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DESIGN FOR A REMOTE SENSING CENTER IN THE JORDAN NATIONAL GEOGRAPHIC CENTER, AMMAN

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INTRODUCTION AND SUMMARY OF THE DESIGN TEAM VISIT TO JORDAN

1.1 INTRODUCTION

Two Environmental Research Institute of Michigan (ERIM) staff members visited Amman, Jordan, from December 15th to 19th, 1985, in order to assist the USAID/Mission to Jordan and the Government of Jordan in preparing a plan to increase the use of remote sensing in planning within the government. Their mission and this report focus on the following:

a. a review of previous remote sensing activities in Jordan,
b. an evaluation of the capability of the Jordan National Geographic Center (JNGC) to administer a Remote Sensing Center (RSC),
c. a list of prioritized developmental applications. Priority applications are those consistent with USAID country development strategy for Jordan and the Jordan five-year plan.
d. recommendations on the type of remote sensing technology best suited to meet Jordan's developmental needs.
e. a program for applying the recommended technology including staff requirements, levels and types of technical assistance and training, and additional equipment,
f. a suggested schedule and budget for the recommended program.

1.2 BACKGROUND

The Kingdom of Jordan (KOJ) is a small country, comprising an area of some 94,000 square kilometers. Therefore it is practical and useful to produce intermediate scale image and map products for the entire country from Landsat satellite data. The value of using satellite images at these scales was understood by the KOJ officials we met.

Figure 1 shows the approximate coverage of Landsat Thematic Mapper scenes over Jordan. At a scale of 1:100,000, each of the eleven scenes may be divided into four subscenes as illustrated for path 172/row 39, or into sixteen subscenes, if the desired scale is 1:50,000. Thus, country-wide image mapping at 1:100,000 scale could be accomplished with 28-30 individual sheets. Country-wide coverage at 1:50,000 scale would be provided by 110-120 image maps.

This report recommends that an image mapping program at these scales be pursued. Such a program would take several years to complete after all the necessary facilities and trained staff are in place, but it would provide immediate, useable products for many users in Jordan. The procedures for conducting this program are described in this report.

1.3 PREVIOUS REMOTE SENSING PROGRAMS IN THE KINGDOM OF JORDAN (KOJ)

Remote sensing in Jordan has been limited primarily to aerial photographic applications. Black and white aerial photos of the entire country at scales 1:50,000 and 1:60,000 were acquired between 1963 and 1967. Black and white coverage of selected areas at various scales has been obtained between 1943 and 1984. This photography has been used for production of topographic maps and for updating these maps.

Although data from space-borne remote sensing systems such as Landsat and other earth resources satellites have been obtained repeatedly since 1972 to the present, very little is in use in Jordan today. Previous experience with using satellite data in Jordan is contained in a single, locally-funded study (1979) in which a generalized mineral atlas for the country was prepared by a foreign contractor. A few poor quality Landsat images were seen at the Water Authority of Jordan (WAJ) and the National Resource Authority (NRA). The level and extent of satellite data applications by WAJ and NRA has been limited by the poor quality of products available to them.

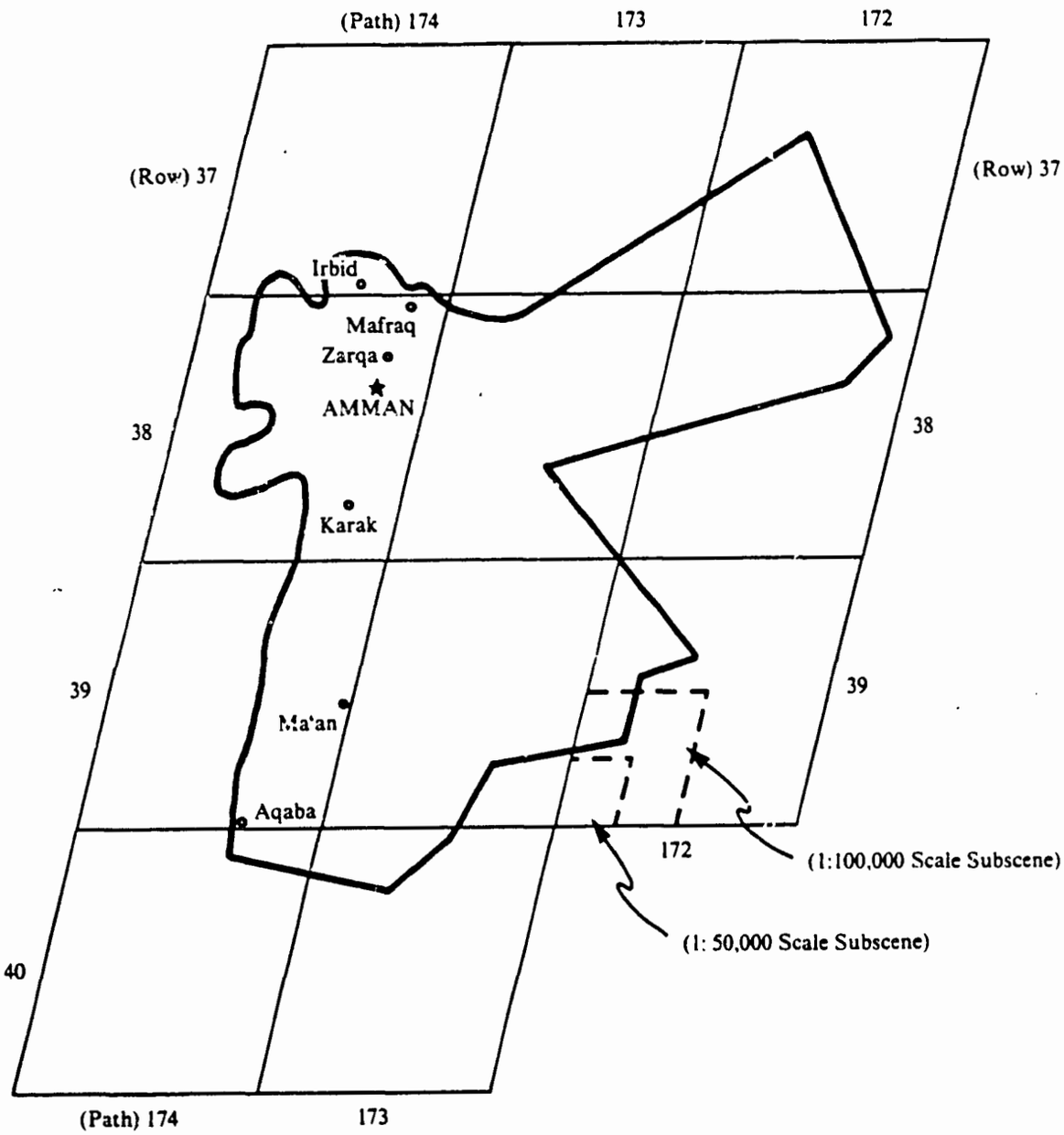


FIGURE 1. KINGDOM OF JORDAN—THEMATIC MAPPER COVERAGE

To the best of our knowledge no Landsat Thematic Mapper (TM) data has been introduced or applied in Jordan. Further, there is neither an in-country capability to process or analyze standard satellite digital data, nor is there a capability to make high quality color photographic products.

1.4 JORDAN NATIONAL GEOGRAPHIC CENTER CAPABILITY TO ADMINISTER A REMOTE SENSING CENTER

Jordan's current plans are to establish a Remote Sensing Center (RSC) within the JNGC (see Appendix A). The JNGC will provide overall logistical, administrative, technical, financial and manpower support for the RSC. JNGC staff and facilities currently support programs using black and white aerial photography, and this activity provides the JNGC with the necessary foundation of generic experience in remote sensing principles and methods to build a viable remote sensing program. However, we note there is a technological gap between the classical expertise that the JNGC has accumulated through the use of aerial photos and the experience necessary for conducting modern operational remote sensing programs, which include processing, analyzing and applying data from spaceborne and airborne sensors in addition to photographic systems.

With appropriate training, equipment, and data products the JNGC can effectively administer a remote sensing center. Adequate space for equipment, laboratories, offices and training has already been allocated. Staff at the JNGC are highly motivated and possess expertise sufficient to initiate the recommended program.

The proposed program is designed for the RSC to function in two distinct ways. First, the RSC could provide important technical capabilities to the JNGC, and secondly, the center could act as a coordinating and technical assistance group to other resource agencies in the country. Direct benefits to the JNGC would be primarily in facilitating its current planimetric mapping activities. With respect

to other resource agencies, the RSC can archive, reproduce, and distribute available satellite data (Landsat, SPOT, Meteosat and NOAA), and show how these data can be effectively used by those agencies.

1.5 ADVANTAGES OF DEVELOPING A RSC IN JORDAN

Current and reliable information is critical to better decision making within developing country agencies. There is and will continue to be a demand for better information by planners in Jordan. Information concerning resources and the environment is the ultimate product of remote sensing technology. Since the Jordanian national government is the prime mobilizer of resources for development, it is also likely to be the principal user of such information that would be provided by the RSC.

The quality and quantity of that information will increase as Jordan's remote sensing capability develops and as new data become available. Having a RSC in Jordan will allow the continued development of the capability to use this information by Jordanian scientists and decision makers.

Several other advantages of developing a modern remote sensing facility in Jordan are as follows:

a. access to ground truth and to other data such as maps, aerial photography and statistical information allows effective use of remote sensing products,
b. access to user agencies enables the generation of products best suited to KOJ needs,
c. local interagency cooperation is enhanced and reinforced by establishing a common data base,
d. reduced dependency on foreign technical expertise will reduce the demand for foreign exchange and enhance the professional stature of the JNGC,
e. certain proprietary applications may be conducted without foreign involvement.

Finally, many current and planned programs would benefit from the products and services that a national RSC could provide. At each agency visited there were staff experienced with photo interpretation methods (see Appendix B). They were eager to immediately apply satellite (especially TM) data to their investigations. Agencies contacted were:

a. Jordan National Geographic Center (JNGC)
b. Ministry of Planning (MOP)
c. National Resource Authority (NRA)
d. Royal Scientific Society (RSS)
e. Water Authority of Jordan (WAJ)
f. Ministry of Agriculture (MA)

Due to limited time we were unable to identify and meet other potential users, but our experience in other countries encourages us to suggest that the following organizations would be important users:

a. Universities,
b. Ministry of Municipal, Rural and Environmental Affairs,
c. Private industry concerned with agriculture, mineral exploration, and large scale engineering programs,
d. Ministry of Defense.

1.6 SUMMARY OF RECOMMENDATIONS

A detailed description of recommendations, procedures and costs for establishing a RSC within the JNGC is provided in Chapters 2 and 3, and is summarized here. The RSC should be developed in three phases over a three year period. Each phase allows for programmatic checks on how well the RSC and its services are performing, and provides for graceful growth of appropriate technology within the Jordanian environment.

A full-time resident technical advisor with quarter-time backup support in the U.S. is considered key to the implementation of all three phases of this program.

Phase I is comprised of two main activities. The overall objective of this phase is to develop an organization of trained experts who can manage a service oriented RSC, and who can effectively teach users to apply remote sensing data to their particular needs. Second is the production of an initial base of image products which are expected to be put to immediate use by the JNGC and other government agencies. Specific components of Phase I are as follows:

a. produce an initial data base,
b. train JNGC personnel in image and color photographic processing,
c. provide instructor training in resource applications,
d. design the Phase II and Phase III image processing facility.

The budget for Phase I is approximately $550K*.

Phase II is concerned with development of a RSC capability to independently process and analyze remote sensing data. New equipment will be introduced and the expertise to use and maintain that equipment will be developed. Emphasis will be placed on developing a color photographic laboratory and the basic elements of an image processing facility. Specific components of Phase II are:

a. establish color photographic laboratory,
b. establish basic (PC-type) image processing facility,
c. conduct workshops/management seminars in Amman,
d. provide new image products,
e. provide new interpretation equipment and supplies.

The budget for Phase II is approximately $740K.

Phase III is devoted to expanding of the image processing facility as needs demand. An upgraded computer and additional peripheral equipment will be installed, enabling the RSC to produce high-quality,

*Refer to Section 3.5 for Cost Details.

large-scale image products and to support sophisticated data analysis needs. Specific components of Phase III are:

a. upgrade the image processing facility to Micro VAX II configuration,
b. add high quality film recording capability,
c. conduct image processing facility training in Amman,
d. conduct maintenance training at vendor sites,
e. provide on-call support visits (4) by experts (optional).

The budget for Phase III is approximately $830K.

2

RECOMMENDATIONS

The proposed program is organized into three, one-year phases to provide orderly, systematic development of the RSC. The RSC will achieve increasingly sophisticated levels of institutional capability as each phase is completed. At the end of Phase I (12 months after program start-up) the RSC will possess a basic institutional capability for contributing to development planning in Jordan with remote sensing technology. Completion of Phase II (24 months after start-up) will increase the center's capability to generate its own data products to satisfy more varied user demands. By the end of Phase III (three years after start-up) the RSC will be a self-sufficient institution with all the capabilities normally associated with a modern remote sensing center.

2.1 RSC ORGANIZATION (PHASE I)

We recommend that a RSC be developed within the JNGC (Figure 2). This RSC should be guided by an advisory committee headed by the Director General of the JNGC. The committee will establish policy guidelines and give overall direction to the RSC. The Managing Director of the RSC should be the secretary of this committee so as to facilitate communication between the committee and the RSC. The committee will be comprised of high level representatives from all user agencies, including: the Ministry of Planning, Ministry of Agriculture, National Resource Authority, Water Authority of Jordan, and the Ministry of Municipal, Rural, and Environmental Affairs.

In all phases a full-time U.S. technical advisor should be assigned to work with the Managing Director and RSC staff. The advisor will help to promote institutional ties, plan and implement facility growth, and

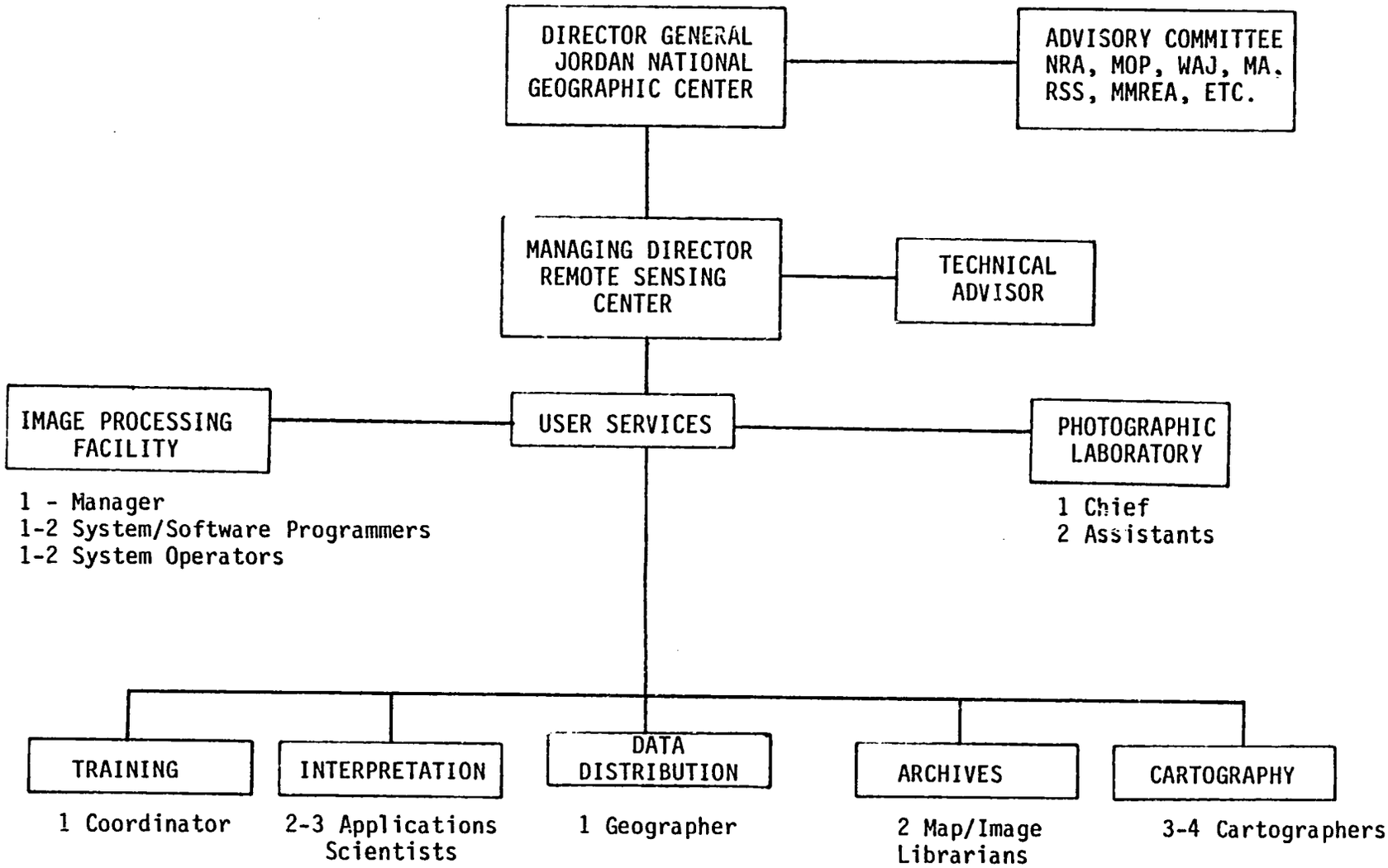


FIGURE 2. EXAMPLE ORGANIZATION CHART FOR A REMOTE SENSING CENTER AT THE JORDAN NATIONAL GEOGRAPHIC CENTER

monitor the RSC development program. The advisor will coordinate foreign contractor assistance and serve as team leader of all U.S. consultants to the project.

The Managing Director of the RSC oversees operation of the three divisions of the Center, those being the Image Processing Facility (IPF), User Services, and a Photographic Laboratory. Between 14 and 16 persons will staff the RSC. Since a black and white photographic laboratory already exists in the JNGC, the Managing Director would be concerned with the operations of a specialized unit for color processing. Both the IPF and the Photo lab will have managers to supervise operations on a day-to-day basis. The main role of the Managing Director will be to supervise the activities of User Services. This is the most important part of the RSC because it serves as the interface between the users conducting remote sensing applications and the resources of the RSC.

The User Services Division is comprised of five sections. The training section, led by a coordinator, provides training services for both the JNGC staff and for user agency personnel. Training staff are applications scientists from the interpretation section, cartographers, staff of the IPF, and experts from other government agencies. Experts from these organizations will participate in the initial training we recommend during the first and second year of the program.

The interpretation section applies remote sensing data to projects of the JNGC and user agencies. The staff of this section will be engineers and earth scientists led by a senior scientist. Their expertise should be sufficiently generalized to enable them to relate remote sensing technology to a wide range of applications in cartography, soil surveys, environmental studies, agricultural studies, hydrological issues, geologic mapping and mineral exploration, and land use classification. Interpretation staff will not always be the project managers but they should be able to facilitate investigations and appreciate the

concerns of users from outside the JNGC. Field investigations are supported by this section. The JNGC is already well equipped for such surveys.

The Data Distribution Section is responsible for access to remote sensing data by all users. A geographer is recommended to be in charge of the section because a broad background is necessary in order to relate data and RSC resources to diverse applications. This section is also responsible for pricing if service fees are required.

The Archive Section contains files of images, maps, and reproducible materials organized for easy access. Usually, multiple copies of frequently used images are filed so that user requests can be promptly filled. Published maps should be available to facilitate the interpretation of images.

Cartography is one of the major activities of the JNGC and maps are a routine product of data applications.

The following JNGC staff, some with engineering backgrounds, should be considered appropriate for the following positions in the RSC:

a. Managing Director (1)
b. IPF Manager (1)
c. System operator (1)
d. Application scientist (1)

Candidates for long term training are those who will occupy managerial or supervisory positions at the RSC such as:

a. Managing Director
b. IPF Manager
c. Chief of the Photographic Laboratory
d. Senior Application Scientist

Long term training may include a graduate academic program in remote sensing (MS or PhD) or in a discipline involving the application

of remote sensing. However, on-the-job training should be an important component of a long term program.

2.2 INITIAL DATA BASE (PHASE I)

To start a RSC, JNGC should obtain an initial set of Landsat TM images and film transparencies of the entire country and distribute copies to user agencies such as the NRA, MOP, MA, WAJ, and others (see Appendix C). These images will meet immediate needs for current data, and establish a common data set (mapping base) for these agencies. Such images are available from various commercial organizations in the U.S. and could be processed in conjunction with on-the-job training for JNGC staff. The transparencies may be used for production of paper prints by the proposed color photographic processing laboratory.

These images could be used for a number of projects which are listed below. These projects are discussed in greater detail in Sections 2.9.1 through 2.9.5.

a. Updating of 1:50,000 and 1:250,000 - scale topographic maps by the JNGC.
b. Land use classification by the Ministry of Planning.
c. Soil surveys at 1:250,000 and 1:50,000 scale by the Ministry of Agriculture.
d. Geologic mapping at 1:50,000 scale by the NRA.
e. Hydrologic mapping by the Water Authority of Jordan.

2.3 TRAINING (PHASE I)

Training sessions for JNGC/RSC staff should be initiated in conjunction with processing the above mentioned image products. Trainees will participate in the production of images using systems similar to those to be installed at the JNGC during Phase III. Also, instructor trainees will use the images for applications oriented training. Several photo technicians will be trained in color photographic processing technology.

2.4 COLOR PHOTOGRAPHIC LABORATORY (PHASE II)

Develop a color photographic laboratory at the JNGC. There is no color photographic processing facility in the KOJ capable of producing high quality products. Composite color transparencies prepared earlier should be available at the RSC color lab for reproduction and distribution to a growing user community. These image products will satisfy anticipated user requirements until the JNGC/RSC has developed its own image processing capability.

2.5 WORKSHOPS/MANAGEMENT SEMINARS (PHASE II)

Workshops on remote sensing applications to specific resource and planning investigations should be conducted in Jordan. Local seminars of shorter duration should be arranged for management level personnel from the various user agencies in the KOJ or the user agency. These workshops and seminars will serve to sensitize users to the applications of remote sensing.

2.6 IMAGE PROCESSING FACILITY (PHASES II AND III)

Develop an image processing facility (IPF) in the JNGC. An off-the-shelf micro-computer based IPF will be installed during Phase II. This micro-computer based system would consist of a stand-alone micro processor, tape drive, coordinate digitizer, and hard copy (ink-jet) printer. It will include fully tested and documented software for performing practical digital image processing and geographical data manipulation functions. It will allow the RSC to custom process and produce enhanced images from standard satellite data computer compatible tapes (CCTs). It will also allow exposure of the staff to a modern digital GIS capability, which combines and displays geographically-referenced information from a variety of sources and scales.

While such a facility allows a full range of digital processing functions, the memory-size limitations of micro-based systems restricts processing to an area of approximately 410 square miles for Landsat MSS data and 100 square miles for Landsat TM data.

Such a facility has many practical advantages for Jordan and performs a valuable training function for the RSC staff. The major components of this system can be used in the larger facility designed for Phase III of this project.

The actual design and planning for the more advanced Phase III IPF will be implemented during Phase I. However, the advanced IPF would be the last component of the RSC to be installed. This will ensure that (1) appropriately trained staff are available to operate the facility, (2) a well-oriented user group has been developed through workshops and application projects, and (3) a color photographic lab is in place to produce the quality products generated by the advanced IPF. A list of desired outputs from the IPF is in Appendix D.

2.7 ACQUIRE NEW IMAGE PRODUCTS (PHASE II)

New images or new types of data products from different satellites will be introduced as the project develops.

2.8 ACQUIRE NEW INTERPRETATION EQUIPMENT AND SUPPLIES (PHASE II)

The JNGC possesses much of the equipment necessary for manual interpretation of remote sensing data. However, additional map cases, light tables, spare parts and the latest model zoom transfer scope may prove necessary. It is also likely that existing equipment will require routine maintenance and parts replacement.

2.9 DATA APPLICATIONS (PHASES I-III)

All resource agencies are conducting important programs using geographical information. This section summarizes the information presented to the team during the one week visit to Jordan. A more

thorough evaluation would be required to prioritize activities most suited to proven satellite applications. It is likely that some significant programs or applications are not adequately presented here due to the brevity of the team's visit. However, these applications are illustrative of the many candidates for using remote sensing data. They are listed under topical headings as follows:

2.9.1 AGRICULTURE

a. Soil survey - the Ministry of Agriculture has proposed a soil mapping program at three levels of detail to be accomplished over a 66 month period. The first and second levels of regional mapping (1:250,000 scale and 1:50,000 scale respectively) could be completed in less time and at less cost if TM color images were used instead of aerial photography. Some of the reasons for making this claim are:

- TM coverage for the entire country can be acquired, processed, and distributed within 6 months, while comparable color aerial photography would require several years for aerial survey design, clearances, selecting a vendor, acquiring the coverage, processing the film, printing the photos and finally distributing them to the Ministry of Agriculture.

- TM images serve as an accurate planimetric compilation base at their printed scales.

- TM data may be processed to create images with maximum contrast enhancement of surface information.

- TM data allow an opportunity to observe terrain in additional spectral bands not available from normal aerial photography.

It will still be necessary to obtain a small number of aerial photographs to complete Level III, 1:10,000 scale mapping.

This coverage could be acquired during the time that Level I and II mapping are in progress.

b. National inventory of total area under cultivation - this project could be undertaken annually in order to determine changes in the area or extent of particular crops such as barley or wheat.

c. National inventory of forest resources - current government programs to reforest large areas can be monitored using repetitive TM data coverage.

d. Inventory of range resources - large areas of Jordan are used almost exclusively for grazing. Natural vegetation and associated landforms can be identified by ground truth surveys and then mapped on TM image products.

2.9.2 CARTOGRAPHY

a. Updating cultural features on 1:50,000 scale and 1:250,000 scale topographic maps - the JNGC needs recent (1984-1985) TM images for updating geographic information on previously published maps. A total of 192 maps at 1:50,000 scale cover the country of which 60 are scheduled to be revised. Landsat TM images at 1:50,000 scale can be produced to match the format of these 15 x 15 minute quads. TM data are well suited for detection and mapping of settlements down to village size, roads, tracks, agriculture, pipelines, and other expressions of human activity. Image products serve both as an interpretative tool and as a planimetric compilation base.

2.9.3 GEOLOGY

a. Geologic mapping - the National Resource Authority (NRA) is currently compiling 155 geologic maps at 1:50,000 scale. This project would be expedited if geologists have access to TM images. The Thematic Mapper was designed with geologic

interests in mind. Rock units, structural features and a variety of other geologic data are easily discriminated on TM images. The NRA is currently using black and white aerial photograpy which limits the amount of information that can be interpreted and compiled and increases the amount of time spent in the field. In addition to 1:50,000 scale mapping, the NRA has a need for images and mosaics at smaller scales for regional maps.

The NRA is planning to install a map production facility which may include an IPF. It is our understanding that this proposed installation will not be a national service facility, but will be for NRA use only. If the JNGC/RSC acquires all the resources we describe in this report, then it will be necessary to coordinate this development effort with the NRA in order to avoid expensive duplication by the NRA. The JNGC/RSC will be able to provide CCTs to the NRA, and reproduce in bulk quantity hardcopy of images initially identified as useful on the NRA system.

b. Mineral exploration - TM data can aid in detecting indicators of mineral occurrences such as phosphates or possible fossil fuel deposits in the Jordanian panhandle.

2.9.4 HYDROLOGY

a. Drainage maps - the Water Authority of Jordan needs TM images for detecting features which suggest exploitable water resources and/or which benefit conservation measures. Many of their current programs to map surficial drainage networks, seasonal vegetation, and geomorphic features associated with the recharge of aquifers could benefit from using large scale satellite image data. Specially processed TM images to accentuate structural information relevant to determination of watersheds and drainage systems would prove very useful.

2.9.5 PLANNING

a. Land use/land cover maps - Ministry of Planning staff expressed a desire for immediate access to large scale images in support of national land use mapping programs. In addition, local site and infrastructure development projects were also highlighted as tasks where current image data would be extremely valuable.

3

PROGRAM AND BUDGET

3.1 INTRODUCTION

ERIM has helped several nations develop national remote sensing centers (Egypt, Peru, Nepal). While each center has its own structure and operation in response to unique requirements and opportunities, most centers have certain capabilities and structures in common. The program recommended for Jordan contains the basic elements which may be modified over time.

The recommended program will require a serious commitment of personnel and resources by the participating KOJ agencies. The long term success of the RSC will be measured by its support for and involvement in applications of remote sensing. If the JNGC/RSC fails to support the user community then the RSC will, at best, only serve internal JNGC needs. These needs are not sufficient to justify development of the kind of facility described in this report, and the RSC will not make a significant contribution to development in the KOJ.

Participating government agencies, starting with those represented on the RSC Advisory Committee, should make a commitment to learn and use remote sensing data. A knowledgeable user community is essential to the success of this RSC. Providing images to the user community is only the first stage in the development of the RSC. There is a long period thereafter which requires users to be trained so that they can eventually successfully interface with the proposed JNGC image processing and analysis facility. Manpower is the main commitment.

Key personnel will have to be identified and then assigned to the project in order to participate in the training activities outlined herein. Implementation schedules for the three year program are provided in Figures 3, 4, and 5.

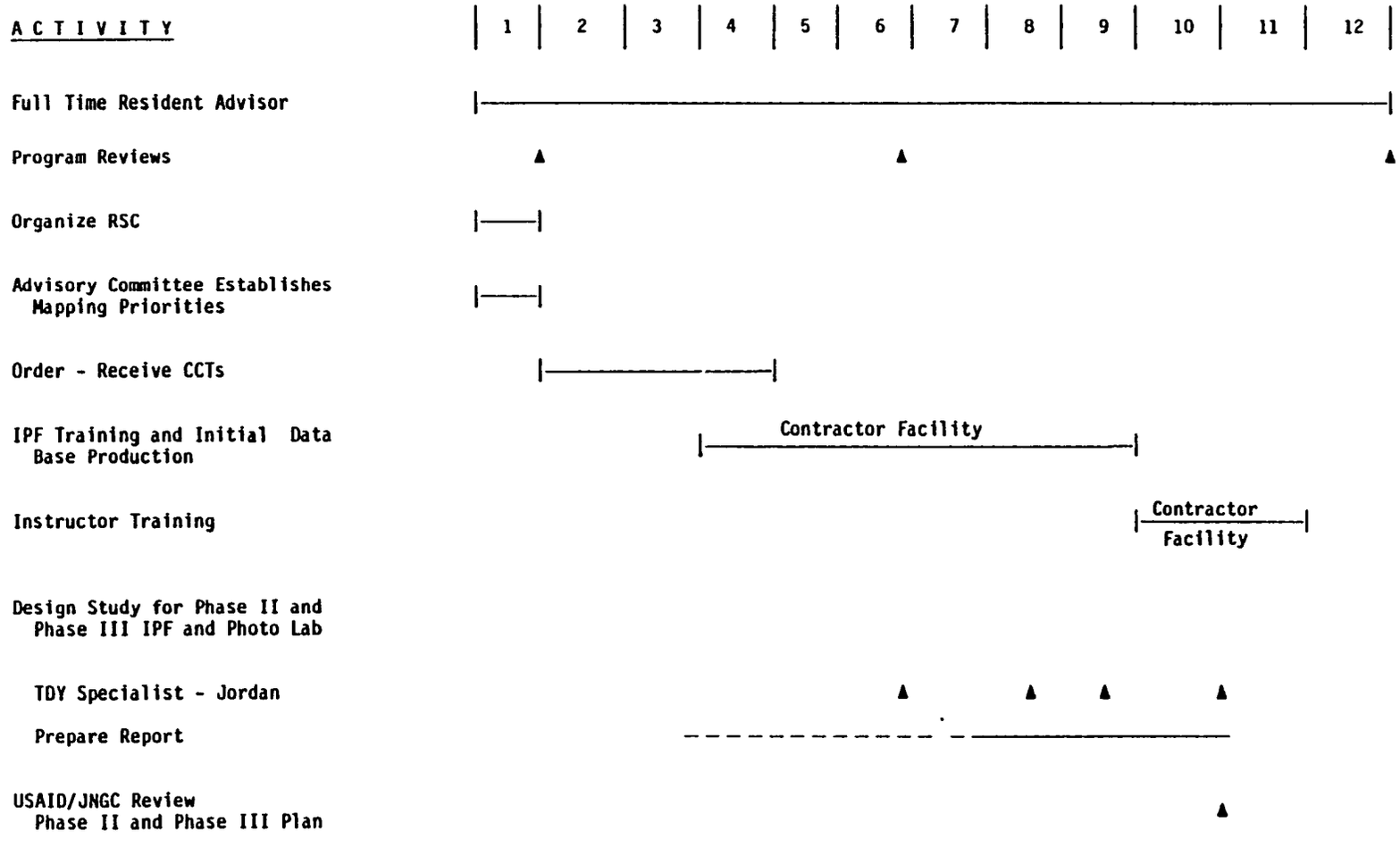


FIGURE 3. IMPLEMENTATION SCHEDULE FOR PHASE I/YEAR 1

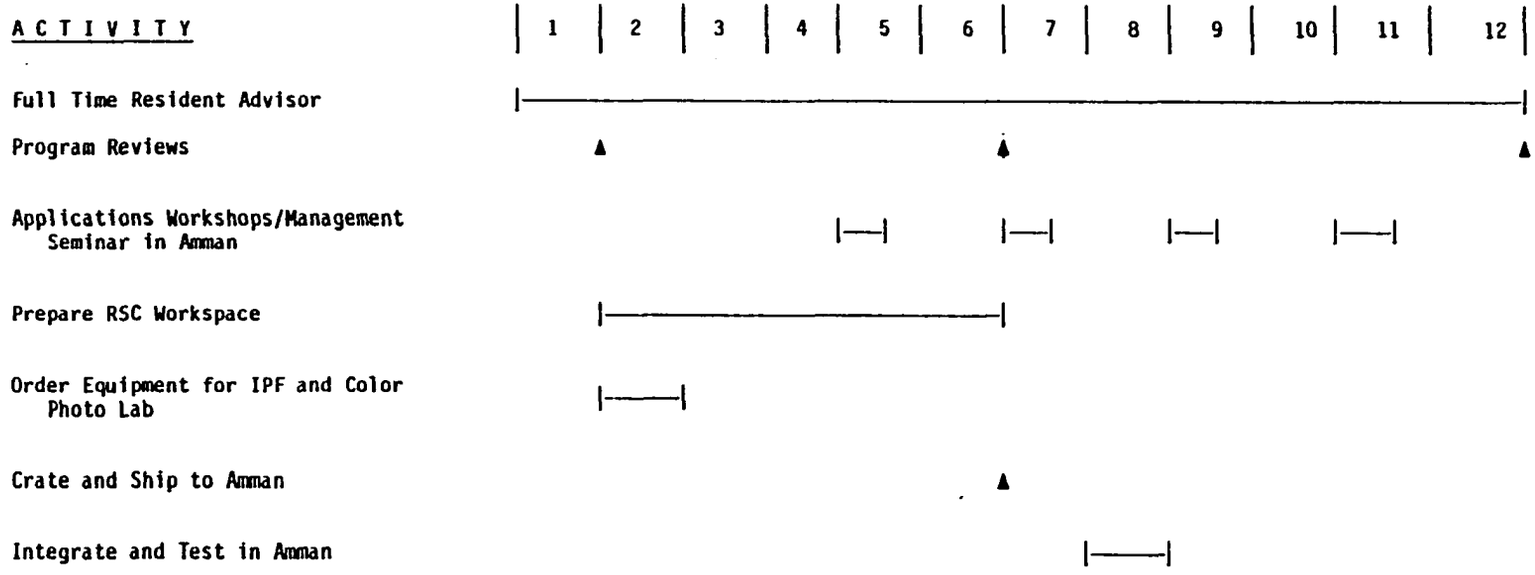


FIGURE 4. IMPLEMENTATION SCHEDULE FOR PHASE II/YEAR 2

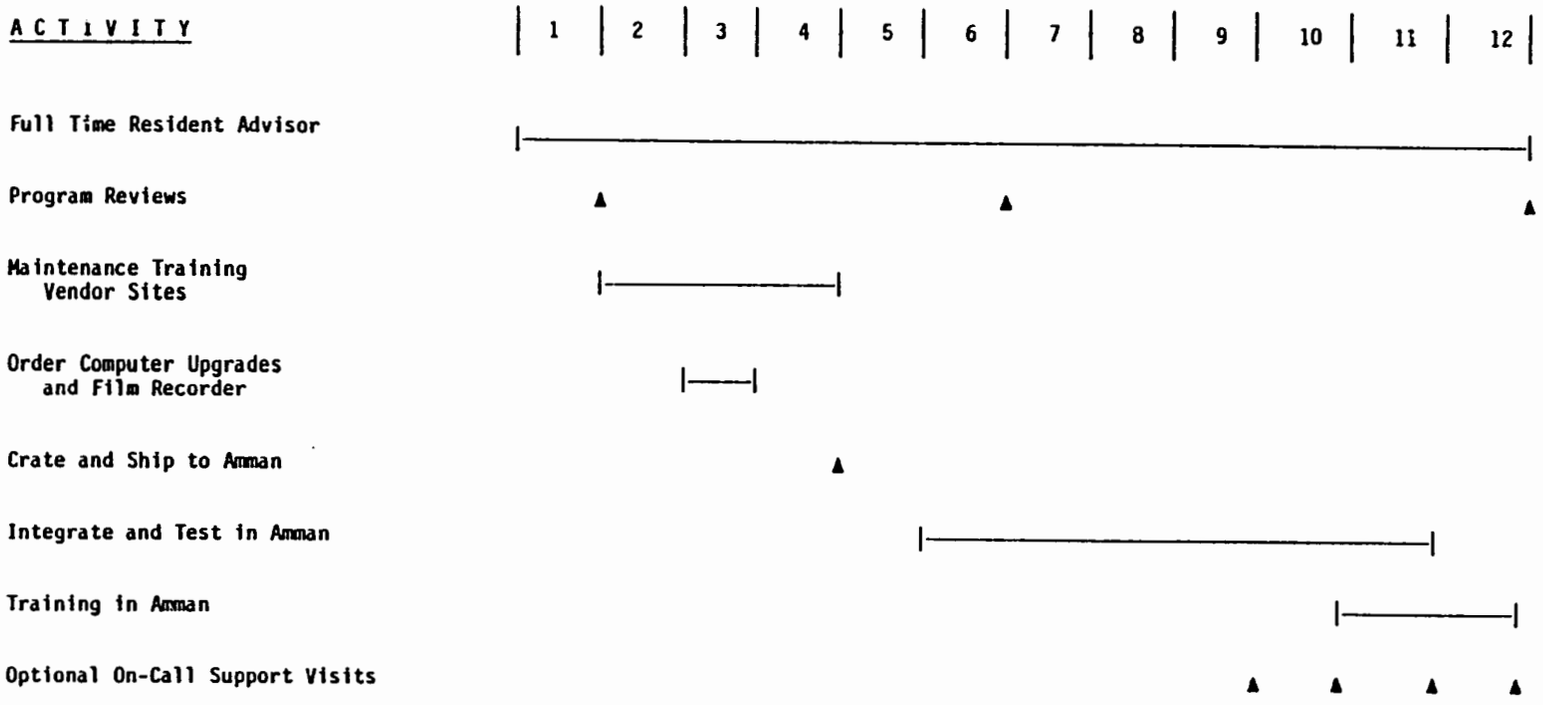


FIGURE 5. IMPLEMENTATION SCHEDULE FOR PHASE III/YEAR 3

Each element of this proposed program requires further consideration before a final plan is prepared and initiated. ERIM believes that it will take 3 years to build an operational center -- one capable of generating its own program and supporting KOJ resource agencies without outside help. During these 3 years it will be necessary to have contractor support for the center in the form of a resident technical advisor, home office support, and visiting consultants.

Foreign specialists will provide up-to-date expertise which does not exist in Jordan at this time. We believe that there are deficiencies in the following fields at the JNGC, all of which are relevant to establishing a viable RSC:

a. Computer systems engineering,
b. Computer programming and software development
c. Color photographic processing,
d. Applications technology.

The $2.122 million cost estimated in this report (Sec. 3.5) for a 3 year program may be too low. In Nepal, a similar USAID-supported facility was developed for $2.4 million over a 54 month period. In Egypt a USAID development program for a RSC has been underway for over a decade and the cost has been several million dollars. In Peru the cost for a USAID RSC amounted to about $3 million, spent over a three year period.

When developing plans for an Image Processing Facility (IPF) first we determine the types of image products or output required; second, we determine the kinds of software needed to meet output requirements; and third, we identify hardware components that are best suited to operate appropriate software and generate the desired products. Development of the IPF involves two levels of micro-computer capability. The initial phase uses a stand-alone PC based system and peripherals. The second phase enhances the initial capability by adding a second, more powerful micro-computer. The PC then becomes a smart-terminal for the larger

micro-computer. Appendix D is a list of the IPF processing capability necessary to produce products required by the user community. Appendix E lists Phase II and III image processing and analysis system characteristics. The color photographic lab capabilities are listed in Appendix F. Photo lab system characteristics are listed in Appendix G.

3.2 TRAINING

The objective of training is to develop a cadre of experts who will maintain operation of the RSC, and who can stimulate user awareness and applications for RSC data products and services. This objective could be accomplished within a period of two years by providing: (1) on-the-job training in the U.S. and Amman, (2) training for Jordanian specialists who would organize and present workshops and seminars in Jordan, and (3) contractor assistance to support workshops and seminars and to conduct special advanced training activities. Major elements of this program are discussed in the following sections.

3.2.1 IPF TRAINING (PHASE I)

To obtain the skills needed to manage and operate the IPF, ERIM recommends that the RSC staff obtain training first using a contractors IPF, and later in Amman using the PC based RSC IPF. Staff will be trained to operate the more advanced IPF system (Phase III). The RSC staff would have hands-on use of the contractor IPF to generate, as a training project, some of the Landsat images needed by users in Jordan.

Experience shows that the best method of teaching image analysis and processing techniques is by on-the-job training, as opposed to an exclusively classroom-oriented approach. On-the-job training would focus on specific projects with concrete goals rather than "laboratory" exercises. The selected projects should be of sufficient scope both to exercise most of the system and to continue over a sufficient period of time for reinforcement through repetition. The training methodology would be initiation of the work by contractor personnel with RSC

personnel observing, with a continual transition to RSC personnel performing the work with contractor personnel observing and advising.

We suggest that the following materials be generated by the RSC trainees during an on-the-job training project at the contractor's facility.

a. a Jordan image-mosaic at 1:500,000 scale.
b. 1:250,000 scale false color images for each of the eleven (11) scenes needed to cover the country (refer to Figure 1).
c. 1:100,000 scale images covering the country with associated digital tape files.
d. 1:50,000 scale images of three (3) selected areas.
e. 1:100,000 scale color coded land cover/land use images, digital tape files, areal tabulations for three (3) selected areas.

Copies of these images should be distributed immediately by the JNGC/RSC to user agencies having the greatest need and used again later in workshops and seminars in Jordan.

This training period will take about six months, depending upon the number of trainees involved and their level of qualification. During this six month period the following RSC staff should be trained at the U.S. contractor's facility.

a. Proposed manager of the IPF
b. One or two system operators
c. One computer systems engineer
d. One or two photo lab specialists

The IPF course would be tailored to train RSC staff in the computer assisted interpretation of Landsat (satellite) data, generation of digital data bases from Landsat, aerial photography and map sources, and applications for these data in planning and monitoring Jordan's natural resources.

The courses should consist of a half day of classroom training, and a half day of hands-on experience using the contractor image processing facility and color photo lab. Classroom sessions should include information on basic concepts of remote sensing, Landsat characteristics, computer assisted interpretation of Landsat data, construction of digital files from Landsat, aerial photography, and map sources (e.g., topography, soils, etc.), selection of data sources considering factors such as cost and detail, development of program plans, and specifications for obtaining and processing data and applications. Instruction would be provided in the use of color monitors and computer terminals for processing Landsat data and viewing digitized data bases, digitizer operation (for converting map information into a digital data base format) and various photo interpretative equipment.

Considerable emphasis should be placed on the generation and interpretation of false color images which the recommended Phase III IPF will be capable of generating. Since manual interpretation of airborne and satellite multispectral imagery is so important in remote sensing, it is essential that the staff be able to manually interpret such imagery. Further, because the interpretation of imagery is facilitated by contrast stretching, filtering, ratio processing, principal component analysis and data restoration, the trainees should also become familiar with when to use these varirous transformations of data.

The photo technician(s) will be trained in procedures used by modern remote sensing color photo labs to maintain image to image quality control, provide control information feedback to the digital image processing facility, perform precision scaled enlargements, and provide cost effective production of registered products.

ERIM assumes that the staff selected for this training will be familiar with the operation of darkroom facilities.

We also recommend two months of training in Amman using the Phase III IPF and color lab soon after installation. Experts (e.g., photo lab

specialists, systems engineer, senior system operator) from the U.S. contractor facility would provide lectures and demonstrations, in the operation and use of the new systems.

In addition to training in the operation and management of the IPF, we recommend equipment maintenance training. The U.S. contractor should arrange for RSC staff to receive training on trouble-shooting to the circuit board level for IPF hardware.

3.2.2 TRAINING FOR RSC INSTRUCTORS IN U.S. (PHASE I)

Many new Landsat products and services will be available from the RSC when the initial data base of images has been delivered. As part of its efforts to stimulate user awareness and applications for these services, we recommend that the RSC use examples of these new products in four two-week workshops taught by RSC instructors. We recommend two (2) months of training at a contractor facility for four (4) instructors selected to conduct these workshops.

The RSC instructors should be selected by the JNGC based on their involvement in future workshops. We suggest providing instructor training in the following areas:

Training Program	Desired Instructor Background
Photogeology	Geologist
Remote Sensing	Agriculture
Remote Sensing	Hydrology
Remote Sensing	Regional Planning and Cartography

The instructors will be expected to use training modules and other training aids which incorporate the images generated by the IPF (section 3.2.1).

The recommended training activity supports preparation for the in-country workshops by accomplishing the following specific objectives:

a. jointly developing the workshop and seminar curricula with the RSC and the four instructors,
b. providing a two month training program at a contractor's facility for the four instructors,
c. jointly developing the specifications for images and other materials required from the RSC for use in exercises and modules to be used in workshops.

It should be stressed that the training provided for the instructors is not a substitute for, or extension of, the on-the-job training provided for RSC staff on the U.S. contractor IPF (3.2.1). IPF training prepares the system operators and photo technicians to use an image processing facility and color photo lab in an operational program. Instructor training is focused on preparing four RSC instructors to teach workshops on how-to extract useful information from remote sensing data using imagery and other capabilities of the proposed IPF.

Material required for instructor training at the contractor facility and for later use at the workshops in Jordan would include:

a. One set of all images and data generated by RSC staff participating in IPF training.
b. Standard false color images, 1:250,000 scale.
c. False color/high pass filtered image, 1:250,000 scale.
d. Hybrid ratio color image, 1:250,000 scale.
e. Principal component image, 1:250,000 scale.
f. Restored images, 1:100,000 scale.
g. Maps used for ground control points.
h. Other available ground truth information, e.g., geologic maps, regional planning maps, aerial photographs.

3.2.3 APPLICATION WORKSHOPS (PHASE II)

Workshops would be organized and conducted in Jordan by the RSC instructors who received training at the U.S. contractor facility. Contractor support would be provided if needed.

An applications workshop should be held for each of the key applications: Agriculture/Forestry, Geology, Hydrology, Planning and Cartography. The format of each workshop should consist of lecture/lab/field work in about equal parts. The duration of each workshop should be 10-14 working days.

Lecture material should stress the fundamentals of remote sensing and emphasize the use of data products which the RSC can produce. Lab exercises should be related to the lectures and show practical application of theory. Field trips should be structured around projects of interest to the trainees with the goal to prepare reports that will be presented at the end of the workshop.

During the workshop it is important that the trainees learn how to use the resources of the remote sensing center image processing facility (data, equipment, expertise of staff). Some time should be set aside for discussing how the RSC might aid the trainees in their everyday work assignments. RSC staff should then look into ways of providing the types of assistance that were identified as needed.

A typical size workshop should be from 10-15 persons. Sufficient advance notice should be given to participating agencies to allow them to select qualified personnel to attend.

3.2.4 IN-COUNTRY SEMINARS FOR MANAGERS (PHASE II)

Two day seminars would be organized and presented by RSC staff. These seminars would be conducted at the beginning of workshops and contractor support would be available if needed. The seminars would be designed to acquaint decision makers in resource management agencies with different aspects of the RSC and remote sensing technology. Typically a seminar would have a keynote address by a senior government official followed by reports from local agencies/experts on their activities.

These seminars would include tours of the RSC facilities and demonstrations of equipment. Handouts and reports should be distributed. The goal is to increase the awareness of resource managers of how remote sensing data can be used, what is available, and how the data/results may be obtained.

One seminar is recommended when on-the-job training is completed and the initial data base of 1:100,000 scale images is available at the RSC. A second seminar is recommended when the RSC has received and initiated operation of the Phase II IPF and color photo lab.

3.2.5 ON-CALL SUPPORT (PHASE II)

On-call contractor support could be used to help RSC organize and conduct workshops and training on topics of special interest to the RSC. Contractor specialists could be called "as needed" to provide training on advanced topics in areas such as photographic laboratory techniques, cartographic data production, and various remote sensing applications.

The recommended activity consists of preparation and support for four (4) two week trips to Amman, when needed. It is anticipated that this support will be provided during the first 12 months of operation of the new image processing facility.

3.3 FACILITY IMPLEMENTATION

The objective is to establish an operational IPF and color photographic laboratory in the RSC tailored to meet the needs of the JNGC and Jordanian user community. The recommended approach is to acquire additional information concerning user and systems requirements and to develop and present to JNGC and USAID a detailed system design and cost which would be implemented. The elements of the recommended work are discussed in the following two sections.

3.3.1 DESIGN STUDY (PHASE I)

A design study is recommended as an essential step in the establishment of an IPF that is most responsive to RSC needs. The study to

be completed during Phase I would provide the detailed design and plan for the IPF which would be installed in Phases II and III. We anticipate that the RSC will need a micro-computer based (PC type) image analysis system and color photo lab capability during Phase II. The image analysis system would be expanded during Phase III. At a minimum, this facility must be able to generate and update products similar to the ones the RSC staff will produce during hands-on training at the U.S. contractor facility. These products include false color and color coded planimetric images at scales of 1:50,000 to 1:100,000, digital tape files, and area land cover tabulations. All maps and data products must be presented at the same scales and projections as previously published 1:50,000 and 1:100,000 scale maps of Jordan. Geometric accuracy should meet national map accuracy standards.

The IPF and color photo lab should have, at a minimum, the characteristics and features we have listed in Appendices D through G. The design study would firm up these characteristics as well as recommend the required hardware and software modules. The study would continue USAID's investigation of the remote sensing mapping needs of Jordan as perceived by the JNGC and USAID staff, prepare a detailed definition of the IPF configuration required to meet those needs, and conclude with a system design plan. The system design plan would cover hardware and software costs and development schedule, system integration and checkout, and installation and training in Amman. The design study would incorporate additional information gained from the RSC staff's evaluations of IPF features used in training at the U.S. contractor facility and information gained by the contractor's experts visiting Amman to inspect JNGC facilities and review user needs.

The recommended design would be completed by the end of the fifth program month of Phase I with the delivery of a written report and oral presentation of the study results in Amman, permitting interaction between the RSC staff, USAID and U.S. contractor personnel on the factors considered and the conclusions reached during the design study.

The report would cover the following topics.

a. System Design and Performance Requirements
   - Jordan's User Needs
   - System Performance Requirements
   - Adaptation of Existing Facilities
b. Design Evaluation and Analysis
   - Data Display and User Interface
   - Data Input and Storage
   - Data Output
   - Data Processing
c. Recommended System Configuration and Options
   - Basic System Design
   - Options
   - RSC Facility Requirements
d. Training and Technology Transfer
   - Staff Requirements
   - System Operations, Maintenance and Trouble-shooting
   - User Training and Technology Transfer
e. Program Schedule
f. Estimated Program Costs

3.3.2 IMPLEMENT DESIGN (PHASES II AND III)

The IPF design presented to RSC and USAID would be implemented upon approval. Implementation would include:

a. JNGC/RSC preparing the workspace and facilities for the equipment in Amman.
b. Ordering the needed hardware, software, vendor supplied documentation, and spare parts.
c. Integrating and checking out the equipment in the U.S. to demonstrate that equipment satisfies design specifications before shipment. (It may be possible to eliminate this step and do all integration and checkout in Amman.)

d. Crating and shipping the system to the integration site at the JNGC.

e. Uncrating, setting-up, installation, and checkout in Amman to demonstrate that equipment satisfies the design specifications.

We estimate the Phase II IPF could be installed and made operational in Amman within 8 to 10 months after USAID/RSC approval of the design study.

There are several organizations which provide systems which should be able to meet RSC Phase II and Phase III image processing requirements. Examples of suppliers include: Dipix- Columbia, Maryland; ERDAS - Atlanta, Georgia; and I^2S - Milpitas, California.

It would not be advisable to consider purchasing second hand equipment since such equipment tends to be obsolescent and would eventually need to be replaced, and there is a greater risk of maintenance problems.

3.4 PROGRAM REPORTING (PHASES I-III)

The U.S. contractor will submit monthly reports to USAID/Amman which provide a review of the program and the status of each contracted task. In addition to the IPF design report, the contractor will submit two annual reports. The annual report of year one will (1) provide a review of the status of the overall program, (2) provide sections prepared by each user agency that received representative images to document their utility and value to that agency's interests, and (3) contain a formal report by each trainee on his/her accomplishments. The second annual report will provide an assessment of the level of self-sufficiency achieved by the RSC and summarize and justify requirements for additional support.

3.5 ESTIMATED BUDGET

Phase I

1.	FULL-TIME RESIDENT TECHNICAL ADVISOR WITH 1/4 TIME U.S. BASED BACK-UP		$170K
2.	IPF TRAINING AT U.S. CONTRACTOR FACILITY (6 MONTHS)		$238K
	Labor (6 mm)	$72K	
	Materials & Supplies (see Appendix C)	166K	
	(Exclusive of JNGC staff travel)		
3.	TRAINING FOR INSTRUCTORS (2 MONTHS)		$44K
	Labor (2 mm)	$24K	
	Materials and Supplies	20K	
	(Exclusive of JNGC staff travel)		
4.	DESIGN STUDY		$25K
	Labor (1.5 mm)	$15K	
	Travel includes four (4) round trips Amman, 20 days per diem and local travel	10K	
ESTIMATED BUDGET PHASE I (ITEMS 1-4)			$477K
Contingency (15%)			72K
			$549K

PHASE II (YEAR 2)

5.	FULL-TIME RESIDENT ADVISOR WITH BACK-UP		$180K
6.	ESTABLISH COLOR PHOTOGRAPHIC LABORATORY		$200K
	Labor (2 mm)	24K	
	Travel	7K	
	includes one round trip, 30 days per diem and local travel		
	Equipment (Appendix G)	139K	
	Spares and Consumables	20K	
	Crating and Shipping	10K	
	Integrate and Test, Amman (included in labor and travel)		
7.	ESTABLISH IMAGE PROCESSING FACILITY (MICRO-COMPUTER PC)		$112K
	Labor (1 mm)	12K	
	Travel	7K	
	includes one (1) round trip, 30 days per diem and local travel		
	Equipment (Appendix E)	76K	
	Spares	7K	
	Crating and Shipping	10K	
	Integrate and Test Amman (included in labor and travel)		
8.	SUPPORT FOUR TWO-WEEK WORKSHOPS/SEMINARS - AMMAN		$53K
	Labor (3 mm)	$36K	
	Travel	17K	
	includes four (4) round trips Amman, 60 days per diem and local travel		
9.	NEW IMAGE PRODUCTS		$50K
10.	MISCELLANEOUS INTERPRETATION EQUIPMENT AND SUPPLIES		$50K
ESTIMATED BUDGET PHASE II (ITEMS 5-10)			$645K
Contingency (15%)			97K
			$742K

PHASE III (YEAR 3)

11.	FULL-TIME RESIDENT ADVISOR WITH BACK-UP		$190K
12.	EXPAND COMPUTER PROCESSING CAPABILITY		$280K
	Micro Vax II Computer (Appendix E)	146K	
	Application Software	75K	
	CRT Camera Recorder	10K	
	Spares	20K	
	Crating and Shipping	10K	
	Integrate and test Amman	19K	
	Labor (12K)		
	Travel (7K) includes one (1) Round Trip and 30 days per diem		
13.	ADD HIGH QUALITY FILM RECORDING CAPABILITY		$120K
	Film Recorder	81K	
	Spares	10K	
	Crating and Shipping	10K	
	Installation	19K	
	Labor (12K)		
	Travel (7K) (includes one (1) round trip and 30 days per diem		
14.	IPF TRAINING AMMAN		$38K
	Labor (2 mm)	$24K	
	Travel includes two (2) round trips Amman, 60 days per diem and local travel	14K	
15.	MAINTENANCE TRAINING VENDOR SITES		$42K
	Labor (1 mm)	$12K	
	Vendor Subcontracts	30K	
16.	FOUR (4) OPTIONAL ON-CALL SUPPORT VISITS (2 WEEKS EACH)		$53K
	Labor (3 mm)	$36K	
	Travel includes four (4) round trips Amman, 60 days per diem and local travel	17K	
ESTIMATED BUDGET PHASE III (ITEMS 11-16)			$723K
Contingency (15%)			108K
			$831K

APPENDIX A

PLANNING DOCUMENT BY THE JNGC FOR AN RSC
(Translated from Arabic to English by the JNGC)

INTRODUCTION

The Remote Sensing Center (RSC) will function under the umbrella of the Jordan National Geographic Center (JNGC) who will be responsible for providing the overall support: logistic, administrative, technical, financial and manpower. The Director General (DG) of JNGC would also be the Chief Executive of RSC.

ADVISORY COMMITTEE OF THE RSC

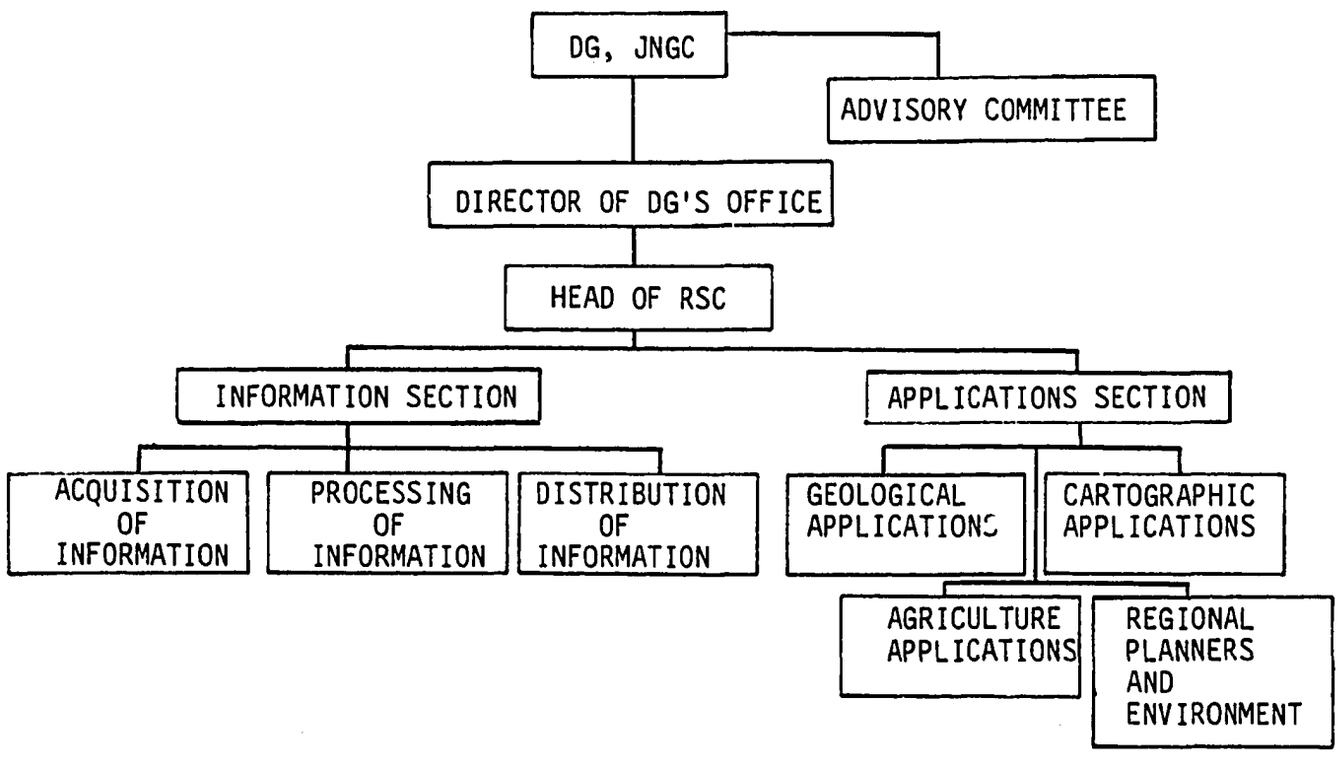
The RSC will be guided by an advisory committee headed by the DG, JNGC which will lay down the policy guidelines and give overall direction to the RSC. The committee would have high level representation from all national user agencies: Ministries of (i) Planning, (ii) Agriculture, (iii) Energy and Mineral Resources, and Water Authority.

FUNCTIONS OF RSC

1. Establish, operate and maintain the RSC.
2. Provide services in the form of information, training, satellite data, analytical aids, leads for applications of remote sensing data etc., to the national user agencies and the planners.
3. To develop an independent capability for analyzing and interpreting the RS data, in order to assist the development of antural resources of Jordan.
4. Establish institutional linkage with the national users, planners, universities, and scientific bodies like the Royal Scientific Society (RSS).

5. Maintain active cooperation and coordination with international agencies including the UN bodies concerned with RS/space technology.
6. Draw up a national policy paper identifying priority problems that can be solved through remote sensing.
7. Establishment of a specialized library having books, reports and journals dealing with various aspects of RS.

ORGANIZATION CHART OF RS



MANPOWER

1.	Head of RSC (Engineer)	1
2.	Head of Information Section (Engineer)	1
3.	Head of Applications Section (Engineer, Geologist, Agriculture)	1
4.	Acquisition of Information (Assistant Engineer)	1
5.	Processing of Information	
	Engineer	2
	Assistant Engineer	2
6.	Distribution of Information	
	Engineer, Geographer	1
	Assistant Engineer	1
7.	Applications (Geology)	1 + 2 (Natural Resources)
8.	Applications (Hydrology)	1 + 2 (Water Authority)
9.	Applications (Agriculture)	1 + 2 (Min of Agriculture)
10.	Applications (Regional Planning)	1 + 2 (Min of Municipality & Planning)
11.	Applications (Cartography)	
	Engineer	2
	Assistant Engineer	3
12.	Development, Printing & Photography Expert	
	Engineer	1
	Assistant Engineer	2
13.	Maintenance (Technicians)	2
	TOTAL	25 + 8 (From Other Governmental Bodies)

EQUIPMENT

- Digital Image Analysis System
- Zoom Transfer Scope (2)
- Densitometer
- Color Additive Viewer
- Diazo Color Composite
- Diazo Film Transparencies
- Optronics P-1500
- Calibration, Measurement, Test Equipment for Maintenance Purposes
- Multispectral Camera
- Enlarger and Accessories
- Development of the Photographic Laboratory for Color Processing Purposes

TRAINING

Training is a very important aspect of the project. It is proposed that scientists/engineers should be sent abroad for higher studies/specialized training and some of them in the field of applications and information get their training in Jordan, as follows:

In Jordan (Duration 3 months)

Subjects	Number of Trainees
Agricultural Applications	3
Geological Applications	3
Hydrological Applications	3
Regional Planning (Land Use)	3
Cartography	7
Remote Sensing Technology	3
TOTAL	22

ABROAD (Duration 6 months)

Digital Data Processing	4
Remote Sensing Techniques	3
Printing and Photography	2
TOTAL	9

(2-3 years leading to MS/PhD Degree)

Digital Image Processing	1
Remote Sensing through Active Sensors like SARs	1
Sensor Design	1
TOTAL	3

In addition, the training in Jordan by the manufacturer's engineers visiting the country for installation and commisioning of the equipment.

APPENDIX B

PERSONS CONTACTED

Jordan National Geographic Center

Lt. Col. Ghazi Asaad	Chief, Reproduction Department
Omar Malkawi	Chief, Remote Sensing Center
Dr. Albair Simonian	Remote Sensing Specialist
Faisal Al-Zureigat	Geographic Engineer
1st Lt. Salti Ibrahim	Cartographer
1st Lt. Mahmoud Ahmad	Chief, Photogrammetric Section
Maj. Ali Odeh	Chief, Photogrammetric Branch
Dr. Abdulrahim Masad	Chief, Research Studies Division
Mofid Hamza	Head, Research Studies Section
Mazen Shotar	Chief, Geodetic Section
Capt. Khalaf Madan	Chief, Photographic Laboratory Section
Lt. Col. Mohammed Momani	Chief, Photographic Laboratory Branch
Munir al Farra	Photogrammetric Maintenance Technician
Ziad Abduljawad	Photographic Technician
Bishara Jadallah	Photographic Technician
Tarik Khasawneh	Geographer

Water Authority of Jordan

Eng. Bader Hirzalla	Director, Water Resources Department
Dr. Eng. Bishara Naber	Hydrogeologist
Amin Jerry Wardem	Hydrogeologist, Surface Water Division
Mohammed Abu Taha	
Jamil Rashdan	Hydrogeologist, Water Resources Development Department
Eng. Hamid Abu Obeid	Asst. Project Manager North Jordan Ground Water Investigation Department

Royal Scientific Society of Jordan

Dr. Fakhruddin Daghestani	President
Dr. Yousef A. Nusseir	Director, Computer Systems Department

Ministry of Planning

Nabil Sweis	Asst. Secretary General
Boulos Kefaya	Director, Infrastructure Department
Eng. Sami Nsour	Director, Science & Technology Department
Eng. Moustafa Zahran	Director, Productive Projects Department
Dr. Marwan Mnasher	Science & Technology Department
Eng. Ahmad Sammour	Infrastructure Department, Highway Section

Eng. Nadia M. Jouharie	Infrastructure Department, Water & Sewage Projects
Dr. Rima Khalaf	Economic Planning Department
Saif Zahir	Telecommunications & Information
Harry Garnett	Regional Planning Advisor
Dr. Akdulilah Abu Ayyash	Regional Planning

Ministry of Municipal and Rural Affairs and Environment

Dr. Saleh al-Shari	Department of Environment

National Resource Authority

Mohammed Abu Ajamieh	Director, Geological Survey and Bureau of Mines
Kays K. El-Kaysi	Head, Geophysics Division
Moussa Hadadin	Acting Head, Geology Division
Dr. Cedric Mortimer	Technical Advisor (British Geological Survey)

Ministry of Agriculture

Mr. Osama Belbeisi	General Director, Projects Department
Mr. Zulkifl Ghosheh	Director, National Agricultural Research Center and Technology Transfer, Department of Projects
Bakr Hussein Ahmad Qudah	
Nazeem Abu Rub	
Raghab Shammoutt	

APPENDIX C

INITIAL DATA BASE MATERIALS AND BUDGET

Acquire TM Tapes Country (11 scenes) @ $4,400/scene	$48,400
Data Conversion 11 Tapes @ $400/tape	4,400
1:250,000 scale images, five copies each of 11 scenes @ $1,230/scene	13,530
composite, positive film transparencies @$120/scene	1,320
Jordan Mosaic 1:500,000 scale, five copies (each additional print $360)	19,322
1:100,000 scale images, five copies each, digital tape file, images covering country, and digital files @ $3,430 image data set	59,160
composite, positive film transparencies @$120/scene	5,280
1:50,000 scale .5° x .5° area, five copies each generate three (3) images for training @ $1,230/image	3,690
1:100,000 scale color coded land cover/use image area, digital files, area tabulations (4-6 areas), generate three (3) images for training @ $3,730/data set	11,190
	$166,292
	$166,000

APPENDIX D

PROCESSING CAPABILITY OF THE PROPOSED PHASE III IMAGE PROCESSING FACILITY

A. Radiometric Corrections
   - o Replace Dropped Scan Lines
   - * o Destriping
   - o Atmospheric Correction and/or Color Balancing

*B. Correct and Transfer Data into Common Map Projection

*C. Digital Level Slicing

*D. Contrast Stretch
   - o Linear
   - o Equal Occupancy

*E. Digital Filtering
   - o High Pass
   - o Restoration
   - o Directional
   - o Low Pass

*F. Ratioing

*G. Principal Component Analysis

H. Select Training Sites with any Shape Quadrilateral

*I. Statistical Operations
   - o Histograms
   - o Covariance Matrices

*Capability of Phase II IPF Processing a Small Sub-set of Data

*J. Classification
- o Maximum Likelihood
- o Unsupervised

K. Digital File Generation
- o Digitizing Software
- o Conversion from Polygonal to Cellular
- o All common map projections
- o Conversion from Cellular to Polygonal

L. Specialized Models for File Manipulations
- o Construct multilayer geographic data base
- o Merge Landsat, aerial photography, and map sources
- o Digital mosaicking

APPENDIX E

EXAMPLE OF BASIC PC TYPE IMAGE PROCESSING FACILITY FOR PHASE II

1.	PC/AT System with 512 x 512 x 32 Bit Image Processor	31K
	Processor	
	13" Monitor	
	Joystick	
	IBM-PC Math Co-processor	
	Image Processing Software	
2.	Digitizing Module with Software and 24" x 36" Tablet	12K
	Price includes international power and preparation.	
3.	Tape Module with 9-Track Tape Drive, Controller and Software	13K
4.	Mass Storage Option with 85 Mb Disk Drive	9K
5.	Color Ink Jet Printer and Software	5K
6.	GIS Software Package	5K
7.	Software Tool Kit	1K
		$76K

EXAMPLE OF MICRO VAX II COMPUTER SYSTEM FOR PHASE III

Micro Vax II	38K
Floating Point Processor	
1 Mbyte Main Memory	
One or Two 205 Mbytes Removable Pack	50K
Disk Drives	
1600/6250 BPI Magnetic Tape Drive	31K
Serial Line Terminal Multiplexer	2K
Two Alphanumeric CRT Terminals	3K
Black and White Graphics Terminal	2K
300 LPM Line Printer	10K
Console Terminal	3K
Micro VMS Operating System	4K
VMS Fortran System	3K
	$146K

APPENDIX F

OUTPUT CAPABILITY OF THE PROPOSED PHASE II COLOR PHOTOGRAPHIC PROCESSING LABORATORY

During Phase II the RSC will need to add a color processing capability to its existing black and white photographic laboratory. This lab will be required to transform the film negatives generated by the IPF into color prints and color display transparencies up to 40" x 40" in size. The lab will require the following capabilities:

a. Process film negatives up to 10" x 10" in size. If the image processing system produces black and white separation negatives this will, of course, be a black and white film processor. If the recorder produces color negatives this will require a color processor.
b. Film registration. This is needed if film recorded produces black and white separation negatives.
c. Densitometry. This is needed for quality control.
d. Color Contact Prints. Needed to produce proof prints up to 10" x 10" in size.
e. Enlarged Color Prints and Display Transparencies. Needed to enlarge the black and white separation negative or color negatives up to 40" x 40" in size.
f. Color Print Processing. Needed to process the enlarged prints and display transparencies.

APPENDIX G

EXAMPLE OF A COLOR PHOTOGRAPHIC LABORATORY SYSTEM FOR PHASE II

Function	Item	Estimated Cost
Film Processing	11" black and white film processor	$20,063
Film Registration	4 - 12X Magnifying lens	188
	plate glass pieces	63
	2 - registration punches	875
	Register contact frame	750
	Light Table 30"x40"	1,875
Densitometry	Color transmission and reflectance densitometer	5,625
Color Contact Prints	Light Unit	1,000
	Filter	250
	Timers 3 @$200 each	750
	Static eliminator dust brush	438
	Mis. safelights/paper safes	375
Enlarged Color Prints and Display Transparencies	Registration enlarger; 10' Model Chassis; color head; pin register carrier; 40"x60" vacuum baseboard; scale memory	27,500
	Lenses for enlarger; 105 mm, 180 mm, 240 mm, 300 mm	5,000
	Roll paper dispenser/cutter	2,500
	Misc. timers, safelights, focusers, analyzers	2,500
Color Print Processing	Color print processor	28,750
	25-gal chemical mixer	1,875
	stainless steel clean-up sink	1,875

Color Transparencies and Color Negatives up to 8"x10"	8"x10" Nitrogen Burst Agitation equipment 3 1/2 gal. Manual sink line C-41 color film process	12,500
----------Optional Products----------		
Large Black and White Prints/Transparencies	Black and White Processor	25,000
		$139,752

APPENDIX H

ACRONYMS

ERIM	-	Environmental Research Institute of Michigan
U.S.AID	-	U.S. Agency for International Development
JNGC	-	Jordan National Geographic Center
RSC	-	Remote Sensing Center
WAJ	-	Water Authority of Jordan
KOJ	-	Kingdom of Jordan
NOAA	-	National Oceanic and Atmospheric Administration
DG	-	Director General
MSS	-	Multispectral Scanner System
TM	-	Thematic Mapper
SPOT	-	Systeme Probatoire d'Observation de la Terre
RSS	-	Royal Scientific Society
NRA	-	National Resoure Authority
MMREA	-	Ministry of Municipal, Rural, and Environmental Affairs
MOP	-	Ministry of Planning
IPF	-	Image Processing Facility
MA	-	Ministry of Agriculture
PC	-	Personal Computer

ERIM

FERGUSON, KENNETH P. RESEARCH AND APPLICATIONS SCIENTIST

EDUCATION

MA	Geography	University of Texas-Austin	1981
BA	Geography	University of Florida-Gainesville	1974

EXPERIENCE

Research and Applications Scientist, Environmental Research Institute of Michigan, October 1985 through Present. Participate in ERIM international remote sensing activities. Provide consultation on how to design, develop, and implement foreign remote sensing center operations, i.e., user services, data processing and analysis methods, training, and staff structure. Consult with potential users on conducting projects requiring application of Landsat data to a broad range of topics including: agricultural assessment, soil mapping, range management, land cover/use mapping, environmental-wildlife studies, engineering planning, mineral exploration, geologic mapping, and geographic map compilation.

Remote Sensing Specialist/Geographer, U.S. Geological Survey, Saudi Arabian Mission January 1977 to October 1985. Was responsible for coordination and management of the USGS remote sensing program in Saudi Arabia in cooperation with the Saudi Arabian Deputy Ministry for Mineral Resources (DMMR). Established the first remote sensing center in Saudi Arabia. This facility specializes in the application of Landsat data products for mineral exploration, and geologic and geographic mapping. Consulted with and trained Saudi geologists in remote sensing methods. Operated a DIPIX Aries II image processing system. Compiled geographic maps using an Intergraph computer graphics system, or used conventional compiling methods. (See list of publications). Geographic information on these maps was obtained by field investigations and satellite image interpretation.

In addition to services to the DMMR I provided valuable assistance to other organizations in Saudi Arabia, outlined as follows.

<u>Meteorological and Environmental Protection Administration</u>

1. Consulted with the Deputy Director and selected staff on rangeland monitoring methods using Landsat data.

EXPERIENCE (Cont'd.)

2. Identified habitat of endangered species of gazelle and ibex, and made recommendations for protecting these areas.

3. Assisted staff in interpreting Landsat imagery and compiling maps for a report on management of critical habitats on the Red Sea coast.

4. Advised staff on methods for establishing a remote sensing applications unit.

Ministry for Agriculture and Water

1. Consulted with staff on methods for compiling a schematic soil map of Saudi Arabia at 1:1,000,000-scale using Landsat data products.

2. Written captions for Landsat images used to illustrate Saudi Arabia's first National Water Atlas.

3. Advised staff on methods for mapping agricultural development in the country using Landsat imagery.

Ministry of Planning

1. Advised staff of methods for showing geographic information on Landsat image products for a new National Planning Atlas.

Military Survey Department, Mininstry of Defense and Aviation

1. Advised the Director and senior staff on establishment of a Landsat image processing and analysis unit.

King Abdul Aziz City for Science and Technology

1. Co-authored part of a national position paper on Landsat applications in Saudi Arabia.

2. Advised senior staff on establishment of a Landsat ground receiving station.

EXPERIENCE (Cont'd.)

3. Served by request as an un-official observer at the Second United Nations Conference on Peaceful Uses of Outer Space (UNISPACE), in Vienna, Austria, 1982.

Arabian American Oil Company (ARAMCO)

1. Cooperated with ARAMCO on a seven year project to produce a new geographic map of the Arabian Peninsula at 1:2,000,000 scale.

2. Conducted workshops in remote sensing and Landsat image interpretation.

Consultant, Brooks, Barr, Graeber and White, Austin, Texas - June 1976 to December 1976. Services to this engineering, planning, and architectural firm were concerned with remote sensing analysis of the immediate vicinity of Buraidah, Saudi Arabia and Qasim Province in the north-central part of the country. The analysis included writing a formal report and providing staff briefings intended to facilitate planning and design of a new town.

Geographer, U.S. Geological Survey, Reston, Virginia - June 1974 to December 1976. Duties included: compiling and synthesizing geographical data from various sources such as high altitude aerial photography and satellite imagery for production of land use and land cover maps; report editing; training summer employees in cartographic techniques; setting up and operating a photographic system for producing 35mm slides at precise scales showing study areas on aerial photography and satellite imagery; briefing and leading tours for foreign visitors.

Instructor, Center for Middle Eastern Studies, University of Texas-Austin from June 1976 through August 1976. Instructed junior and senior level students in a course entitled "Adjustment and Change in the Middle East". Subject matter was geographical and geo-political.

Teaching Assistant, University of Texas-Austin, September 1974 through May 1976. Taught three laboratory sections per week totalling about 40 students per semester on the subjects of climatology, map and aerial photographic interpretation and cultural geography.

FERGUSON, KENNETH P. RESEARCH AND APPLICATIONS SCIENTIST

EXPERIENCE (Cont'd)

Peace Corps Volunteer, August 1966 through August 1968. Was assigned for two years as an agricultural advisor to a small South Indian village to participate in implementation of a joint U.S./Government of India village level food production program. The main objective was to aid local farmers in the introduction of hybrid, high-yielding, proteinous crops to a semi-arid area of the Deccan plateau with recently developed irrigation resources. Tasks included training local farmers in modern tillage and planting techniques, irrigation, insect control, chemical fertilizing, marketing and co-operative management. Played an important role in reopening a local paper factory which had gone out of business. Conducted an extensive feasibility survey concerning the establishment of a large district level farm for the production of commodities used by the CARE organization in their school lunch feeding program. Designed and coordinated a month long exhibit for the Peace Corps in Bangalore in 1968.

LINQUISTIC KNOWLEDGE

I possess a fair knowledge of written and spoken Arabic, French, and German.

OF SPECIAL NOTE:

I have lived for most of my life in developing countries, specifically Saudi Arabia, Iran, Lebanon, and India. My university training focussed on physical and cultural characteristics of the Middle East. As a geographer I am able to interact and relate to a wide range of international development problems. I am experienced in methods of facilitating the transfer and adaptation of technology in developing countries. I enjoy teaching, training and working with citizens of the Third World, and I can effectively communicate with these people. I am able to work and live contentedly in difficult or even harsh conditions for long periods of time.

FERGUSON, KENNETH P. RESEARCH AND APPLICATIONS SCIENTIST

PROFESSIONAL AFFILIATIONS

Fellow - Royal Geographic Society
Regular Member - Association of American Geographers
Chairman - Saudi Arabian Natural History Society (1979-1981)

PUBLICATIONS

Greenwood, W.R. and Ferguson, K.P., Jr., Instructions for Compilation of 1:250,000 Scale Geologic and Geographic Maps, U.S. Geological Survey Saudi Arabian Mission Administrative Document, Jiddah, 1980.

Ferguson, K.P., Jr., "Application of Landsat Data to Earth Science Investigations in the Kingdom of Saudi Arabia", in Exploration and Peaceful Uses of Outer Space, National Paper of the Kingdom of Saudi Arabia, Riyadh, Saudi Arabian National Center for Science and Technology, 1982.

Ferguson, K.P., Jr., The Saudi Arabian Deputy Ministry for Mineral Resources Remote Sensing Center: Services and Applications of Landsat Data, U.S. Geological Survey Saudi Arabian Mission Open-File Report, Jiddah, OF-01-2, 1982.

Buttiker, W., and Ferguson, K.P., Jr., "Detection of Faunal Biotopes of Medical Importance in Southwestern Saudi Arabia Using Landsat Images", in Fauna of Arabia, Vol. 5, Jiddah: Saudi Arabian Meteorological and Environmental Protection Administration, 1984.

Ferguson, K.P., Jr., Rogers, Robert H. "Design for a Remote Sensing Center in the Jordan National Geographic Center, Amman: ERIM Report 176510-1-L, Ann Arbor, 1986.

Sellman, A.N., et al., "Thematic Mapper Derived Acreage Estimate of the 1985 Millet/Sorghum Crop in Western Sudan", ERIM Report 192700-1-F, Ann Arbor, 1986.

GEOGRAPHIC MAPS

Ferguson, K.P., Jr., Jackson, R.O., Hadley, D.G., Ramirez, L.F., Mandaville, J.P., and Bowers, S.D., 1984, Geographic Map of the Arabian Peninsula: Saudi Arabian Deputy Ministry for Mineral Resources Arabian Peninsula Map AP-5-B2, scale 1:2,000,000.

GEOGRAPHIC MAPS (Cont'd.)

Ferguson, K.P., Jr., 1984, Preliminary Landsat Image Map of the Asir Quadrangle, Kingdom of Saudi Arabia: U.S. Geological Survey Saudi Arabian Mission Technical Report TR-04-3/IR 624, Scale 1:500,000.

Ferguson, K.P., Jr., 1984, Preliminary Landsat Image Map of the Tihamat ash Sham Quadrangle, Kingdom of Saudi Arabia: U.S. Geological Survey Saudi Arabian Mission Technical Record TR-04-2/IR 623, Scale 1:500,000.

Ferguson, K.P., Jr., 1984, Preliminary Landsat Image Map of the Southern Hijaz Quadrangle, Kingdom of Saudi Arabia: U.S. Geological Survey Saudi Arabian Mission Technical Record TR-04-6/IR, Scale 1:500,000.

Ferguson, K.P., Jr., 1984, Preliminary Landsat Image Map of the Wadi ar Rimah Quadrangle, Kingdom of Saudi Arabia: U.S. Geological Survey Saudi Arabia Mission Technical Record TR-04-7/IR 665, Scale 1:500,000.

ERIM

ROGERS, ROBERT H. APPLICATIONS SCIENTIST

EDUCATION

Ph.D.	Electrical Engineering	Michigan State Univ.	1963
MS	Engineering	Southern Meth. Univ.	1959
BS	Electrical Engineering	Tri-State College	1956

EMPLOYMENT

Applications Scientist, Environmental Research Institute of Michigan, Ann Arbor, Michigan, 1978 - Present.
Applications Scientist, Bendix Aerospace Systems Division, Ann Arbor, Michigan, 1964 -
Staff Engineer, Ling-Tempco-Vought Aerosystems Division, Greenville, Texas, 1963 - 1964.
Instructor, Michigan State University, East Lansing, Michigan, 1960 - 1963.
Group Supervisor, Collins Radio Company, Dallas, Texas, 1956 - 1960.

EXPERIENCE

Staff Engineer, Remote Sensing Services and Applications Department: Assist users with studies and planning required to apply remote sensing technology. Identify, develop, and evaluate new remote sensing equipment and techniques. Work with user organizations to identify natural and cultural features that can be monitored through remote sensing. Develop and demonstrate the best combination of aircraft and spaceborne experiments, sensors, data processing, and data interpretation techniques for gathering and understanding data. Participate in the planning and administration of the International Symposia on Remote Sensing of Environment.

Visiting lecturer, Eastern Michigan University: teach off-campus course in Remote Sensing Technology.

Manager, Applications Group: Established and monitored more than 40 contracts for the processing and applications of Landsat data including statewide land-use inventories (Ohio and North Dakota) and regional inventories in 20 other states. Appointed by the National Aeronautics and Space Administration (NASA) to be Principal Investigator for program to transfer Landsat technology to private industry using community colleges. Other programs included applications of Landsat to the surveillance of Lake Eutrophication in the Great Lakes Basin; Investigation of Techniques for Correcting Landsat Data for Solar and Atmospheric Effects; Monitoring Strip Mine and Reclamation; and Inland Lake Water Quality.

ROGERS, ROBERT H. APPLICATIONS SCIENTIST

Co-investigator on programs such as Landsat Management of Delaware's Marine and Wetland Resources and Skylab/EREP Studies of Delaware Bay. Managed large-scale system studies. Performed Shuttle System Payload Design Study.

PUBLICATIONS AND PAPERS

"Position Measurement of a Target Missile," Master's Thesis, Southern Methodist University, 1959.

"On Properties of a Class of Differential Equations and Corresponding Higher Order Differential Equations," Ph.D. Dissertation, Michigan State University, 1963.

"Multispectral Data Gathering Systems and Analysis," International Remote Sensing Institute, 1st Annual Symposium Proceedings, Vol 1, 21 April 1969.

"Investigation of Multispectral Techniques for Target Acquisition Improvement," Meeting of the IRIS Specialty Group on Infrared Imaging - 28-29 November 1972, ERIM Report 102400-3-X, August 1973.

Co-author, "Satellite Studies of Turbidity and Circulation Patterns in Delaware Bay," Proceedings of the American Society of Photogrammetry Fall Convention, Vol II, 2-5 October 1973.

"Machine Processing of ERTS and Ground Truth Data," (Radiometric Calibration), Proceedings of Conference on Machine Processing of Remotely Sensed Data, LARS, Purdue University, IEEE Catalog No. 73CHO 834-2GE, 16-18 October 1973.

"Automated Strip Mine and Reclamation Mapping from ERTS," Proceedings of 3rd ERTS Symposium, 10-14 December 1973.

"Techniques for Correcting ERTS Data for Solar and Atmospheric Effects," Proceedings of 3rd ERTS Symposium, 10-14 December 1973.

Co-author, "Monitoring Coastal Water Properties and Current Circulation with ERTS-1," Proceedings of 3rd ERTS Symposium, 10-14 December 1973.

Co-author, "Inventories of Delaware's Coastal Vegetation and Land-Use Utilizing Digital Processing of ERTS-1 Imagery," Proceedings of 3rd ERTS Symposium, 10-14 December 1973.

Co-author, Monitoring "Coastal Water Properties and Current Circulation from Spacecraft," Proceedings of 2nd Joint Conference on Sensing of Environmental Pollution, 1-12 December 1973.

"Automated Land Use Mapping from Spacecraft Data," Proceedings of National ACSM-AS Convention, St. Louis, MO, 10-15 March 1974.

"ERTS-1: Automated Land-Use Mapping in Lake Watersheds," Proceedings of 3rd Annual Remote Sensing of Earth Resources Conference, The University of Tennessee Space Institute, 25-27 March 1974.

"Automatic Classification of Eutrophication of Inland Lakes from Spacecraft Data," Proceedings of 9th International Symposium on Remote Sensing of Environment, ERIM, 15-19 April 1974.

Co-author, "Correlation of Coastal Water Turbidity and Circulation with ERTS-1 and Skylab Imagery," Proceedings of 9th International Symposium on Remote Sensing of Environment, ERIM, 15-19 April 1974.

Co-author, "Inventories of Delaware's Coastal Vegetation and Land-Use Utilizing Digital Processing of ERTS-1 Imagery," Proceedings of 9th International Symposium on Remote Sensing of Environment, ERIM, 15-19 April 1974.

"Automatic Mapping of Strip Mine Operations from Spacecraft Data," Proceedings 1974 ASCM/ASP National Convention, Washington, D.C., 10-13 September 1974.

Co-auther, "Automatic Categorization of Land-Water Cover Types of the Green Swamp, Florida, Using Skylab Multispectral Scanner (S-192) Data," Proceedings of American Astronautical Society, 20th Annual Meeting, University of Southern California, Los Angeles, 20-22 August 1974.

Co-author, "Skylab and ERTS-1 Investigations of Coastal Land-Use and Water Properties in Delaware Bay," AIAA Paper No. 74-1220, AIAA/AGU Conference on Scientific Experiments of Skylab, Huntsville, Alabama, 30 October 1974.

Co-author, "Water Management Models in Florida from ERTS-1 Data," Proceedings of ERSS, Houston, Texas, June 1975.

Co-author, "Ohio's Statewide Land Use Inventory," Proceedings of the ERSS, Houston, Texas, June 1975.

"Automated Mapping and Inventory of Great Barrier Reef Zonation with Landsat Data," Proceedings of Ocean '75 Conference and Exposition, San Diego, California, September 1975.

Co-author, "Classifying and Monitoring Water Quality by Use of Satellite Imagery," Proceedings of International Conference on Environmental Sensing and Assessment (ICESA), Las Vegas, September 1975.

"Application of Landsat to the Surveillance and Control of Lake Eutrophication in the Great Lakes Basin," Tenth International Symposium on Remote Sensing of Environment, ERIM, 6-10 October 1975.

"Landsat-1: Automated Land-Use Mapping in Lake and River Watersheds," Proceedings of ASP-ACSM Fall Convention, Phoenix, Arizona, 26-31 October 1975.

"Computer Mapping of Landsat Data for Environmental Application," Proceedings of Workshop for Environmental Applications of Multi-spectral Imagery, Fort Belvoir, Virginia, 11-13 November 1975.

Co-author, "A Strategy for Land Use/Cover Data File and Map Preparation," Bendix Report BSR 4239, 3 May 1976.

Co-author, North Dakota Statewide Land Cover Analysis from Computer Processed Landsat Data: (BSR 4258) Proceedings of the 43rd Annual Meeting of ACSM-ASP Convention, Washington, D.C., 27 February - 5 March 1977.

Co-author, Variability of Wetland Reflectance and Its Effect on Automatic Categorization of Satellite Imagery, Proceedings of 43rd Annual Meeting of ASP, Washington, DC, 1977.

Co-author, A Procedure for Merging Land Cover/Use Data from Landast, Aerial Photography, and Map Souces: Compatibility, Accuracy and Cost, Proceedings of 43rd Annual Meeting of ASP, Washington, DC, 1977.

"Forestland Type Identification and Analysis in Western Massachusetts: A Linkage of a Landsat Forest Inventory to an Optimization Study," Proceedings of the 11th International Symposium on Remote Sensing of Environment, Ann Arbor, Michigan, April 1977.

"Application of Landsat to the Surveillance and Control of Lake Eutrophication in the Great Lakes Basin," NASA Final Report, Bendix Report No. BSR 44291, August 1977.

"Land Use Inventory Through Merging of Landsat (Satellite), Aerial Photography, and Map Sources," Proceedings of the Fall meeting of the American Congress on Surveying and Mapping," Little Rock, Arkansas, October 1977.

Co-author, "Landsat Derived Land Cover and Impervious Categories for Metropolitan Washington: An Urban/Non-Urban Computer Approach," Proceedings of Spring Meeting of American Society of Photogrammetry, Washington, DC, 26 February - 4 March 1978.

"Summary Report: Applications of Landsat to the Surveillance of Lake Eutrophication in the Great Lakes Basin," Proceedings of ACSM-ASP Annual Convention, Wasngton, DC, 26 February - 4 March 1978.

Co-author, "Use of Landsat Satellite Remote Sensing for Regional Environmental Planning and Management," Invited Paper at XV Convention Pan American Federation of Engineering Societies, Santiago, Chile, October 1978.

"Landsat Offshore Studies Along the Western Coast of Libya," Program Survey Department of Libya Final Report, ERIM Report No. 307000-1-F, July 1979.

Co-author, "Landsat Eight Band Two Season Land Cover Classification Compared with Aerial Photographic Interpretation of the Toledo, Ohio Area," Corps of Engineers Program, Final Report, ERIM Report No. 139100-1-F, 6 September 1979.

Co-author, "Remotely Sensed Data Processing Techniques Present and Future," Symposium Proceedings, Identifying Irrigated Lands Using Remote Sensing Techniques: State of the Art, Missouri River Basin Commission, Sioux Falls, S. Dakota, November 1979.

"Spreading NASA's Wealth," Detroit Engineer, Engineering Society of Detroit, April 1980.

"Landsat Technology Transfer to the Private and Public Sector Through Community Colleges and Other Locally Available Institutions," Proceeding ACSM-ASP Fall Technical Meeting, Niagara Falls, NY. ASP Technical Paper ISSN9271-4040, October 1980.

"Mapping Earth Resources and Indicators of Desertification from Landsat Data," Proceedings of Seminar on Environmental Monitoring for the Arab World, Amman, Jordan, 26-29 October 1980.

"Landsat Technology Transfer to the Private and Public Sectors Through Community Colleges and Other Locally Available Institutions," Proceedings of the 1981 ASP-ACSM Annual Convention, Washington, DC, February 1981.

"The Remote Analysis Station (RAS) as an Instructional System, for Remote Sensing and Geographic Information System (GIS) Technology," Course on Remote Sensing Education (CORSE-81), Purdue University, 18-22 May 1981.

"Landsat Technology Transfer to the Private and Public Sectors Through Community Colleges and Other Locally Available Institutions, Phase II Program," NASA Final Report, ERIM Report No. 154700-1-F, March 1982.

"Survey and Evaluation of Techniques Required for the Analysis and Interpretation of Spacecraft MSS Data by Organizations Involved in Exploration for Oil and Gas Fields During the 1980's," Prepared for Japan Petroleum Exploration Co. Ltd., ERIM Report No. 314400-2-F_2. June 1982.

Co-author, "Land Use Capability Assessment Using Geographic Information System," Proceedings of Auto-Carto 5, Fifth International Symposium on Computer-Assisted Cartography, Crystal City, Virginia, 22-28 August 1982.

Co-author, "Application of Geographic Information Systems in Land Use Planning," Proceedings of 20th Annual Conference of the Urban and Regional Information Systems Association (URISA '82 Conference), Minneapolis, Minnesota, 22-25 August 1982.

Co-author, "Design for a Remote Sensing Center in the Jordan National Geographic Center, Amman," Prepared for USAID, ERIM Report No. 176510-1-L, January 1986.

ROGERS, ROBERT H. APPLICATIONS SCIENTIST

PROFESSIONAL SOCIETIES

American Society of Photogrammetry (ASP): Board of Directors, Eastern Great Lakes Region (1981-1986), President EGLR (1980), Vice President EGLR (1979).
Science Research Club of the University of Michigan.
American Society of Photogrammetry-Hydrospheric Sciences Committee
Michigan Map Society
American Defense Preparedness Association

AWARDS AND PATENTS

U.S. Patent 3,050, 642, "Combined Squelch Circuit and Amplifier," August 21, 1962.

U.S. Patent 3, 193,177, "A Transistor Amplifer-Osillator with a Feedback Switching Circuit," July 6, 1965.

During his term as President of ASP EGLR, EGLR received the Region of the Year Award and he was given the Ford Bartlett Award for outstanding service to the Society.