accomplish these general goals, the Centre should pursue the specific objectives listed in the following recommendation:

Recommendation 3: Specific objectives of the proposed Centre, in order to increase the skills of existing human resources within the Kingdom, should be:

3.1. To develop specific needed software packages within the Kingdom, or Arabize existing packages that may be available in other languages, to meet important needs. This software development should explicitly address the need to increase the effective utilization of existing computing facilities (primarily mainframes).

3.2. To develop a "core" of high-trained Saudi nationals to lead Centre projects in areas and disciplines mentioned under item 2 within Recommendation 2.

3.3. Using that core Centre staff, to introduce a variety of qualified personnel from both private industry and government to these tools and techniques, through hands-on development projects, consulting activities, and seminars and workshops.

3.4. To establish proper physical and computational facilities allowing modern computing techniques to be investigated and used by both Centre staff and participants in Centre activities.

3.5. To provide a center of excellence to which both private industry and government can turn for consulting and advisory services regarding the best computing tools and techniques.

3.6 To continuously monitor the fast-changing computer field in leading industrialized countries, and select and choose to highlight in Centre activities those tools and techniques that are most promising and important.

3.7. To acquaint a wide segment of Saudi software developers and users with the tools and techniques developed and promoted by the Centre.

Given these objectives, what activities should the Centre undertake to accomplish them? The following seven activities should be the main work programme of the Centre:

Recommendation 4: The main activities of the proposed Centre allowing it to achieve the above objectives should be:

4.1. Carry out "hands-on" software development projects, allowing 8 to 10 participants on each project to conduct a major software development project using the tools and techniques recommended by the Centre.

Of all the Centre activities, the most central one is the conduct of software development projects. At any time, a number of projects should be underway, each involving perhaps 10 students and an instructor/project leader. These projects should be actively engaged in developing software using advanced tools and techniques. The software might be a database system for some application, a management information system, a model or simulation, etc. These projects would be chosen to be of potential use to some Ministry, agency, or private sector company. Useful software products will emerge from this activity, to be given or licensed to anyone needing them from the Centre. A project participant would spend from 3 to 6 months, either half-time or full time, working with a project to gain expertise. After a period of startup, the Centre might support perhaps five or six such projects underway at the same time. Projects might last six months to a year, depending on their nature and how ambitious the project is. Specific examples of projects that might be undertaken are listed in Annex F.

In considering software development projects, special consideration should be given to:

(1) Educational programmes and curricula for secondary and primary schools in the Kingdom. The educational programme within the Kingdom is not the same as that within countries such as the U.S. that form a large market for commercially available educational software. Therefore, special Arabic-language educational software, software emphasizing the religious basis of the Kingdom, and tailored "authoring" systems are needed to allow the rapid and effective creation of instructional software for use on personal computers in schools. (Some Arabic education software and authoring systems are available commercially; however, their use is not widespread, and this form of specialized software development needs further growth, promotion, and dissemination.)

(2) The Saudi banking system, which has some unique characteristics, and in which the use of personal computers and workstations is spreading to permit greater productivity in software development and to provide better service to customers.

(3) Medical research and applications, in which graphic workstations are important in visualizing and modeling complex biological processes. In more advanced hospital information systems, personal computers or terminals are bringing information to the patient's bedside, for update and access by nurses and physicians.

Every effort should be made by the Centre to promote the use within the Kingdom of software developed by the Centre. Its availability should be publicized and it should be licensed to anyone wishing to use it.

The Centre should work actively toward protection of its software, and all other software products in the Kingdom through the development and enforcement of copyright laws for software. Without such

laws and their enforcement, a vital commercial software industry cannot be established in Saudi Arabia, because expensive development efforts cannot be rewarded with adequate sales.

4.2. Use international experts in software development to train a core staff in tools and techniques, then use these international experts to assist in consulting activities, software development projects, workshops, etc.

Within three or four years of its initiation, the Centre is expected to be operated by a core staff of Saudi nationals who lead software development projects, conduct workshops and seminars, etc. To assure that this staff is fully trained in the best modern software development tools and equipment, a staff of international experts will be used for a limited time at the Centre to first train the resident staff, then to assist in all Centre activities. This international staff also provides useful ties between the Centre and software companies and other organizations within the U.S. and Europe.

4.3. Conduct seminars or workshops to acquaint groups of from 10 to 20 participants in new software development ideas and techniques.

There are some topics that the Centre might introduce that are best handled by a seminar or workshop, each lasting three to five days. (The length of the workshop depends on the topic; some topics might require two weeks.) Examples of topics that might be covered in these workshops include:

- The design and construction of relational data bases
  - -- Normal forms for relational data, and putting data into "third normal form"
  - -- Survey of existing software packages that support a good relational structure (e.g., DB2, Adabas, Oracle, Paradox)
  - -- The SQL language for querying databases.

- Modeling and simulation techniques
  - -- Comparison and survey of languages specialized for modeling and simulation (e.g., Simscript, Simula)
  - -- The design of graphic front-ends to simulations, to permit observation of their operation during execution
  - -- Object-oriented simulations: advantages, disadvantages, and languages supporting this technique.

- The UNIX operating system
  - -- Underlying concepts: filters, pipes, I/O redirection, textual streams, hierarchical file system
  - -- Applications available within the system: grep, awk, yacc, lex, make, ...
  - -- Survey of UNIX-based systems available within the Kingdom (e.g., DEC's ULTRIX, IBM's AIX, ...)

- Advanced statistical analysis techniques using the SAS system

- Comparison of graphic workstations offered within the Kingdom
  - -- Speed, graphic resolution, adherence to standards for graphics and networking
  - -- Software applications available
  - -- Price/performance tradeoffs

- Estimating the cost and schedule required for a software development project
  - -- Factors to be considered
  - -- Use of formal models such as Boehm's COCOMO
  - -- How to monitor ongoing projects to assure that the schedule is being met

- The use of expert system "shells" to design expert system applications
  - -- Comparison of shells available on PCs and workstations
  - -- Features: goal-directed vs. data directed, explanatory facilities, debugging aids
  - -- Introduction to process-control applications for the oil and water industries

- Interfacing to the coming X.25 standard for data networking within the Kingdom
  - -- Software products available for X.25 interfacing
  - -- Advantages and disadvantages of use of X.25
  - -- Interconnection options available to sites outside the Gulf

- Documentation standards for software developed within the Kingdom
  - -- What are modern standards for software documentation?
  - -- Tailoring of these standards for Kingdom requirements

- The status of standards for Arabic keyboards and fonts for display and printing
  - -- Key groups involved in standardization efforts
  - -- Results achieved to date
  - -- Schedule for future standard announcements
  - -- Tradeoffs and criteria for good standards.

Some of the above proposed workshops are topics worthy of an entire semester of university education (indeed, some are worthy of a professional career's worth of study). The above workshops do not at all duplicate what is taught at universities; rather than concentrating on the theory of these subjects, these workshops will give practical, survey information to computing professionals who are currently involved in computer operations, and who need an update on new tools and techniques becoming available.

It is likely that some private sector companies, or university professors, may be able to provide some of the instruction, or have developed some course materials that are relevant to the above topics; in this case, the Centre should contract with that company or individual to help in the conduct of such short courses for a specified fee.

In addition to the above workshops, it is expected that the proposed Centre would on occasion conduct a special seminar or conference to reach specialized audiences, or help coordinate computer-related activities in the Kingdom. Such seminars and conferences would of course be coordinated with the existing Saudi Arabian National Computer Conference, and with the Saudi Computer Society. Examples of seminars or short conferences that might be offered periodically include:

- A seminar for key government ministers or their deputies, covering the current state of computing within the Kingdom, international trends in computing, policies affecting computing (e.g., patent and copyright regulations) and options to be considered in developing new computer applications. This seminar might either be held in Riyadh, or at a pleasant site or resort offering a change of scenery and a chance to get away from the interruptions of the office.

- A coordination seminar at which members of the Saudi PTT discuss forthcoming plans for the X.25 data communication network implementation with managers and technical leaders from the key government ministry computing centers.

- It is important to conduct periodic "interface workshops" between members of the Centre and other sectors of the Kingdom, to obtain feedback on priorities regarding the most important projects to accomplish. (However, it is also important to note that the objective of the Centre is to upgrade software development *skills*, not to be a problem-solver and thereby conflict with the activities of the private sector.)

We emphasize that all of the above workshops and seminars are *suggestions only*; the actual program of activities will be developed for local needs by the management and advisors to the Centre.

4.4. Provide consultancy services to both private industry and Government Institutions and Organizations.

The proposed Centre will be a major repository of information on new computing tools and techniques. As such, it might well be called upon to assist various government ministries with future computing plans, upgrades, choice of new equipment, etc. It should be capable of providing excellent consulting services as needed in areas not currently adequately addressed by private enterprise within the Kingdom. A few examples of the many types of consulting assignments that could be undertaken by the Centre include:

- Survey the software packages available for a specific application (e.g., modeling, computer-aided design), compare and contrast their features, and recommend the best software (and perhaps the best hardware configuration on which to run it) to meet a client's specific requirements.

- Study the requirements for a planning model (e.g., for the Ministry of Planning) and design a model or simulation to meet their analysis needs. Either these designs could be used as the basis for a Request for Proposals by the Ministry, or else the Centre could undertake the development of the model using a modeling language and/or object-oriented techniques.

- Provide assistance to a private sector company in establishing cost-effective telecommunication links with its counterpart organization(s) in other countries, for the electronic transmission of data, electronic mail, etc. Compare and contrast the effectiveness of the coming PTT X.25 links, IBM's SNA architecture, dedicated vs. dialup telecommunication lines, etc. as parts of the total network required.

A staff of two to three international computer experts at the Centre, as well as the Saudi staff, would be available to provide such consulting as needed throughout the Kingdom.

4.5. Conduct workshops and conferences, and publish papers and conference proceedings to publicize Centre findings, recommendations and results for broad dissemination.

The Centre should actively participate in the conduct of the yearly Saudi National Computer Conferences, and it is expected that the Centre would in addition conduct one specialized conference each year, using this opportunity to invite international experts in specialized software development topics, and to publicize software systems it has developed and tools and techniques it has found to be valuable.

4.6. Develop active links to international and other external organizations, such as software development companies, to permit exchange of technology and the arrangement of licensing agreements that provide access to needed source code, documentation, etc.

As mentioned previously, the project activities of the Centre will most likely result in useful software products (e.g., particular data base or management information system (MIS) applications), or versions of existing software products. Although some software products might be given free of charge to government ministries (e.g., in exchange for a guaranteed number of students per year, or other consideration), the Centre should also be capable of entering into licensing arrangements with the private sector to distribute and promote software products or other useful products emerging from the Center's activities. The Centre might also sponsor fellowships for certain trainees or instructors to study abroad to obtain key skills or information needed for Centre operations. These external activities

would also include travel to major software firms (e.g., Microsoft, Lotus, Ashton-Tate) to negotiate for rights to Arabize existing software packages. In addition, the Centre should invite key international computing experts to the Kingdom to give lectures or seminars on their areas of expertise, to increase the flow of information regarding the state of computing throughout the world.

4.7. Procure necessary equipment and physical facilities for the operation of a center of excellence in modern software development techniques.

The specific physical facilities and recommended computing equipment required for the Centre are discussed below.

In order for the Centre to conduct its activities and meet its goals, it is recommended that the following policies and procedures be established for the Centre. We feel that each of the following policies is highly desirable; however, some of them may be difficult or impossible to implement. These policies are not felt to be absolutely necessary for the successful operation of the Centre, and they are therefore considered only as suggestions:

Recommendation 5: Because of the strategic importance of the proposed Centre, and in accordance with the regulations of the Kingdom, the following policies should be strongly considered for the Centre:

5.1. The Centre should enter into contracts with the private sector for development work, to provide consulting services, license private companies to use and distribute Centre-developed software products, etc.

A growing portion of the Kingdom's activities will be performed by the private sector, since encouragement of the private sector is an explicit government policy. It is important that software development activities within the private sector be up-to-date and efficient, as this benefits the entire Kingdom. The Centre can act as an important integrating and coordinating force within the Kingdom, providing a link between the public and private sectors. Software systems developed as part of the Center's activities will also be useful to a variety of organizations in the Kingdom; the Centre should have the ability to enter into contracts with private sector companies to distribute these software products, with a portion of the revenues accruing to the Centre to support its activities.

5.2. The Centre should consider the participation of women in developing its programme, for example by having one of its "hands-on" software development projects be remotely located and supervised by women.

The design of the Center's program, involving a number of ongoing software development projects, allows the participation of women in its activities. One of these projects can be conducted at a separate location, with women participants and project leader. Electronic mail links can connect this remote site to the main Centre facilities. In general, software development is an excellent activity for the growing number of educated women within the Kingdom, as it can be done at separate locations, or even within the home (e.g., on a modern personal computer). Computer-based information systems are a unique discipline that, due to its nature, provides great freedom for this kind of remote operation. It should also be noted that other centres and institutes within the Kingdom are also upgrading the skills of women by similar remote operations.

5.3. Because the Center's activities are deliberately ones that are quite new to the Kingdom, the Centre should not attempt initially to obtain certification of its activities by the Civil Service Bureau. This policy could be subject to review after the activities of the Centre become well-known and the excellence of its programme is established.

Certification is the process by which the Civil Service Bureau, with the technical assistance of IPA, provides quality control on training given by other governmental organizations. (For non-governmental organizations, certification is provided by the General Organization for Vocational Training.) Certified courses are useful to government employees in being considered for jobs with increased responsibility and salary.

It is recommended that the proposed Centre *not* apply initially for certification of any of the software development projects or workshops it provides, for the following reasons:

- The persons responsible for the certification process in the Civil Service Bureau and IPA are not working computing professionals familiar with the latest tools and techniques. Therefore, the subjects on which the Centre concentrates its attention will be sufficiently far from those covered by their normal procedures that long delays and discussions will ensue. This is a distraction during the initial phases of the development of a Centre;

- Persons attending the Center's activities should participate for the knowledge and skills involved, not to obtain a piece of paper aiding them in attaining a higher salary;

- The concept of the Centre is sufficiently novel that it will not become clear for several years whether it will succeed in its goal of providing advanced, practical computer skills up to the standards of professional workshops and seminars abroad. It must demonstrate this level of competence before there is sufficient evidence to present in defense of certification;

- It is expected that a significant part of the Center's activities will directly involve the private sector, for which such certification is not required;

- Some institutions have mentioned that when certification is achieved for some courses, it has been interpreted by some government institutions that *only* those courses may be taught. Such restrictions, if real, could not be permitted in a Centre whose subject matter changes as new projects are adopted, new computing tools are introduced, etc.

5.4. The Centre should consider charging a fee to participants and organizations for its services.

If the Centre is to provide advanced software development services and consultation to both government ministries and the private sector, it should use a fee schedule for these services. In this way, a government agency is not providing free services to private companies. It is also important that participants in the Center's activities realize that they are receiving information and services equivalent to those for which thousands or tens of thousands of dollars are spent in sending persons to the U.S. or Europe for specialized training or workshops. In addition, such revenues can help recover the costs of highly trained personnel and modern computing equipment required by the Centre. So that the Centre might use these revenues directly to enhance its staff and equipment, we recommend that:

5.5. An arrangement should be made whereby the Centre is allowed to use earnings thus received, to be used to upgrade computing and other facilities so that it can remain at the relevant state-of-the-art in computing technology for the benefit of the Kingdom.

We believe this type of arrangement is important so that it is clear to all persons that revenues received by the Centre are offsetting most or all of its expenses. If all revenues received by the Centre flow into the general Saudi treasury, with the Center's expenses covered out of the general KACST yearly budget, this greatly hampers planning of Centre activities, since the size of the KACST budget and its allotment for Centre activities are difficult to predict from year to year.

The final recommendation concerns the institutional affiliation of the proposed Centre. There are several possible institutional settings within which the proposed Centre might be placed:

- Within the Institute for Public Administration (IPA)
- Within the National Computer Centre (NCC) of the Ministry of Finance
- Associated with a university such as KFUPM or King Saud in Riyadh
- As part of the King Abdulaziz City for Science and Technology (KACST)
- As a private sector organization.

A central part of the proposed Center's activities involves interactions with, and contractual agreements with, the private sector. It is also important that the Centre have the freedom to involve expatriate personnel in Centre activities, for reasons mentioned earlier. In addition, the Centre is seen as a software development facility, creating useful and important software products for clients throughout all sectors of the Kingdom. These activities are not ones typically undertaken by government Ministries. (Some of them may even be precluded by existing laws and regulations.) Similarly, although an important source of expertise exists in the universities, it would not be compatible with their charters for them to undertake contracts for specific software development projects, or enter into contracts with external companies (e.g., to undertake Arabization of an existing software product and license the resulting software package for use throughout the Kingdom). Although a totally private sector company could do all of the above activities, it is unlikely that capital investment and operating expenses required to build a center of excellence in software development would provide sufficient payback. The budget for the proposed Centre (to be discussed below) requires some government subsidization, at least in the initial years. The Centre should also be an important source of expertise and consulting services for all government institutions and organizations, and many participants in the Centre are expected to come from various government organizations. For these reasons, we believe that government affiliation for the Centre is important to its success. It is also clear that a contribution to the Centre by the United Nations Development Programme (UNDP) in Riyadh would not be available to a purely private-sector company. For all these reasons, the clear choice for an institutional affiliation for the Centre is within KACST. The KACST charter (see Section III, above) explicitly encourages interactions with, and the promotion of, private industry, and yet KACST is a governmental institution with the benefits that provides. Our final recommendation, therefore, is:

> *Recommendation 6: The proposed Centre should be administratively located within the King Abdulaziz City for Science and Technology (KACST).*

In support of the above recommendation, we summarize points made earlier in Section III of this report: (1) The KACST charter specifically encourages KACST as a link between government and private industry; (2) KACST operates a major worldwide information retrieval service, is the principal node on GULFNET, and is developing major databases for the Kingdom. It therefore has much relevant expertise in practical computing technologies; and (3) KACST has world-class new facilities, an IBM mainframe computer, and could share library, conference room, and similar facilities with the proposed Centre, thereby saving cost and time in the establishment of the Centre.

It is also again noted that the 15 KACST employees currently obtaining Masters and Ph.D. degrees in computer science abroad will be returning over the next several years; some of these persons would form an excellent core staff at KACST for the proposed Centre.

We emphasize that the proposed Centre provides a different but complementary service to that provided by the universities and other government organizations such as IPA and the National Computer Centre. The principle role of the new Centre is to prepare personnel for software development, whereas the principal role of the universities is teaching and research, and of the NCC, for example, service.

The following section discusses in more detail the management, administration, and budget for the Centre.

VII. WORK PLAN, MANAGEMENT, FACILITIES AND BUDGET FOR THE PROPOSED CENTER

A. WORK PLAN

To understand the personnel and facilities required for the proposed Centre, it is first useful to study a work plan showing the various Centre activities as a function of time. For this and other budgeting purposes, we indicate a plan for the Centre over its first four years. After this time, succeeding years are expected to be similar, or else by that time lessons learned from the initial years might cause some modifications to be made to the Center's set of activities that are currently unforeseen.

Figure 4 on the following page presents a workplan for the Center's seven principal activities. From this chart, we can see that the first year is taken up by establishing appropriate facilities and training a Centre staff who will become project leaders and workshop directors. Three of the normal five projects are expected to start during the second half of the first year, with some consulting and workshop activities also starting, along with the establishment of some ties to external organizations.

The following table summarizes the number of participants to be reached during the first four years of the Center's operation. (Succeeding years would be similar to year 4, or modified according to lessons learned from initial activities.)

NUMBER OF PARTICIPANTS IN CENTER ACTIVITIES, YEARS 1-4

Projects:

# projects	# participants per project	# months per participant	Year 1	Year 2	Year 3	Year 4
3	10	3	30			
5	10	4		150	150	150

Workshops and Seminars:

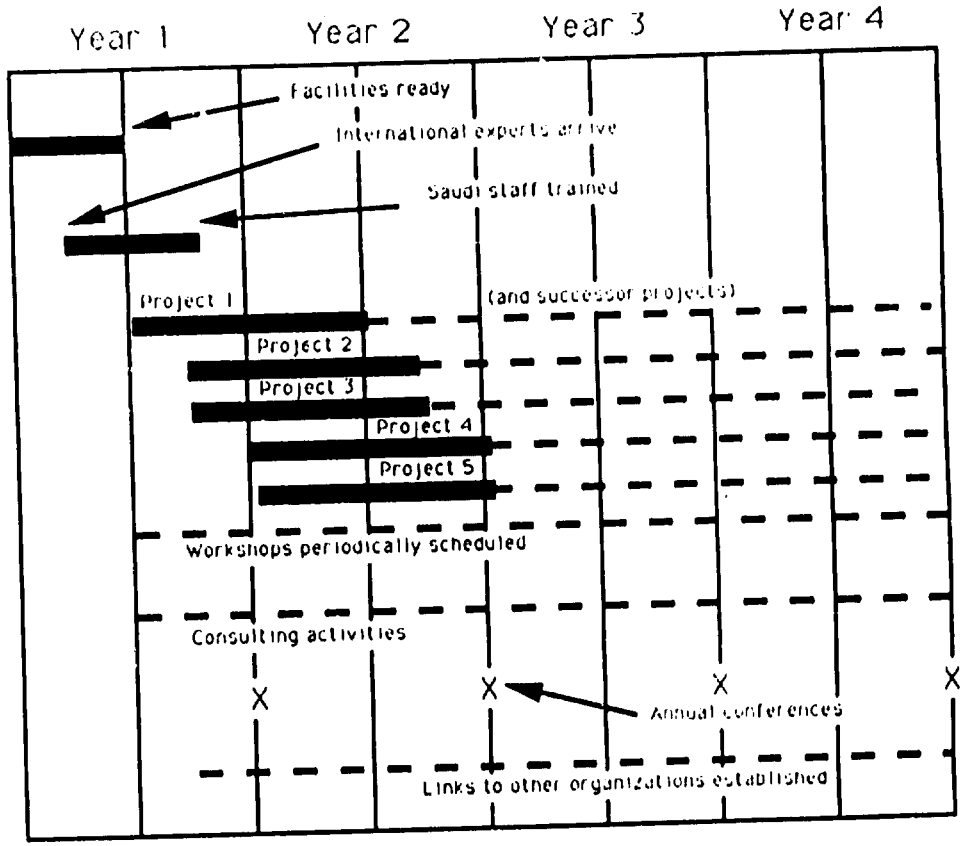
# workshops	# participants per workshop	Year 1	Year 2	Year 3	Year 4
5	20	100			
10	20		200	200	200
	Total Participants per Year:	130	350	350	350

The above figures do not include larger-scale activities, such as the conduct of a conference involving hundreds of participants, and consultations conducted by the Centre. They also do not include the active participation of members of the private sector and universities in leading seminars, workshops or projects.

Figure 4: WORKPLAN FOR CENTER, YEARS 1-4

Activities

1. Establish physical and computational facilities
2. Train Saudi core staff for Center
3. "Hands-on" software development projects
4. Conduct workshops and seminars
5. Consulting activities
6. Conferences, publications
7. Links to other organizations



B. MANAGEMENT

1. Director and Staff of the Centre

The Director of the Centre is responsible for the day-to-day operation of the Centre, including management of the budget, hiring and firing of personnel, establishing contractual arrangements with private sector companies and individuals, procuring physical and computing facilities, etc. The Director would develop an organizational structure for the Centre, to include:

- Project leaders for individual projects
- Administrative staff to handle trainee enrollments, budget, etc.

The Director of the Centre would report to a senior Institute Director within KACST. Descriptions of the job requirements for the Director of the Centre and an Administrative Manager are contained in Annex G to this study.

2. Board of Advisors

There are many institutions within the Kingdom concerned with computer skills and software development.. It is important that the activities of the Centre be coordinated with those of these other institutions. It is therefore proposed that there be a Board of Advisors for the Centre, composed of approximately equal representation from each of the following three sectors:

- Government (including KACST)
- Universities (with representation from the eastern, central, and western districts)
- the private sector.

Membership on the Board of Advisors should not exceed 12 persons, to promote efficiency in its meetings.

The Board of Advisors would review the Center's activities and programme, and suggest high-priority areas for software development, software tools for which in-Kingdom expertise is needed, and standardization and coordination efforts to which the Centre should direct its attention.

3. Panel of Technical Experts

Since the entire function of the proposed Centre relates to the next generations of computing tools and techniques to be used within the Kingdom, it is important that the activities of the Centre be compatible with international computing trends and standards of excellence. To this end, it is proposed that the activities and plans of the Centre be reviewed at least every year by a special Panel of Technical Experts, appointed by the Director of the Centre, with the technical assistance of UNIDO in locating and contacting experts. This Panel would be comprised of internationally recognized computer experts -- preferably ones familiar with the policies and conditions within the Kingdom. This Panel would issue recommendations regarding Centre activities, to assist the Director in establishing Centre priorities, plans and policies.

C. FACILITIES

This section describes both the physical (building, rooms, etc.) and computational facilities required by the proposed Centre.

1. Physical Facilities

As can be seen from the work plan for the Centre, at any one time there might be up to five software development projects underway, a workshop being held, and planning for a conference or seminar underway. At any time, there might be at least 70 participants in these activities, plus a Centre staff of from 10 to 15 persons. Therefore the physical facilities required for Centre operation are estimated to be as follows:

Activity	Type of Space	Total sq. m.
Software development projects	5 project rooms, ea. with 10 workstations plus project leader space. (Est. 100 sq m. ea.)	500 sq. m.
Workshops and short courses	1 room capable of holding 50 people in lecture style, or 20 people in round-table discussion. (Est. 100 sq. m.)	100 sq. m.
Offices for Centre management and admin.	1 Centre Director office (30 sq m.) 1 Admin. Mgr. office (20 sq m.) 7 project leader or workshop leader offices at 12 sq .m. ea. 1 small conference room (20 sq m.)	154 sq. m.
Public areas	prayer room, kitchen, lounge, hallways, entry, etc. (150 sq. m.)	150 sq. m.
	Total:	904 sq. m.

We therefore estimate that initial Centre activities could occupy a space of a bit less than 1000 square meters. If the Centre were to be located within a KACST building already containing a general-purpose conference room, with some public areas (prayer room, kitchen, etc.) shared between the Centre and other KACST activities, it is possible that less space would be required solely for Centre activities. It should also be noted that if some development projects were performed at remote locations, such as at a women's facility or in Dhahran, some of the space listed above would be allocated to those remote locations and not immediately required at the KACST facility. For planning purposes, however, it would be best to allocate space that would allow up to five simultaneous projects to be conducted at the main Centre site within KACST, as the table above does.

2. Computational Facilities

One of the areas of emphasis of the Centre is the use of modern software tools available on powerful personal computers and graphic workstations, and the linking of groups of such workstations into a local area network permitting file sharing among stations and centralized file storage. Due to the widespread use of mainframe computers within the Kingdom, it is also important to link these workstations to mainframes for the querying of databases, exchange of data files, etc.

We therefore assume each software development project will use 10 personal computers or workstations, networked together and linked to a central KACST mainframe. (One of the advantages of housing the Centre within KACST is access to its mainframe and access to Gulfnet and other international networks such as Bitnet and EARN without major additional capital expenditure.) Exactly how powerful the PCs must be, or what configuration of workstation, depends on the particular project; a modeling project has somewhat different needs than a relational database project. In order to make budget estimates, we assume:

The typical personal computer used by a project will be:

Either: a 80386-based IBM-PC-equivalent personal computer with 4 megabytes of RAM, an 80-megabyte hard disk, VGA graphics monitor, and network connection,

or: a Macintosh II personal computer with 5 megabytes of RAM, an 80-megabyte hard disk, a color display and network connection.

The typical graphic workstation used by a project will be:

A Sun Microsystems Sun/4 workstation with high-resolution color monitor, 8 megabytes of RAM, a 300-megabyte hard disk, and network connection

or: an equivalent DEC MicroVAX graphic workstation, or Data General, Silicon Graphics, or PRIME workstation, or similar device from other manufacturers.

We assume that each PC will have an average of three software packages at $200 each, and each graphic workstation will have three software packages at $700 each plus a major software system (e.g., operating system) at $10,000. In addition, the proposed budget provides for several laser printers for high-quality output, and desktop scanners to allow entry of text and graphic materials; each of these devices would reside on local area networks tying the workstations together and linking them to the mainframe. We have reserved funds for one mass file storage facility--for example based on optical storage principles--for archival storage of data.

D. BUDGET

The worksheets on the following two pages indicate expected expenses and possible revenue for the proposed Centre during its first four years of operation. (The Centre may choose *not* to charge for its activities, in which case the discussion of possible revenues below is not relevant.) All dollar figures are in U.S. dollars. Where Saudi riyals are shown for local salaries, they have been converted to dollars at the rate of 3.75SR = $1 US. As can be seen, initial expenditures are higher than revenue, primarily during the first two years, due to major capital equipment purchases for workstations, networks, etc. Starting in year 3, the Centre reaches a "steady state" in which expenses are greater than revenues by about $230,000 per year. Unless greater fees are charged for Centre services, this amount should be covered by a yearly government subsidy of the Centre's operation. The total net expense for the first four years' operations for the Centre is shown to be $1,833,567. This should be considered as the investment required to initiate the Centre and provide excellent facilities, resulting in a Centre that should require only modest subsidies thereafter. (These calculations depend of course on the Center's charging for its services, and being able to use earnings for paying certain expenses -- policies that were recommended earlier in this report.) The expense figures shown do not include rent or other expense for the physical facilities occupied by the Centre, since it has been assumed that the approximately 900 square meters of incremental space required by the Centre could be found within the excellent buildings currently being constructed for KACST operations. If this assumption proves invalid, then assuming a rental cost of SR 800 per square meter, approximately 900 * 800 / 3.75 = $192,000. of additional expenses must be included in the Center's budget each year, plus an approximate 20% additional for maintenance and utilities, or $38,400.

SAUDI NATIONAL SOFTWARE DEVELOPMENT CENTER
EXPENSES, YEARS 1-4

3.75 SR/$ exchange rate

CENTER MANAGEMENT AND ADMINISTRATION, YEARLY EXPENSES

	SR/mo., ea.	$/yr., ea.	#	Year 1	Year 2	Year 3	Year 4
Center Manager (grade 12)	20,000	$64,000	1	$58,667	$64,000	$64,000	$64,000
Admin. Deputy (grade 11)	17,000	$54,400	1	$49,867	$54,400	$54,400	$54,400
Project Leader	20,000	$64,000	5	$160,000	$320,000	$320,000	$320,000
Secretary, bi-lingual (gr. 6)	8,000	$25,600	2	$42,667	$51,200	$51,200	$51,200
Technician, chief	6,000	$19,200	1	$9,600	$19,200	$19,200	$19,200
Technician, regular	5,000	$16,000	2	$16,000	$32,000	$32,000	$32,000
Administrative aide	3,000	$9,600	3	$26,400	$28,800	$28,800	$28,800
Driver or aide	2,500	$8,000	2	$14,667	$16,000	$16,000	$16,000

CONSULTANTS

	SR/hr., ea.	hrs/mo., ea.	# man-mo	Year 1	Year 2	Year 3	Year 4
PhD professor	150	40	9	$14,400	$14,400	$14,400	$14,400
MS professor	100	40	9	$9,600	$9,600	$9,600	$9,600

INTERNATIONAL EXPERTS

	# man-mo./yr.	$/man-mo.	airfares/yr.	Year 1	Year 2	Year 3	Year 4
Full-time	24	$12,000	$12,000	$300,000	$300,000	$300,000	$300,000
Short-time	3	$12,000	$12,000	$48,000	$48,000	$48,000	$48,000

TRAVEL EXPENSE WITHIN KINGDOM FOR INTERNATIONAL EXPERTS — $3,750 | $3,750 | $3,750 | $3,750

UNIDO COORDINATION TRIPS

# days/yr	DSA $/day	fee $/day	airfares/yr.	Year 1	Year 2	Year 3	Year 4
75	$160	$0	$12,000	$14,400	$14,400	$14,400	$14,400

SAUDI STAFF TRAVEL EXPENSE

# days/yr	expenses/day	airfares/yr	Year 1	Year 2	Year 3	Year 4
50	$160	$10,000	$18,000	$18,000	$18,000	$18,000

EXPENSE TO HOST AN INTERNATIONAL CONFERENCE — $50,000 | $50,000 | $50,000 | $50,000

HARDWARE CAPITAL EXPENSE

	cost $ ea		Year 1	Year 2	Year 3	Year 4
Personal computers	$6,000	# =	20	10	0	0
		$ =	$120,000	$60,000	$0	$0
Graphic workstations	$20,000	# =	10	6	2	2
		$ =	$200,000	$120,000	$40,000	$40,000
Laser printers	$6,000	# =	5	2	0	0
		$ =	$30,000	$12,000	$0	$0
Desktop scanners	$8,000	# =	2	1	0	0
		$ =	$16,000	$8,000	$0	$0
Mass file storage facility	$12,000	# =	1	0	0	0
		$ =	$12,000	$0	$0	$0
Local area networks	$5,000	# =	2	0	0	0
		$ =	$10,000	$0	$0	$0
Spare parts inventory	$10,000	# =	1	1	1	1
		$ =	$10,000	$10,000	$10,000	$10,000

SOFTWARE EXPENSE

	cost $ ea.		Year 1	Year 2	Year 3	Year 4
Software packages, small	$200	# =	60	30	10	10
		$ =	$12,000	$6,000	$2,000	$2,000
Software packages, larger	$700	# =	30	30	6	6
		$ =	$21,000	$21,000	$4,200	$4,200
Software packages, major	$10,000	# =	10	10	2	2
		$ =	$100,000	$100,000	$20,000	$20,000

COMPUTER HARDWARE MAINTENANCE FEES
computed at: 25 % of installed equipment base (including hardware and software) — $130,250 | $212,000 | $228,550 | $245,100

OTHER:

	Year 1	Year 2	Year 3	Year 4
Furniture capital expense	$100,000	$20,000	$12,000	$12,000
Software licensing fees	$25,000	$25,000	$25,000	$25,000
Communication services	$30,000	$30,000	$30,000	$30,000
Expendable supplies	$40,000	$40,000	$40,000	$40,000
Automobile expenses	$10,000	$5,000	$5,000	$5,000
Subscriptions (books, magazines, databases)	$5,000	$5,000	$5,000	$5,000
TOTAL EXPENSES PER YEAR =	$1,707,267	$1,717,750	$1,465,500	$1,482,050

SAUDI NATIONAL SOFTWARE DEVELOPMENT CENTER
REVENUES, YEARS 1-4

FEES FROM PARTICIPANTS IN SOFTWARE DEVELOPMENT PROJECTS

# projects	# persons/project	fee, $/day	# days/yr.	Year 1	Year 2	Year 3	Year 4
1	10	$75	110	$82,500			
2	10	$75	55	$82,500			
5	10	$75	220		$825,000	$825,000	$825,000

FEES FROM WORKSHOPS AND SEMINARS

# workshops	# persons/workshop	fee, $/wkshp	Year 1	Year 2	Year 3	Year 4
5	20	$350	$35,000			
10	20	$350		$70,000	$70,000	$70,000

CONSULTING INCOME

consulting assignments/yr.	fee, $/assign.	Year 1	Year 2	Year 3	Year 4
6	$15,000	$90,000			
10	$25,000		$250,000	$250,000	$250,000

SOFTWARE LICENSING INCOME	$0	$15,000	$40,000	$60,000
UN DEVELOPMENT PROGRAMME (UNDP) CONTRIBUTION/YR.	$500,000	$100,000	$50,000	$49,000
TOTAL YEARLY INCOME =	$790,000	$1,260,000	$1,235,000	$1,254,000

NET INCOME CALCULATION:

	Year 1	Year 2	Year 3	Year 4
Revenues	$790,000	$1,260,000	$1,235,000	$1,254,000
Expenses	$1,707,267	$1,717,750	$1,465,500	$1,482,050
Net Revenue	($917,267)	($457,750)	($230,500)	($228,050)

TOTAL NET REVENUE, FIRST FOUR YEARS = $ -1,833,567

It has been shown that the proposed Centre can be operated starting in year 3 with an approximate yearly subsidy of $230,000, with an initial net investment of approximately $1.83 million for equipment and start-up costs during the first 4 years (again excluding rental cost for this analysis) -- if the Centre chooses to, and is permitted to, charge fees for its various services. Is this a good investment for the Kingdom? Those costs must be weighed against the expected benefits.

We do not perform here a formal cost/benefit analysis, because the proposed Centre is not a commercial organization. As a government-related institution, its importance must be considered primarily in terms of the long-range goals and aspirations of the Kingdom.

One obvious benefit from the Centre involves the efficiency of software development activities. Throughout the Saudi government, there are dozens of computer centers, each employing dozens of programmers and system developers. Throughout the private sector (including such "semigovernmental" organizations as SABIC), there are thousands of programmers and system developers involved in the design and creation of database systems, computer models and simulations, specialized accounting and other business packages, scientific applications, etc. A very conservative estimate is that there are (the equivalent of) three thousand full-time professional employees involved each year in software development activities. While it is clear that use of modern software development tools and methodologies can at times allow creation of a system 10 times faster (e.g., using a relational DBMS and associated fourth-generation language) rather than programming an application in COBOL), it is very conservative to estimate that, through the activities of the proposed Centre, a 20% improvement in software development productivity could be achieved, on average, throughout the Kingdom within five to 10 years. This is equivalent to a 20% reduction in professional software developers required, many of whom are expensive expatriate personnel. These savings can be achieved in the development of software for existing mainframe computers, greatly increasing the effective utilization of the Kingdom's major investment in existing equipment.

Yet another saving is long-term, regarding software maintenance. The growing libraries of Saudi software systems written in COBOL and Fortran must be maintained by a staff of persons, to be updated as accounting rules change, new hardware or operating systems are installed, etc. Software written in the higher-level languages to be promoted by the Centre are much easier to maintain, because: (1) they are often 1/5 the size of the comparable COBOL or Fortran program; and (2) they are written in a manner that closely matches the terminology of the application, so they are easier to understand. Also, if programmed in an object-oriented fashion, they are often highly modular, so that changes can be more easily made in one part of a program without affecting many other parts. A 20% saving in software maintenance salaries could well be expected.

There are savings that are more difficult to calculate, but that nevertheless easily amount to millions of dollars per year: For example, use of workstations and local area networks can offload a mainframe computer from some of its most intensive computation, so that an expensive upgrade in capacity can be avoided as it becomes overburdened. In some cases, a business or government ministry contemplating purchase of a major mainframe installation might realize that a minicomputer linked to a set of workstations satisfies its needs better, at a fraction of the cost. A valuable expatriate performing a vital service to the Kingdom might be persuaded to remain in the Kingdom longer if he can upgrade his computer skills while remaining there (e.g., by participating in a Centre development project using new tools and techniques), rather than leaving to stay current in this continually changing field.

Most importantly, however, is the possibility of achieving more self-sufficiency within the Kingdom in developing modern computer software systems. By creating a center of excellence for software development within the Kingdom, simulations, models, database management systems, management information systems, educational software and scientific software can be created as needed, more rapidly and efficiently than at present. This will result in less reliance on expensive and at times unsatisfactory contracts with external organizations for major software development activities, and more control of the software development process.

In summary, the cost of establishing the proposed Centre (assuming recommended fee schedules for services are implemented) is a one-time net expense of approximately $1.8 million. As the techniques and tools to be promulgated by the Centre become more widely known and used throughout both the government and private sectors, it is clear that the savings in software development and maintenance costs can exceed many millions of dollars per year. More importantly, though, the Kingdom's software, databases, models and systems will be much more compatible with those being developed in the U.S. and Europe, making it much easier for organizations in the Kingdom to establish electronic links with counterpart organizations in various other countries, and to adopt their systems much more rapidly and effectively to the evolving information society being developed worldwide. In addition, the Kingdom can, in time, gain control over software development activities which are vital to its economy and its security.

VIII. CONCLUDING REMARKS

There is a growing gap between the software development tools and techniques being used within the Kingdom and those being used in countries such as the U.S. and in Europe. Most international corporations are actively developing decentralized, heterogeneous computer networks comprising powerful personal computers, graphic workstations, minicomputers serving as "file servers" for the network, and network links to mainframes, with telecommunication links from some of these systems to other computers in distant locations. Most of the most innovative and productive software tools (such as CASE, CAD, RDBMS tools) are being developed for this network environment, because it puts a highly interactive graphic "window" directly into the computer in the hands of a user, and because very useful computing can now be done on machines that fit on or under a desk -- power that used to require a medium- to large-scale computer with air conditioning, raised floors, and all the other paraphernalia. Networked, decentralized computing is more reliable, because individual components can fail without bringing down the whole system. It is also more cost effective, since small increments of computing power can be bought as needed.

The proposed Saudi National Software Development Centre, as part of KACST, can act as a center of excellence within the Kingdom for software development techniques, provide a link between the government and private sector companies, provide state-of-the-art consulting services to all sectors, act as a catalyst in helping develop a national plan for the development of computing in the Kingdom, help establish the best standards for Arabic standards for computing, Arabize key software packages needed by many organizations in the Kingdom, and develop particularly difficult or challenging software systems that might otherwise involve expensive development contracts with external companies, with the concomitant problems of making sure that requirements are understood, and that the resulting system really meets the organization's needs. The analyses in this report indicate that such a Centre can be developed in such a way that it will be almost self-supporting after an initial investment -- and that the initial investment that can easily be repaid to the Kingdom many times over in succeeding years. The proposed Centre would be an excellent investment in the Kingdom's future.

GLOSSARY

AppleTalk	A local area network protocol developed by Apple Computer.
bit	The basic unit of information storage, represented symbolically as either one or zero and electronically as a voltage difference
BITNET	An international store-and-forward network linking over 1,400 computers; used primarily by higher educational institutions and other research facilities.
byte	A unit of data storage large enough to store one character of information; usually 8 bits
CAD	Computer-Aided Design
CASE	Computer-Assisted Software Engineering
COBOL	Common Business Oriented Language
DBMS	Data Base Management System
DIALOG	A major U.S. information storage and retrieval service, through which a great many citations and text of articles can be searched for and retrieved
EARN	A European electronic data store-and-forward network linking educational and scientific institutions
Ethernet	A packet-switched network protocol developed by Xerox
GULFNET	A data store-and-forward network linking eleven major computer sites within the Gulf to the principal node at KACST.
IBM	International Business Machines Corporation
ISO	International Standards Organization
IPA	Institute for Public Administration
KACST	King Abdulaziz City for Science and Technology, in Riyadh, Saudi Arabia
KFUPM	King Fahd University of Petroleum & Minerals, Dhahran
LAN	Local Area Network; a computer network in a localized geographical area (e.g., a building or campus) that offers electronic communication among a variety of computing equipment
LEXIS	A major electronic database of legal citations and information in the U.S. Accessed for information retrieval purposes by KACST.
megabyte	One million bytes of information (actually 2 to the 20th power: 1,048,576 bytes)
MIPS	Millions of Instructions Per Second

MIS	Management Information System, a set of programs for business information handling within an enterprise
MS-DOS	Microsoft's Disk Operating System, the standard for IBM-compatible PCs (also called PC-DOS when distributed by IBM)
NCC	National Computer Centre, within the Ministry of Finance
NEXIS	A major U.S. electronic database of news articles from a wide variety of newspapers. Accessed for information retrieval purposes by KACST.
OSI	Open Systems Interconnection, a seven-level standard for data networks
PostScript	A page layout language designed by Adobe Corporation; also exists as "Display PostScript" as a standard for communicating graphic information to display terminals
PC	Personal Computer
RDBMS	Relational DBMS; a method of storing and describing data within a DBMS that has considerable power and flexibility
SNA	Systems Network Architecture, pioneered by IBM
STADAP	Statistics and Data Processing Project, of the U.S. Saudi Arabian Joint Commission on Economic Cooperation
TCP/IP	Transport Control Protocol/Internet Protocol; a standard network protocol developed by the U.S. Dep't. of Defense
TPS	Transactions Per Second
UNIDO	U.N. Industrial Development Organization, headquartered in Vienna, Austria
UNIX	A computer operating system developed at Bell Laboratories; runs on all sizes of computers from supercomputers to the more powerful PCs, and on many different manufacturers' computing equipment. The latest version, being used as a standard by many companies, is called "System V"
VAX	A popular minicomputer series developed by Digital Equipment Corporation; smaller computers in the series used in workstations are called MicroVAX
X.25	A standard for levels 1-3 of the OSI network protocol, being adopted for data communication by the Saudi PTT
X Windows	A standard software interface to interactive display functions, developed primarily at the Massachusetts Institute of Technology (MIT)
4GL	Fourth-generation language; characterizes a programming language having major application-specific capabilities built-in; may be non-procedural

ANNEX A:

PERSONS CONTACTED AND SCHEDULE OF MEETINGS FOR DR. ANDERSON WITHIN SAUDI ARABIA

May 27, 1989

Meeting with Mr. Mohammed Ali Al-Tasan, Director General of Information Systems, King Abdulaziz City for Science and Technology and review of program

May 28, 1989

09.00	Mr. Abdulrahman Al-Rezehi, Director, Computer Center, KACST
10.00	Mr. Mohammed Ali Al-Arfaj, Director, Information Services, KACST
11.00	Mr. Hamad Al-Saadoun, Director, National Databases, KACST
13.00	Mr. Abdulaziz A. Al-Muammar, Director of National Networks, KACST

May 29, 1989

08.30	Visit to New Computer Building
09.30	Visit to Remote Sensing Data Processing Facilities
13.00	Dr. Mohammed Tarabzouni, Director, Institute of Space Research and Remote Sensing, KACST

May 30, 1989 (Tuesday)

08.30	Dr. Abdullah Al-Rasheed (Director General of Patents and Science Awareness, KACST)
10.00	Al-Khaleeg Computers and Electronics Systems Mr. Nash Mikhail, Manager, Riyadh Division (Phone:465-6610)
11.30	Dr. Fadhal Ahmed Noor Mohammed (Director, Institute of Astronomical Research, KACST)
13.00	Advanced Systems Limited Mr. Abdulrahman A. Al-Kassim, Director (Phone: 465-7492)

May 31, 1989 (Wednesday)

09.00 National Computer Center (Mr. Ahmed Ghamdi, Director, Mr. Rehmatulla M. Ahmed, Manager, User Services, Mr. Bob Turner)

June 03, 1989 (Saturday)

08.30 Dr. Abdulaziz Al-Saggar, Head Computer Department Ministry of the Interior, Information Center (478-0210)

10.00 Dr. Hamad Al-Dhaj, Head of Computer Center King Faisal Specialist Hospital (Phone: 4427805; Fax: 4414839)

12.30 Institute of Public Administration (Mr. Abdulaziz Al-Quwaiz (Phone 4777[illegible]9)

June 4, 1989 (Sunday)

08.30 Al-Manar Training Center (Dr. Mohammed Sadeq, Manager, Phone: 476-5558)

10.00 King Saud University Computer Center
Dr. Mohammed Al-Turaiqi, Director, Computer Center
Mr. Daud Matthews, Manager, Technical Services, Comp Ctr
Dr. Abdullah I. Al-Salamah, Supervisor Info Science Dept
KSU College of Computers and Information Sciences

June 5, 1989 (Monday)

09.30 Riyadh House
Mr. Rashad Othman, Vice President Marketing;
Mr. Noor Idrees (405-5889)

11.00 Ministry of Finance & National Economy
Mr. Mohammed Al-Nafie, Economic Advisor, NCFIE

13.00 Ministry of Planning
Dr. Saleem Al-Arf ; Adil Al-Awwad (Phone: 401-3333)

June 6, 1989 (Tuesday)

10.00 General Organization of Social Security
Mr. Rageh M. S. Al-Zahrani, Systems Manager,
(Phone: 4777558; Fax 4777735/101)

11.00 Gulf Cooperation Council
Mr. Mohammed Shatti

13.00 Saudi Office Systems
Mr. Abdulrahman Al-Mazi, Managing Director (463-2263)

18.00 National Center for Training and Computer Services
Dr. Farouk R. Zalatimo, General Manager

June 7, 1989 (Wednesday)

08.00 Dr. Abdulrahman Ulfat, Director of Planning and Implementation, KACST

10.00 Ministry of Education,
Dr. Abdulaziz Al-Mansour

13.30 SABIC
Mr. Abdulrahman Al-Shaikh

June 8, 1989 (Thursday)

09.30 Al-Alamiyah
Mr. Khalid Zakaria (Mr. Mohammed Turani was out of town)
(478-2406; 479-2720)

June 10, 1989 (Saturday)

King Fahd University of Petroleum and Minerals

09.00 Dr. Mohammed Abul A. Hamayel, Director, Data Processing Center (Phone: 860-3900)

10.00 Dr. Mohammed Ibrahim Al-Suwaiyel, Dean, College of Computer Science and Engineering
(860-2140)

Dr. Muhammad A. Al-Tayyeb, Assistant Professor
College of Computer Science and Engineering

June 10, 1989 (Saturday) .....continued

13.00 Mr. Ibrahim S. Al-Mishari, General Manager, EXPEC Computer Center, ARAMCO (876-4964)

14.00 Al-Falak Electronic Equipment and Supplies Co.
Mr. Leonce Kealy, Sales Representative, Software Product Division (894-6560)

June 11, 1989 (Sunday)

10.00 **King Saud University**

Dr. Mohammmed M. Al-Mandora
Dean, College of Computer Sciences

14.00 Mr. Mohammed Ali Al-Tasan

June 12, 1989 (Monday)

10.00 Submission of preliminary report and discussion with Mr. Mohammed Ali Al-Tasan

June 13, 1989 (Tuesday)

Visit to Western Region

1030 Saudia Corporate Training and Development Center
Mr. Dale S. Tucker, Asst Manager, Aviation and Microcomputer Training (651-6064)

13.30 SAMACEC (Petroserve)
Mr. Abdul-Ilah Z. Al-Muhanna, Vice President, Information Technology (Phone: 667-2111)

14.30 IBM Country Training Center, Jeddah
Jean-Claude Mouton, Manager (02-660-0007)

13.00 Prince Faisal bin Sultan
Deputy Minister of Planning for Information

June 17, 1989 (Saturday)

10.00 Civil Service Bureau
Mr. Abdulrahman Al-Shehab, Training Manager
(402-0701)

11.00 Mr. Ibrahim Al-Abdulwahab (CSB)
Mr. Ahmed Bil Qasim (CSB)

13.00 Mr. Mohammed Ali Al-Tasan
Mr. Abdulaziz Al Muammar
Mr. Mohammed Ali Al-Arfaj

June 18, 1989 (Sunday)

10.00 KACST Directorate for Technology Transfer
Adnan J. Al-Saati
Mohammed A. Al-Fawzan

June 19, 1989 (Monday)

11.00 Saudi Business Machines, Riyadh office (IBM distributor)
Jean-Claude Mouton
Hassan Faroun
Adnan Rashid

June 20, 1989 (Tuesday)

13.00 Mr. Abdulaziz Al-Muammar, KACST

June 21, 1989 (Wednesday)

8.30 Dr. Abdulrahman Ulfat, Director of Planning and Implementation, KACST

10.00 Dr. A. Al-Kadhi, Vice President, KACST

11.00 Saudi American Bank
Salman Al-Fares and associates

June 22, 1989 (Thursday)

10.00 Dr. Ahmed Namek, Resident Representative and Resident Co-ordinator, UNDP
Kyaw Lwin Hla, Deputy ResRep, UNDP, Riyadh

11.00 Abdullah A. Al-Ateeq
Assistant Secretary General, Foreign Affairs
Council of Saudi Chambers of Commerce and Industry

ANNEX B:

SCHEDULE AND ATTENDEES FOR REVIEW MEETING, RIYADH, SEPTEMBER 11-13, 1989

A draft copy of this report was discussed at a review meeting held at the facilities of the King Abdulaziz City for Science and Technology (KACST) in Riyadh during September 11-13, 1989. At this meeting, recommendations in the report were substantially approved by the participants, with some modifications which have been incorporated into this final report. Participants who attended some or all of these meetings were:

KACST representatives:
- Dr. Abdullah Al-Kadhi
- Mr. Mohammed Ali Al-Tasan
- Dr. Hassan Tayyim
- Dr. Abdulrahman Ulfat
- Dr. Mohammed Fasihuddin

Other Saudi University and Government representatives:
- Dr. Mohammed M. Mandurah (King Saud University)
- Dr. Ahmed M. Sahab (Ministry of Municipal & Rural Affairs)
- Mr. Rehmatullah Mohammed Ali (National Computer Center)
- Mr. Abdulaziz Al-Quwaiz (Institute of Public Administration)
- Mr. Anwer Abdullah Banjer (National Information Center)
- Mr. Saleh Ali Al-Dhalan (National Information Center)

U.N. Development Programme (UNDP) representatives:
- Dr. Ahmed Namek
- Dr. Jamil Sofi

U.N. Industrial Development Organization (UNIDO) representatives:
- Dr. Wafa Kamel
- Dr. Georgios Anestis
- Dr. Robert H. Anderson (consultant)
- Dr. Thomas Greene (consultant)
- Dr. Anthony Hearn (consultant)
- Mr. Peter Norton (consultant)

The schedule for the three-day review meeting is shown on the following page.

UNIDO/KACST REVIEW COMMITTEE MEETINGS TO CONSIDER PREPARATORY REPORT FOR THE ESTABLISHMENT OF A NATIONAL SOFTWARE DEVELOPMENT CENTER IN SAUDI ARABIA

September 11, 1989 (Monday)

9:00 am	Meeting with Mr. Mohammed Ali Al-Tasan, Director General, Information Systems, King Abdulaziz City for Science and Technology
	Introduction of UNIDO delegation (Dr. Ahmed Namek, Resident Representative and Resident Coordinator, UNDP, Riyadh)
	Welcome to the delegates and overview of KACST charter and activities (Mr. Mohammed Ali Al-Tasan)
10:00 am	Meeting with Dr. Abdullah Al-Kadhi, Vice President, King Abdulaziz City for Science and Technology
11:00 am	Film about KACST
	Intermission for Dhuhar Prayers
12:30 pm	Visit to the Computer Center

September 12, 1989 (Tuesday)

9:00 am	Review of the UNIDO technical report prepared by Dr. Robert H. Anderson
	Introduction of UNIDO mission (Dr. A. Namek, Resident Representative and Resident Coordinator, UNDP, Riyadh)
	UNIDO activities in the field of software development in the developing countries (Dr. Wafa Kamel)
	Presentation of key recommendations and conclusions of project study (Dr. Robert H. Anderson)
	Review of recommendations and conclusions of the project study
1:30 pm	Lunch

September 13, 1989 (Wednesday)

9:00 am	Conclusions and recommendations of the Review Committee
12:15 pm	Future trends in personal computers (Dr. Peter Norton)
	Computer-aided symbolic mathematics (Dr. Anthony Hearn)

ANNEX B:

KING ABDULAZIZ CITY FOR SCIENCE AND TECHNOLOGY

King Abdulaziz City for Science and Technology
P.O. Box 6086
Riyadh 11442
Phone: 4788000
Telex: 261590 SANCST SJ
Cable: MOASSOUAH

The King Abdulaziz City for Science & Technology (KACST) is an independent scientific organization, administratively attached to the Prime Minister. It was established by a Royal Decree No. M/60, dated Dual Hijjah 18, 1397. In accordance with the Bylaws, the City's headquarters shall be located in Riyadh and branch offices may be established in the Kingdom's other cities.

KING SAUD UNIVERSITY PRESS

KACST Supreme Board

KACST bylaws issued by Royal Decree No. M/8, dated Rabi.-II 19, 1406, stipulates that the City shall have a Supreme Board that will be the controlling authority in all matters affecting the City's functions and managing its affairs. The Supreme Board consists of the following :

- Prime Minister	Chairman
- Deputy Prime Minister	Vice Chairman
- Minister of Defence and Aviation and Inspector-General	Member
- Minister of Higher Education	Member
- Minister of Agriculture & Water	Member
- Minister of Industry and Electricity	Member
- Minister of Petroleum and Mineral Resources	Member
- Minister of Planning	Member
- Minister of Finance and National Economy	Member
- President of Intelligence Directorate	Member
- President of KACST	Member
- Three members to be nominated by the Chairman, H.M. the King.	

KACST Objectives

- To formulate the national policy for science and technology development, and to draw up the strategy and plan for its implementation,
- To conduct applied scientific research programs to promote further the Kingdom's development,
- To assist the private sector in the research and development of agricultural and industrial products,
- To support joint research programs between KACST and international scientific institutions,
- To award scholarship to develop necessary skills of individuals and to award grants to institutions to undertake applied research work,
- To coordinate with government agencies, scientific organizations and research centers in the Kingdom.

KACST's DIRECTORATES AND OFFICES

1. Directorate For Scientif Research :

This directorate supports, awards and monitors the applied research activities in the Kingdom's universities, research institutions and other leading agencies and helps in utilizing the research results. Additionally, it supports several national research projects for the development of the Kingdom.

2. Directorate of Information Systems & Technical Services :

In the support of R&D infrastructure, this directorate is providing latest information to scientists, researchers, experts in the Kingdom through online search from its own databases and from selected foreign databases. Its divisions include Information Services, National Databases, Computer, Communication Network, Terminological Data Bank and Library.

3. Directorate of Scientific Awareness :

It promotes scientific awareness among the general public and help them to understand science and technology through the publication of scientific journals and magazines.

4. Directorate for Technology Transfer :

The activities of this directorate, among other things, include to transfer and adapt suitable technologies, develop and diffuse indigenous technologies, and render assistance in the field of technology to different sectors in the Kingdom.

5. Atomic Energy Department :

This department has been entrusted with the responsibility to develop technical skills in the atomic energy for peaceful uses, formulate regulations pertaining to protection from radiation's hazards, and establish necessary facilities for protection from radiation and to conduct research on atomic energy and its applications with a view to transfer nuclear technology to the Kingdom.

In addition to the above activities, KACST has a permanent reprcsentative, representing the Kingdom, at the International Atomic Energy Agency, Vienna, to keep abreast with the latest information and developments in the atomic energy.

6. Space Science Department :

This department supervises KACST's space programs and projects in the establishment of a Remote Sensing Center and a Ground Station to receive satellites transmissions. This department has cooperative agreements with international organizations of friendly nations in the field of space and its related sciences.

7. Patent Office :

This office has been entrusted with the responsibility to formulate Saudi Patent Law and recommend guidelines for its effective application and to regulate Patent Rights under contracts entered into by the Kingdom.

8. Facilities Development :

The Facilities Development Office is responsible for the construction of infrastructure and permanent facilities for KACST at its new site, south of King Saud University. In addition, this office is providing consultative and design services to various KACST projects.

9. General Administration :

The General Administration includes the following departments, namely, Finance, Personnel, Warehouse, General Services and Auxiliary Services. It provides a back-bone service to KACST programs and projects both administratively and financially.

10. Public Relations Department :

This department publicizes KACST's activities, and issues publications on KACST's plans and programs and its achievements.

11. Solar Energy Program :

It undertakes an integrated research program in solar energy research and helps its technology transfer for the development of the Kingdom. It is responsible for the operation of solar energy research station and is engaged in several other research activities in the solar technology.

12. Aquaculture Project :

The Aquaculture Project located in Dirab undertakes research experiments on fish culturing in the fresh water on both foreign and native fishes.

13. National Observatory Project :

This project is engaged in the studies of a site selection for the establishment of the National Observatory Project. Also, it is entrusted with the responsibility to establish a number of lunar observatories in various parts of the Kingdom to help sight Crescent (Hilal).

KACST's Staff

The City has presently 233 staff working with it in different categories. Of which, 19 are Ph.Ds, 21 post-graduates, and 124 university graduates. In addition to this, the City seeks the assistance of several university professors and researchers to help implement its program.

In accordance with Council of Ministers' Decision No. 84, dated Rabi.-II 20, 1404, the City has been granted a university status thereby eliminating the differential between KACST researchers and the teaching staff of the universities. With a view to develop Saudi skilled manpower, the City awards scholarships for training and higher studies both within and outside the Kingdom.

RESEARCH PROJECTS

*Annual Research Grants (ARs)

In fulfilling its principal responsibilites, KACST announces every year ARS inviting Kingdom's scientists/researchers to submit research proposals with a view to provide local talents an opportunity to participate in the Kingdom's development program. These proposals are reviewed and selected in accordance with a set of selection criteria. Ever since its first Program Announcement in 1399 (1979), KACST has so far awarded 172 research award grants at a total value of SR 203 millions. These projects are being carried out at Kingdom's universities, research institutions and other leading agencies. Of the total recipient of award grants, 50% of the researchers represent the Saudi nationals.

Out of 172 projects, 75 projects have already been accomplished and the results of some of these projects have been published in reputable S&T journals and magazines and presented in the international conferences.

National Research Projects

In view of KACST's popularity amongst S&T community in awarding and monitoring ARs, several government agencies have approached KACST with their problems of national importance to find their S&T solutions. Accordingly, the City is supporting the following five national projects at a total value of SR 48 millions :

- In accordance with a request from the Ministry of Health, KACST has awarded a research grant in the field of 'Native Medicines'.

- In accordance with a request from the Ministry of Health, KACST has awarded a research grant to find remedial measures for 'Leishmaniasis disease'.

- In accordance with a request from the Bureau of Experts at the Council of Ministers, KACST has formed a committee of experts on 'National Highway Project' to find solution to keep number of accidents at minimum and ultimately eliminate it in the Kingdom.

- In accordance with a request from the Minister of Inrterior, KACST has awarded a research grant to study on effects of chewing 'Qat' plant and recommend guidelines to curb its addiction.

- In accordance with a request from the Ministry of Communications, KACST has awarded a research grant to study on 'Early deterioration of Concrete Bridge Decks'.

KACST's ON GOING PROJECTS

Solar Energy Research

In view of abundance source of solar power in the Kingdom, KACST has initiated several R&D projects in the

field of solar energy to find an alternative source of energy. Toward this end, KACST has established a 350 KW photovoltaic power station near Riyadh to supply electricity power to three surrounding villages, namely, Al-Jubaila, Al-Uyanah, and Al-Hegira. On Moharram 12, 1404, the solar village was officially inaugurated. Another achievement of solar energy application is the establishment of a Water Desalination Plant in Yanbu. KACST's other solar projects include urban application in which Kingdom's universities are supported to establish solar cooling laboratories.

In addition to the above, KACST is engaged in illuminating Kingdom's highways through the application of solar energy. KACST is also providing consultative services in the field of solar energy to various institutions in the Kingdom.

Aqualculture Project

In 1401, KACST has established an Aquaculture Research Station in Dirab to conduct research on fish culture with a view to provide additional source of protein in the Central region as it is far off from the sea-coasts. KACST has so far successfully conducted research on Tilapia, Carp and Red larvae in the fresh water and has distributed them amongst the local farmers vis-a-vis the latest technical know-how for culturing them in their respective farms.

This project is first of its kind in the Kingdom and the research result so far has been very encouraging. In order to ascertain the adaptability of these larvaes, they were placed in the Al-Aflaj springs. Presently, KACST is concentrating on investigating the propagation of native fishes in the fresh water.

National Observatory Project

KACST has been entrusted with the responsibility to establish a National Observatory Project in the Kingdom. Toward this end, KACST has undertaken an extensive feasibility studies and selected four sites at Hadad Bani Malik (south of Taif), Al-Khadra (north of Abha), Al-Nimas (north of Abha), and Al-Hariq (south of Riyadh). In order to carry out this program, large optical telescopes, scientific equipment, computers and support services were installed at these sites. Visual conditions were found to be excellent at these sites. After collecting necessary data from these sites, the former two sites were closed down. KACST is presently engaged in computing and analyzing the data collected to help it reach on a final decision on site selection.

Lunar Observatory Project

In accordance with Royal Directives, KACST is engaged in establishing lunar observatories in various parts of the Kingdom to help sight the new Crescent at the beginning of each lunar month. The project concerns the problem associated with observing the very thin lunar crescent of both the waxing and waning moon. After intensive survey, KACST has identified some potential sites at Hail, Halat Ammar (north-west of Tabuk, and Al-Wajh. Different types and configurations of telescopes are being tested to determine the best means for sighting the new moon as soon as possible. Once there is a break-through in the project, KACST has plans to establish similar observatories in Makkah Al-Mokarammah, Eastern Region and Al-Gasim.

INFORMATION AND TECHNICAL SERVICES

KACST, from the beginning, has been striving to support the development of an R&D infrastructure to help the S&T community in the Kingdom. Toward this end, KACST has established an information center which provides the latest S&T information to researchers, scientists, students, etc. in their various fields of interest. KACST services in this direction include as follows :

Information Services

KACST has access, through online search, to its own databases and over 200 foreign databases which provides latest S&T information to the S&T community in the Kingdom in their fields of interest. When requested, KACST supplies the requestors with the hard-copy of print either from its own sources or from Kingdom's Information Centers or from foreign vendors.

KACST Databases

KACST operational databases include in the following areas :

- On-going Research Projects,
- English Bibliographic,
- Arabic Bibliographic,
- Manpower,
- Union List of Periodicals,
- Current Awareness,
- KACST funded projects.

KACST Computer

KACST has installed IBM 4331 Computer. KACST has developed a Retrieval System which enables the researchers to make a free-text searching in the different databases.

With a view to benefit from these databases in KACST, several institutions, including universities, are connected to KACST computer. Many more institutions have expressed their desire to have access to KACST databases.

Terminological Data Bank

KACST, in order to encourage arabicization, is making strenuous efforts to translate scientific and technological terms in Arabic. This data bank is concentrating on developing and collecting technical terminology relevant to S&T fields from various sources and will make them available to users. Also, this will be useful in the Machine Translation.

KACST Library

KACST Library has on its stock 4,045 books, 361 periodicals and 29,067,880 reports on microfiche collection on Nuclear Energy. The collection on microfiche was obtained from the International Atomic Energy Agency in Vienna. Besides these reports, KACST Library has 2,500 books on Nuclear Energy and several UNESCO publications on science policies.

Also, it has compiled a bibliography on alternative energy sources.

GULFNET Program

With a view to encourage exchange of latest S&T information among the Arab Gulf countries, KACST has initiated an ambitious plan to develop an academic and research network (GULFNET) which interconnects computer facilities operated by various institutions in the Kingdom and Arab Gulf countries. As a first step, KACST has interconnected the computer facilities of major Kingdom's universities and the Kuwait Institute of Scientific Research (KISR), Kuwait.

INTERNATIONAL COOPERATION

In order to advance S&T programs in the Kingdom, KACST has entered into following project agreements with friendly nations :

1. Project Agreement with the U.S.Department of Energy (DOE) in the field of Solar Energy.
2. Project Agreement with the U.S. National Science Foundation (NSF) in the field of S&T cooperatiuon.
3. Project Agreement with the U.S. National Oceanic and Atmospheric Administration (NOAA) in the field of Remote Sensing.
4. Project Agreement with the U.S. National Aeronautics and Space Administration (NASA) in the field of Space related Science and Technology.
5. Project Agreement with TFRI of the Republic of China in the field of Aquaculturing.
6. Project Agreement with NRC of Canada for establishing National Observatory project.
7. Project Agreement with BMFT of Federal Republic of Germany in the following areas :
   - A 50 Kw Membrane Concentrator Project,
   - Arabicization of Technical Terminology (BASM),
   - Saudi Arabian Vegetation Map.
8. Project Agreement with the Korea Advanced Institute of Science and Technology, Korea, in the following areas :
   - Development of Building & Construction Materials using available resources in Saudi Arabia (Phase I),
   - The utilization of agricultural by-products for the feeding of farm livestock.
9. Project Agreement with CNES of France in the field of Space and Space related Science.

10. Cooperative Agreement with the London School of Tropical Medicine and Hygiene in the Leishmaniasis Disease Project.

KACST's FACILITIES DEVELOPMENT

One of KACST's objectives is to attract highly trained and skilled manpower for implementing its plans. Additionally, it has been entrusted with the responsibility to provide permanent facilities including housing and laboratories.

KACST is constructing its permanent facilities at a total area of 1,400,000 square meters, south of King Saud University. In accordance with Master Plan, the residential and the communal facilities are located to the north of Al-Mugrazat Road which bisects the site and locates to its south the Headquarters building, Research Institutes, Conference Center, Science Halls and the Utilities. The two sides are linked by two bridges and a service tunnel. The research institutes in the facilities are listed below :

- Energy Research Institute,
- Petroleum & Petro-Chemical Research Institute,
- Arid Lands Research Institute,
- Industrial Research Intitute,
- Instrumentation Institute,
- Environmental & Natural Resources Institute,
- Ground Station for receiving Satellites tramissions,
- National Observatory.

On Jumad.-II 16, 1404, KACST awarded a contract at a total value of SR 447 millions for the construction of its housing project over a period of 910 days. The housing project has been designed preserving Islamic culture and Saudi traditions. The salient features of project include construction of 242 villas (of two different types), 132 apartments in 22 buildings, under-ground car parking, 2 schools, 2 Kindergartens, a guest house, family recreation center and 2 mosques. Additionally, KACST has awarded a contract at a total value of SR 209 millions for the construction of utilities.

KACST's PUBLICATIONS

1. Annual Research Award Grants (bi-lingual),
2. Sample Proposal (bi-lingual),
3. Grant General Conditions (bi-lingual),
4. Manual of KACST funded research projects (bi-lingual),
5. Fish Culture Project (bi-lingual),
6. Solar Village (bi-lingual),
7. Solar Radiation Atlas (English),
8. Abstracts of accepted research papers for presentation at the Second Arab Regional Conference.
9. Natural Forests in the Kingdom and their utilization (a KACST funded project) - Dr. Attalah A. Abou-Hasan,
10. Jeddah Old Houses (a KACST funded project) Dr. Sultan M. Khan,

In Press

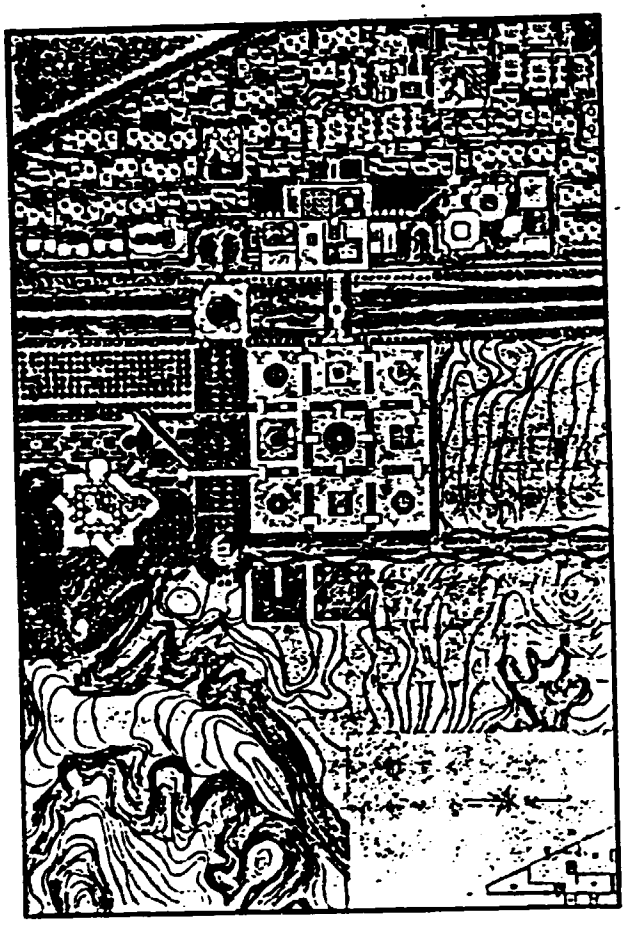
11. Al-Jarodiya Project (Development of a Proto-Type Low Density High Rise Residential Plan for Saudi Arabian Town - a KACST funded project) - Dr. Ahmed Fareed Mostafa,
12. Studies in the termite problem in Saudi Arabia (a KACST funded project), Dr. Ali Ibrahim Badawi,
13. Relationship between Chemical and Microbial contents of potable water and local problems in the Eastern Province (a KACST funded project) - Dr. Abdallah Abou-Melha,
14. Computer-Assisted Translation,
15. Saudi guide for car parking design - Dr. Satish Mohan,
16. Saudi guide for designing inter-sections on high-ways - Dr. Satish Mohan,
17. Native Medicines,
18. Emergency Medical Services,
19. A guide for periodically car checking.

SEMINARS AND CONFERENCES

One of KACST's responsibilities includes the development of national S&T cadres by organizing seminars,

workshops and conferences to help in the exchange of the latest S&T information and disseminate technological developments. Toward this end, in recent years, KACST independently or jointly sponsored or organized the following seminars, symposia and workshops :

1. KACST, in cooperation with the Federation of Arab Scientific Research Council, organized a Conference of Directors of Arab Scientific Research Centers on 'Renewable Energy' in Rabi.-I 1403,
2. KACST, in cooperation with King Abdulaziz University, organized first course on 'Protection of Radiation Hazards' in Jumad.-II 1404,
3. KACST, in cooperation with Ministry of Planning, organized a Seminar on 'Technology and Development in the Kingdom' in Rajab 1404,
4. KACST, in cooperation with King Saud University, on 'Solar Building' in Sha'ban 1404,
5. KACST, the World Intellectual Property Organization (WIPO) and the Gulf Cooperation Council (GCC) jointly sponsored a symposium on 'Industrial Property' in Sha'ban 1404,
6. KACST, Saudi Arabian Basic Industries Corporation (SABIC), the Saudi Chamber of Commerce & Industry and the United Nations Industrial Development Organization (UNIDO) jointly organized a 'Petro-Chemical Conference' in Riyadh, Dammam and Jeddah, in Moharram 1405,
7. KACST sponsored and organized the 'Second Arab Regional Conference on Sulphur and its uses in the Arab World'in Jumad.-II 1405,
8. KACST sponsored and organized a 'Computer-Assisted Translation (CAT) Workshop with special emphasis on Arabic' in Jumad.-II 1405.



صورة جزئية لمجسم مدينة الملك عبدالعزيز العلمية، ويرى موقع الاسكان والمرافق الاجتماعية في الجزء الشمالي، ومبنى إدارة المركز وقاعة العلوم وبرج العلوم في الجزء الجنوبي ويربط بين الجزئين جسر للمشاة وآخر للسيارات عبر طريق المتنزهات.

A photo for part of the design of King Abdulaziz City. Housing and social activities centre is on the northern side. Central Administration, Sciences hall and Sciences Tower are on the southern side. The two sections are connected for pedestrians and cars through a bridge over the highway together.

ANNEX C:

ADDITIONAL DATA REGARDING THE NATIONAL COMPUTER CENTER (NCC):

Instructor-Led Courses and Some Training Statistics

COURSE TITLE

ADVANCED PL/I PROGRAMMING TECHNIQUES WORKSHOP

DATA SECURITY SEMINAR

IBM 3741 DATA ENTRY STATION OPERATIONS

IDMS-ADS ONLINE

IDMS: CULPRIT AND EDP AUDITOR (ASI-6003)

IDMS - DATA BASE DESIGN.

IDMS-DB/DC PROGRAMMING

IDMS-DB FOR THE APPLICATIONS PROGRAMMER

IDMS/EASYTRIEVE PLUS INTERFACE

IDMS - INTEGRATED DATA DICTIONARY (IDD)

IDMS-INTRO: INTRODUCTION TO DATA BASE MANAGEMENT SYSTEMS

IDMS ONLINE QUERY

INTRODUCTION TO ASSEMBLY LANGUAGE PROGRAMMING.

INTRODUCTION TO AUTOMATIC DATA PROCESSING

INTRODUCTION TO CICS COMMAND LEVEL PROGRAMMING

INTRODUCTION TO EASYTRIEVE PLUS PROGRAMMING

INTRODUCTION TO MANTIS PROGRAMMING

INTRODUCTION TO THE CENTS 4 TABULATION SYSTEM

INTRODUCTION TO THE STATISTICAL ANALYSIS SYSTEM (SAS)

INTRODUCTION TO VIRTUAL STORAGE ACCESS METHOD (VSAM)

MVS/JES2 JOB CONTROL LANGUAGE

ON-LINE FACILITIES FOR NCC USERS (TSO, ISPF, and IBM Utilities).

OS DEBUGGING FOR THE COBOL PROGRAMMER

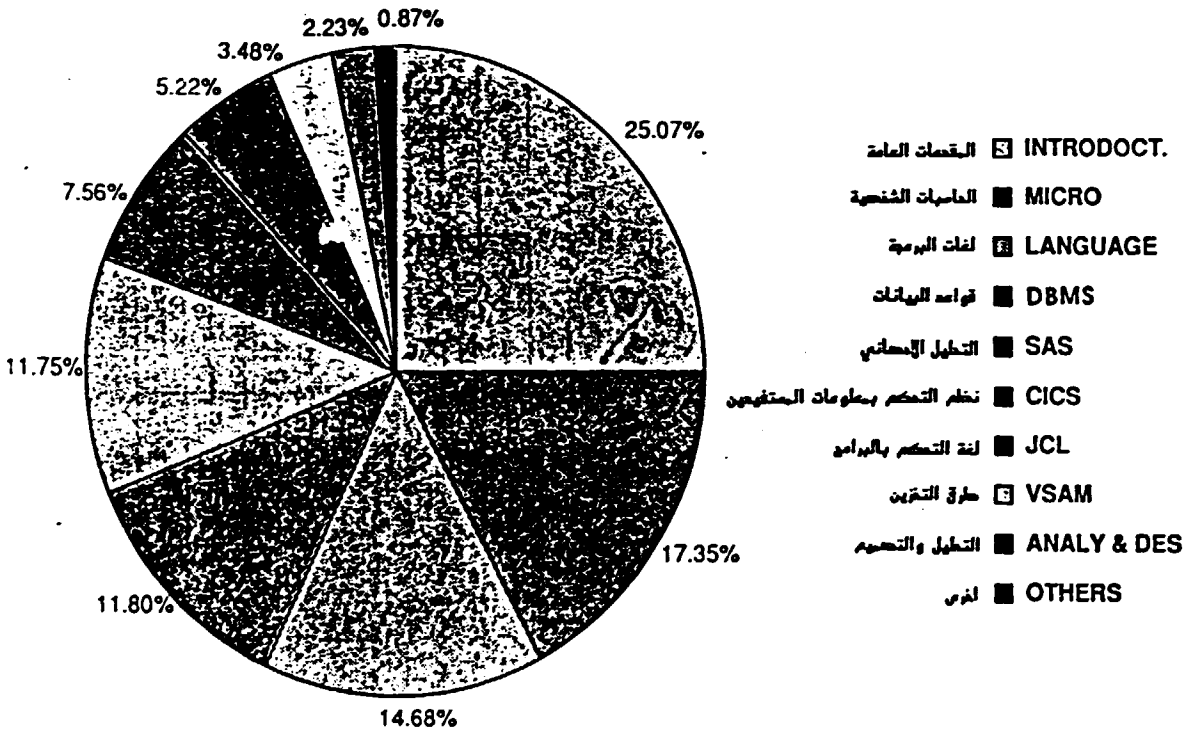
PROGRAMMING USING THE CONCOR EDITING PACKAGE-
(CONsistency and CORrection System)

INSTRUCTOR LED COURSES (CONTINUED)

COURSE TITLE
STATISTICAL ANALYSIS SYSTEM (SAS): ADVANCED SAS PROCESSING
STATISTICAL ANALYSIS SYSTEM (SAS) CALCULATOR/SPREADSHEET.
STATISTICAL ANALYSIS SYSTEM - FULL SCREEN PRODUCT (SAS/FSP)
STATISTICAL ANALYSIS SYSTEM (SAS) GRAPHICS - ENGLISH VERSION
STRUCTURED PL/I PROGRAMMING
STRUCTURED PROGRAMMING I - INTRODUCTION TO ANS COBOL
STRUCTURED PROGRAMMING II - ANS COBOL Part 2
STRUCTURED TECHNOLOGY FOR ANALYSTS AND PROGRAMMERS.

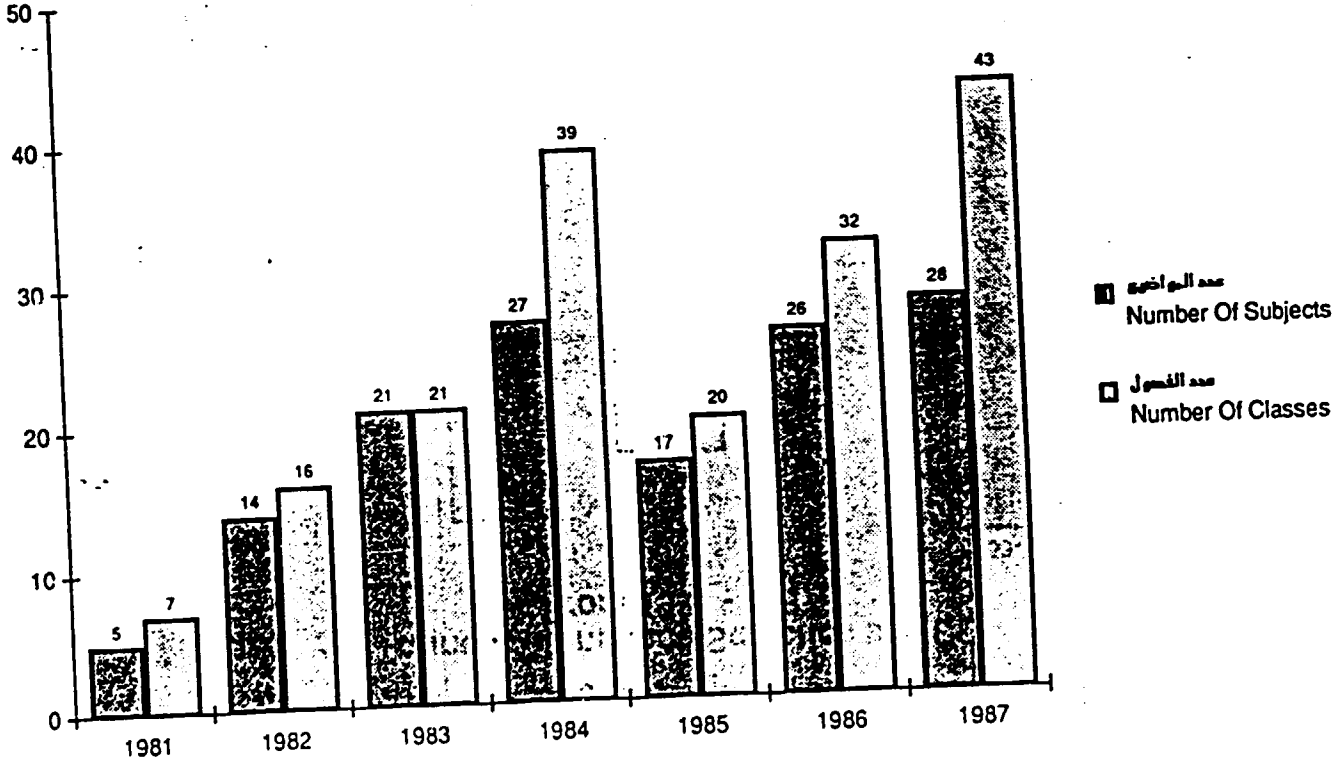
احصائيات المتدربين مصنفة حسب البرامج

Trainee Count Statistics Grouped by Course Type



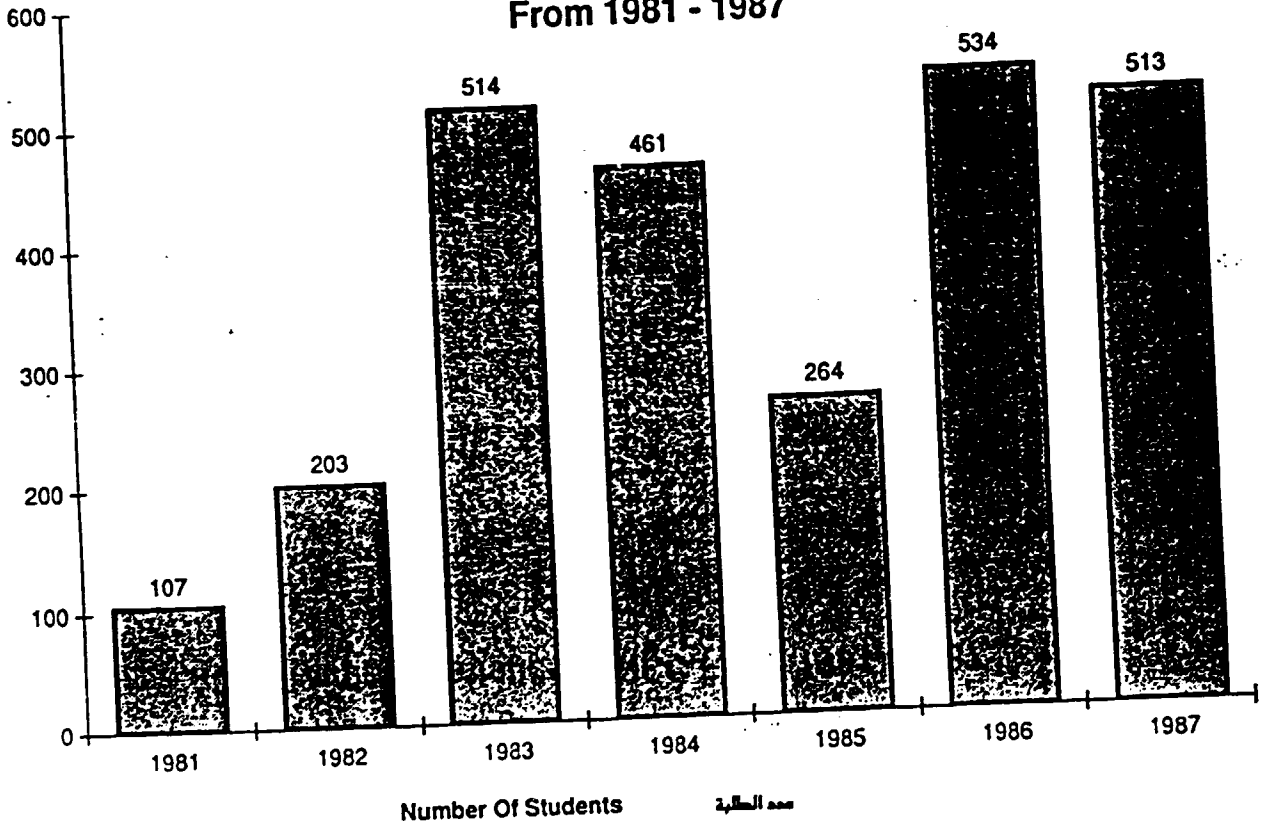
احصائيات التدريب في المركز من عام ١٩٨١ - ١٩٨٧ م

ADP Training Statistics at NCC From 1981 - 1987



احصائيات المتدربين في المركز من عام ١٩٨١-١٩٨٧ م

Trainee Attendance Statistics at NCC From 1981 - 1987



ANNEX D:
ADDITIONAL DATA REGARDING THE
UNIVERSITY OF PETROLEUM & MINERALS (UPM), DHAHRAN

(Note: The following list of computer-relevant short course offerings is not complete; other courses are taught on demand, as the interests and needs of the community indicate would be useful.)

COLLEGE OF COMPUTER SCIENCES & ENGINEERING

SHORT COURSE OFFERINGS DURING THE ACADEMIC YEAR 1988-89

Department: Computer Engineering

Course Title	Duration	Date	Language	Coordinator
Desinging Microprocessor Based Systems	5 days	Sat./Nov. 19-23, 1988	English	Dr. U. Kalayoioglu
Digital System Design using MSI and LSI Devices	5 days	Sat./Dec. 17-21, 1988	English	Dr. S.M. Sait
Digital System Design Automation	5 days	Sat./Feb.25 to March 01,1989	English	Dr. M. Masud
Data Communication Networks	5 days	Sat./March 25 to March 29, 1989	English	Dr. M. Bozyigit
Application of Logical Analysers to Maintenance of Digital Equipments	5 days	Sat./May 13-17, 1989	English	Dr. M. Al-Mouhammed

COLLEGE OF COMPUTER SCIENCE & ENGINEERING

SHORT COURSE OFFERINGS DURING THE ACADEMIC YEAR 1988-89

Department: Information & Computer Science

Course Title	Duration	Date	Language	Coordinator
Database Processing	5 days	Sat./Nov. 5-9, 1988	English	Dr. M. Ouksel
Computer Systems Performance Evaluation	5 days	Sat./Feb. 11-15, 1989	English	Dr. Mostapha Ziad
Programming in C Language	10 days	Sat./ March 4-15, 1989	English	Mr. Saleh uddin Ahmed
Personal Computers & their Applications	10 days	Sat./ March 11-22,1989	English	Dr. M.G. Khayat.
Structured Systems Analysis and Specifications	10 days	Sat./ May 20-31, 1989	English	Dr. M.A. Al-Tayyeb

IMPORTANT NOTE It is possible that some changes may take place on the scheduling of these short courses without a prior notice, To be sure, please consult the desired short course brochure or contact us by phone or writing on the address mentioned in the attached form.

COLLEGE OF COMPUTER SCIENCE & ENGINEERING

SHORT COURSE OFFERINGS DURING THE ACADEMIC YEAR 1988-89

Department: Systems Engineering

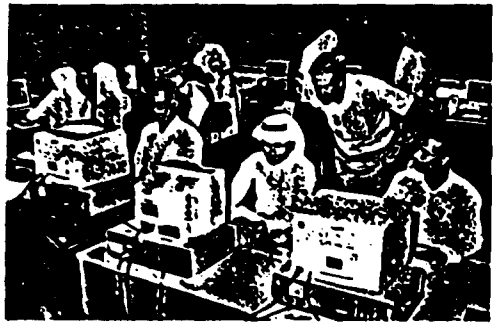
Course Title	Duration	Date	Language	Coordinator
Linear Programming in Refinery Petrochemical & Manufacturing	5 days	Sat./Dec 31, 1988 to Jan.4, 1989	English	Dr. M.H. Al-Haboubi
Planning and Designing Productive Systems	5 days	Sat./Feb. 18-22, 1989	English	Dr. Salih O. Duffuaa
Productivity Improvement through Quality Managnient	5 days	Sat./March 25-29, 1989	English	Dr. M. R. Reda
Distributed Industrial Computer Control Systems	5 days	Sat. April 1-5, 1989	English	Dr. M.A. El-Shafei

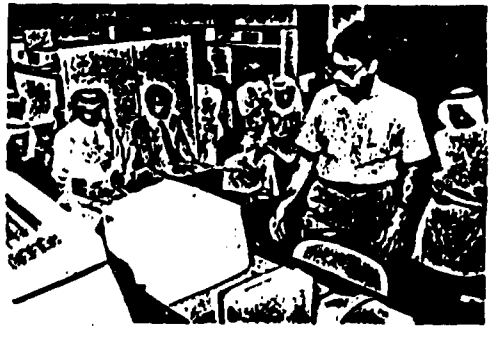
DATA PROCESSING CENTER

SHORT COURSE OFFERINGS DURING THE ACADEMIC YEAR 1988-89

Department: Data Processing Center

Course Title	Duration	Date	Language	Coordinator
Computer Fundamentals	10 days	Sat./Oct. 15-26, 1988	English	Dr. M.A. Abul-Hamayel
Introduction to Programming in Basic	10 days	Sat./Nov. 5-16, 1988	English	Dr. M.A. Abul-Hamayel
Structured COBOL Programming	15 days	Sat./Dec.17, 1988-Jan.4, 1989	English	Dr. M.A. Abul-Hamayel
SAS/Statistics	5 days	Sat./Feb.11-15, 1989	English	Dr. M.A. Abul-Hamayel
SAS/Graph	5 days	Sat./March 18-22, 1989	English	Dr. M.A. Abul-Hamayel





ANNEX F:

EXAMPLE PROJECTS TO BE UNDERTAKEN BY THE CENTER

This annex lists some examples of projects that might be undertaken by the proposed Centre. These projects are designed both to create useful software products to benefit the Kingdom, while at the same time introducing project participants to "hands-on" use of modern computing tools and practices.

The following project descriptions are meant as examples, although they are instances of use of the most important tools and techniques that will form the core of the Center's activities. Actual projects would be chosen by joint agreement between the management and project leaders at the Centre, and a sponsoring ministry or private sector company having an important problem to be worked on.

A. CHANGING AN EXISTING COBOL-LANGUAGE DATABASE INTO RELATIONAL FORM

Many of the Kingdom's existing databases are designed as "flat files" of records that are written and accessed by COBOL code. Each record contains fixed fields of information. When the structure of the database needs to be modified (for example, to add a new field of information), changes to the COBOL program are required. All of this is time-consuming and subject to error.

Because of the importance of such database applications in the Kingdom, an excellent project for the Centre would be to take an existing, substantial database in COBOL form and transform it into a modern relational database form. Rather than performing this task "by hand," the Centre should explore techniques for performing this conversion semi-automatically -- for example, by writing a program to scan for COBOL statements that define the record layout of the database, and to generate new relational statements in a fourth-generation language (4GL) that define an equivalent database. Existing commercial tools that convert COBOL code into higher-level languages, such as the ORACLE or INGRES database systems, should also be explored and tested by the Centre as a means of automating portions of the conversion process.

The Centre should attempt to collect the best tools and techniques for performing database conversion into a standard "package" that can be offered to any organization needing it, along with instructions on the best way to proceed. The result would be that many data bases could be converted into a modern relational form in which changes to their structure and content are much easier, and they can be queried using a standard query language such as SQL. As a result, the maintenance of database systems could be dramatically improved.

B. MODELING AND SIMULATION

A second major need within the Kingdom is the development of flexible, useful models or simulations that might form the basis for decisions regarding the economy, planning of developments, or other policy decisions. Too often, major models are imported from the outside -- but then they are very expensive and are hard to change or understand. Some other models are developed within individual companies or ministries, but they tend to be created in Fortran or COBOL, taking considerable development time, and resulting in models that are difficult to maintain and change. This project concentrates on the development of models using modern tools and techniques, such as languages specialized for modeling (e.g., Simscript, GPSS, Simula), or object-oriented modeling techniques in which real-world entities (such as a factory, or a component of a manufacturing process) is modeled by a software "object" having various attributes, and that communicates with other modeled objects by an interchange of messages among them. Often, these object-oriented models are much

easier to develop on a graphics workstation, in which graphic displays can be "hooked up" to underlying model attributes, showing the workings of the model as it executes. Such displays can occur in one or more "windows" on the display screen, while other data (e.g., the program code itself, or messages from the program) are displayed in other windows.

Such a modeling project would ideally be undertaken for the Ministry of Planning, because they have a wide variety of situations to be analyzed with the aid of models, and because to our knowledge they do not yet use the techniques to be explored in this project. Again, the project is expected to involve eight to ten participants over four to six months, resulting in a working model of some current situation that can be used as the basis for policy analysis and decision. As with the previously-described project, this one would develop a clear statement of requirements, investigate commercially available modeling languages and tools, select an appropriate hardware and software modeling environment, then implement the model for use and evaluation.

C. RULE-BASED EXPERT SYSTEMS

The Kingdom currently relies upon skilled expatriate personnel to help run a number of important installations and processes. Reliance on such expatriate skills is both expensive and troublesome, because after building up considerable knowledge of Kingdom systems, they leave taking that knowledge with them. Although considerable numbers of Saudi citizens are graduating from universities throughout the world and taking the expatriates' place in key industries, the heavy reliance on external personnel and knowledge remains.

What is needed is a means of capturing the knowledge brought to the Kingdom and accumulated while on the job by expatriate personnel, so that this knowledge can be used to control processes and aid decision-making. The discipline of "expert systems" aims to do precisely this. An expert system is a software program that encodes knowledge about any process or procedure as a set of rules, of the form:

```
IF:
        system_state is Normal
        AND the temperature at control_point_1 is greater than 30 deg_C
        AND the pressure at gauge_3 is less than 250 psi
        AND the flow_rate at control_point_7 is greater than 12 lps
THEN:
        reduce the flow_rate at control_point_4 by 1.5 lps
        AND set system_state to Reduced_Flow.
```

Such rules are acquired from experts through a process known as "knowledge engineering," in which an expert is interviewed and observed in action, and the logic by which he makes decisions is recorded. Given a group of 200 or 300 such rules covering the different situations that can arise, and what is called an "inference engine" -- software that can apply those rules to incoming data -- it is possible for the expert system software to mimic the actions of an expert. In some situations, this software can eventually substitute directly for an expert, for example as part of real-time process control monitoring and regulation. More often, such expert systems are used only as electronic advisors, to obtain their recommendation as part of a human decision-making process.

It has recently become quite easy to develop such expert systems, because of the widespread availability of "expert system shells" -- programs that provide a built-in inference engine and a language for expressing the rules. These "shells" also often have an "explanatory facility" built-in, so that one can query the system to discover the chain of logic by which it made a particular recommendation. For smaller expert systems (e.g., under 200 rules), such shells operate on the more powerful personal computers; for larger expert systems, a faster workstation or minicomputer is usually required.

There are a number of advantages to using expert system technology, many of them directly relevant in the Kingdom:

- They capture expertise in a very readable form, so it can be examined (e.g., by managers or supervisors) and reviewed for accuracy;

- Since all knowledge in the system is in a very modular form, it is often easier to update and modify the logic than in traditional programming languages;

- With the explanatory facility, the expert system can explain, in quite natural language, the reasoning behind any recommendation that it makes. The logic can therefore be checked before the recommendation is acted upon, or before the system is put into regular service;

- The explanatory facility also makes the expert system an excellent training tool: A trainee, examining the same inputs, can compare his logic and recommendations with those of the system, tracing each step in the logical process.

- The knowledge contained in key expatriates' heads can gradually and systematically be captured in readable form, so that upon their departure they might be replaced by a less expensive expatriate, or a Saudi citizen with less experience in the process, but who can learn from the stored knowledge within the expert system.

This proposed project would develop an expert system for some process or procedure that is considered important within the Kingdom. It could either be in process control (such as within the oil industry, or the water purification or desalinization processing) or else be an expert advisor for some management decision of importance. A group of eight to ten participants would take the following steps for an application chosen by the project leader in consultation with Centre management. (Note: the choice of an appropriate subject matter for use of an expert system is one worthy of considerable attention. The domain must be a limited one, not involving the need for "common sense" information, at which people excel but computers do not (yet).) The steps to be taken by this project are:

1. Study and practice the process of "knowledge engineering," then apply it to generating a set of rules and data objects capturing the expertise for the chosen application;

2. Study the available expert system shells available commercially, and select one for use based on its attributes being relevant to the current situation;

3. Encode the rules and data objects within the expert system shell;

4. Compare the recommendations of the expert system with the expert's, given certain situations and input data. If necessary, upgrade and revise the expert system so that its recommendations are compatible with those of the expert for all of the situations of importance.

The project would be expected to take six to 12 months. If the application were chosen in the oil or water processing industries, such a project could be conducted at Dhahran in association with the University of Petroleum & Minerals, or in Jeddah, to be near the relevant application experts.

D. COMPUTER-ASSISTED SOFTWARE ENGINEERING (CASE) TOOLS

A recent development of importance within the computer software industry is the availability of CASE tools for software development. These tools provide a total environment for the development of software, including capabilities for:

- Stating requirements for the system to be developed;

- Describing a top-level design for the system that is compatible with those requirements;

- Developing a detailed low-level design for the system, as an elaboration of the top-level design;

- Coding the system within a high-level programming language;

- Testing individual modules of the system against various inputs;

- Assembling the modules into a total system, and testing the entire system;

- Debugging the system to correct any errors found, with significant tools available to aid in debugging, such as the ability to stop the system at key points and examine the system state at that point, then resume operation;

- Developing documentation for the system design as an integral part of the whole design process.

It is believed by many persons that such total CASE environments can greatly reduce the time and effort required to develop a software system, and can result in one that is better document.

This project would:

1. Review the CASE tools available commercially, and select one that is well-suited to the Kingdom's computing environment;

2. Enter into negotiations with that tool's developer to obtain the source code for the CASE tool, and rights to distribute it under a licensing agreement to other sites in the Kingdom or Mideast;

3. Using that source code (as needed), perform a complete Arabization of the CASE tool, changing all displays and documentation into natural Arabic (not just a word-for-word translation), so that the tool can be used to develop software by persons more comfortable with Arabic than with English.

The Centre could then license the resulting CASE tool package within the Kingdom (or possibly within the entire Mideast) to others needing such a software development tool.

An important related aspect of software development is the ability to accurate predict the time and resources that will be required to undertake a software development project. The participants on this project should also become acquainted with models of the software development process that can aid in making these predictions, such as the COCOMO model designed by Dr. Barry Boehm of TRW and UCLA, and documented in the book "Software Engineering Economics" (Prentice-Hall, 1981). It would be good class project to create a computerized version of this model within a personal computer; given certain inputs (such as expected number of lines of source code to be developed, expertise of the programmers, etc.) this computerized model would then perform the calculations and report on the length of time and number of programmers required to complete the job. Such estimating tools, if not already part of a CASE environment, are a valuable addition that should become more widely known and used within the Kingdom.

ANNEX G:

SAMPLE JOB REQUIREMENTS FOR KEY CENTER PERSONNEL

The following descriptions indicate the general levels of education and experience expected in key personnel for the Center:

Center Director

The Center Director is responsible for all aspects of the daily operational running of the Center. The person must have considerable management experience and a technical computer-related background. Minimum requirements for a Center Director are recommended as:

- At least seven to ten years' experience involving both computer applications or instruction (preferably with a deep involvement with personal computers and/or workstations) and in addition management of a major facility or organization; and
- At least a Masters' Degree in a technical or engineering subject. A Doctorate in one of these subjects is desirable; and
- Fluency in Arabic and English.

Administrative Deputy to the Director

The Administrative Deputy to the Director is expected to have expertise in accounting, personnel matters, and administrative procedures as practiced in Saudi Arabia. Minimum recommended requirements are:

- At least three years' experience in computer applications; and
- At least three years' experience in management or administration of an organization; and
- Experience in accounting, personnel, and administrative procedures in Saudi Arabia; and
- At least a Bachelor's degree in a technical subject, preferably computer-related; and
- Fluency in Arabic and English.

Member of the Board of Advisors

The Board of Advisors for the Centre provides input to the management of the Centre regarding the needs and resources of three sectors within Saudi Arabia: (1) Universities; (2) Government; and (3) the private sector. Each member of the Board of Advisors should be a senior, experienced member of one of these sectors, with:

- At least 5 years' experience in that sector;
- Holding a senior management position within the sector;
- An advanced degree (either Masters or Ph.D.) in computer science or a related scientific subject, or else significant practical experience in the use of computers and information systems within that sector.

Since the Board of Advisors is the main representation of the needs of these sectors within the Centre, each member of this Board should have wide contacts within his sector, so that he can represent the total interests of the sector in helping formulate the projects and programmes of the Centre.

Member of the Panel of Technical Experts

Each member of the Panel of Technical Experts should have all of the background and skills required of the International Software Development Experts (described below), and in addition:

- Have substantial familiarity with the computing environment and computing state-of-the-art within the Kingdom of Saudi Arabia;
- Have substantial contacts within the international community of computer scientists and engineers, so that he can provide major assistance in locating and recruiting international software development experts to reside in Riyadh for periods of approximately one year and thereby provide the on-site expertise required during the initial phases of the Centre.

In addition, it would be useful if a member of the Panel of Technical Experts has experience and contacts with major developers and/or publishers of software systems relevant to the Kingdom, to assist the Centre in making contacts and contractual links with international organizations relevant to its programme.

International Software Development Experts

The budget for the Centre assumes two international computer experts will be resident full-time at the Centre during its first four years of operation. To cover all necessary subjects in depth, it is assumed that these two full-time positions will be held by a total of perhaps eight individual experts, with a pair of experts each residing in the Kingdom for one year each. In addition, it is assumed that guest lecturers in specialized software development topics will visit the Centre for periods of two to four weeks each, to lead workshops and provide advice on ongoing projects and consulting activities. All international computer experts are expected to have the following minimum requirements:

- A Ph.D. from a leading international university with a strong computer science or engineering program; and
- A faculty position or equivalent industry position; and
- Publications in internationally recognized and refereed journals; and
- Be an expert in a field of computer science directly relevant to Centre activities; and
- Fluency in English; Arabic fluency is desirable but not required.

The following software development specialities will be required by the Centre. International experts residing at the Centre for a year (or so) should have their expertise concentrated on at least two of the following topics. Visiting experts should have expertise in other of the topics to provide coverage:

- Relational database systems
- Modeling and simulation languages and systems
- Computer-assisted software engineering (CASE) tools
- Expert systems and knowledge engineering
- Software design and documentation methodologies
- Computer networking (local area nets, X.25 protocols, Ethernet, ...)
- The UNIX operating system and its applications.

Project Leader (Saudi)

Much of the success of the Centre will depend on a staff of Saudi professionals whose primary responsibilities will be to: (1) lead software development projects; (2) provide consulting services to external organizations; and (3) lead workshops and seminars, and organize occasional international conferences on topics of importance to the Centre. Specialized training of this core project leadership

staff will be provided by resident international experts during the first year of the Center's operation, but this staff is expected to have relevant skills and interests. Minimum recommended requirements for the Center's project leader staff are:

- A Master's degree in computer science or engineering, with a Ph.D. preferred; and
- At least two years' experience with personal computers and/or graphic workstations; and
- At least two years' experience in at least two of the computing specialties listed above under "International Software Development Experts"; and
- Fluency in the Arabic and English languages.

In addition, some project leadership experience is highly recommended.