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THE EROS DATA CENTER

PURPOSE

This document provides a brief historical background and look at the future for the U.S. Geological Survey National Mapping Division's EROS Data Center. The attached appendix provides a more detailed description of the Center's activities in 1987.

BACKGROUND

The EROS Data Center was established in 1971 within the EROS Program of the U.S. Geological Survey to archive and distribute NASA land remote sensing satellite data and for applications development and training associated with Department of the Interior use of remotely sensed data. The Data Center facilities were completed in September of 1973. The USGS occupies the facilities under a 20 year lease-purchase arrangement with the USGS acquiring full ownership in 1993.

The Center has significantly broadened its mission over its 16 years of existence and is now recognized as a leader in the accession, archiving, and distribution of aircraft and civil satellite land remote sensing data, in providing analytical services to a wide variety of remotely sensed data users, and in carrying out a broad program of research and development of advanced information systems employing remote sensing, cartographic, and digital earth science data. (Appendix A is a Summary of Significant Activities for 1987.)

In 1983 the Center became a part of the National Mapping Division of the USGS and is now operated as one of five field centers of the NMD.

The Center facilities are valued at roughly $50 million and the total Center operating cost for FY 1987 was $17.7 million including operations at the EROS Alaska Field Office in Anchorage. The Center staff is made up of roughly 55 government employees who provide overall technical management and direction of

Center activities, 260 on-site support contractor personnel who contribute to all elements of Center operations, and a varying number of visiting scientists, research cooperators, and personnel from other Federal agencies.

Funding for Center operations is provided from a part of the EROS appropriation line item ($9 million in FY 1987), several other NMD mapping appropriation line items, and revenue from the "sale" of products and services to a variety of other Federal agencies and non-government organizations. In FY 1987, the USGS received $9.3 million in reimbursable revenue from outside sources for products and services provided by the EROS Data Center. The Center also provided $3.5-$4.0 million in support to NMD mapping activities.

In recent years the Center has become increasingly dependent on non-USGS reimbursable revenue and has significantly increased support to NMD mapping activities.

Reimbursable revenue from all sources other than NOAA increased $600,000 from FY 1986 to FY 1987, and further increases are projected for FY 1988. However, continuation of outside funding at this level is dependent on the ability to maintain USGS appropriations funding for R&D that will keep the Center near the forefront of advanced technology.

THE FUTURE OF THE CENTER

The commercialization of the U.S. Landsat program and uncertainties related to continuation of the program raise many questions about the future of the EROS Data Center. The USGS received $6.7 million (or 38 percent of total Center funding) from NOAA in FY 1987 for archiving, processing, and distributing Landsat data. NOAA is providing $5.2 million to support this activity in FY 1988. As this function is transferred to commercial facilities or otherwise winds-down, the overall funding base and size of the Center could be adversely affected.

Since 1983 when the Center became a part of the NMD, Center support of Division cartographic activities (such as diapositive production, software development to support map inventory and materials tracking, DLG production digitizing, Mark II software development, and NCIC/PIO support) has increased from around $1 million to $3.5-$4 million annually.

Increased support has recently been provided to elements of the DOD and the intelligence community, and it is expected that this support will continue to

increase in the future as these users exploit certain capabilities of both the civil satellite program and the Data Center. In addition, the State Department, through the Agency for International Development (AID), continues to increase its use of the Data Center for support of emerging programs in developing countries, notably famine and early warning activities in North Africa.

NOAA and the USGS have agreed that the Center will be the location of the legislatively required National Satellite Land Remote Sensing Data Archive, but to-date, no funding (other than Landsat 4 and 5 operations funding) has been requested or appropriated for this activity. Approximately $4.0 million annually is estimated to be required to support on-going Archive operations.

In addition, scientists from two other Federal agencies have been assigned to the EDC under an agreement between the USGS and NOAA to operate a Cooperative Federal Land Remote Sensing Research Program.

NASA has recently announced an intent to develop a cooperative agreement with the USGS to use the EDC as the data processing and distribution location for the Space Station Polar Platform EOS land remote sensing data (HIRIS, MODIS, and SAR) in the mid 1990's.

In summary, more than half of current EDC activities, although within the scope of the USGS' authority and areas of expertise, are in support of Federal programs that are outside of NMD and USGS core areas of responsibility and are funded by other Federal agencies and programs.

The Center's facilities, equipment, and staff are uniquely configured to support USGS, DOI, and Federal needs and requirements for remote sensing and GIS data, research, and applications. The continuing operation and activities of the EROS Data Center provide the USGS with a highly visible presence in remote sensing, GIS, and advanced spatial data handling technology. If the USGS is to continue to have an important role in these areas, the continued operation of a facility like EDC is an effective and important element of Survey involvement.

RECOMMENDED FUTURE MISSION

The proposed long-range goals and objectives for the Center include the following:

EARTH SCIENCE DATA BASES AND PRODUCTS

- Provide leadership and Bureau focus for the integration of digital earth science data bases
- Develop, produce, and disseminate standard and special products derived from USGS digital earth science data bases

LAND REMOTE SENSING

- Conduct research, development, and application of aircraft and civil satellite land remote sensing data
- Provide aircraft and civil satellite land remote sensing products and analytical services

ADVANCED DATA SYSTEMS

- Develop and implement advanced data accession, distribution, archiving, and management technologies
- Investigate the application of advanced data systems integrated with USGS earth science data bases

SPATIAL DATA HANDLING AND GIS TECHNOLOGY

- Conduct GIS and spatial data handling basic research
- Develop, demonstrate, and implement advanced GIS and spatial data handling technologies

EROS DATA CENTER
FY 1987 SIGNIFICANT ACTIVITIES

- **Data Production** - Produced remote sensing and earth science data totaling over $10,500,000. Landsat data sales (with revenue to NOAA and EOSAT) accounted for roughly $8 million of this total, while $1.5 million was from the sale of USGS aerial photographic, cartographic, and earth science data (with revenue to the USGS). An additional $1 million in USGS products were supplied to USGS users on a non-reimbursable basis. About half of these non-reimbursable sales were diapositives for the other mapping centers, and the remainder of the non-reimbursable activity was largely custom digital and photographic processing. In FY 1987, EDC product distribution was approximately 14 percent above FY 1986.

- **Pecora 11 Conference** - Hosted the 11th Pecora Memorial Symposium in May in Sioux Falls. The Symposium, with the theme "Satellite Remote Sensing–Current Programs and a Look to the Future," was sponsored by the USGS, NASA, and NOAA, with support from the EOSAT Company and the American Society of Photogrammetry and Remote Sensing. Over 300 scientists from around the world attended the 3 days of technical sessions and roundtable discussions.

- **Assistant Secretary's Visit** - Hosted a visit by the new Department of the Interior Assistant Secretary for Water and Science, Mr. Jim Ziglar, on April 7, 1987. The Assistant Secretary was briefed on the activities of the EROS Data Center, the status of the Landsat program, and future plans for the Center.

- **Landsat Anniversary** - Provided financial and program planning support for a celebration of the 15th Anniversary of the launch of Landsat 1 which was held at the Kennedy Center in Washington, D.C. on July 23, 1987, and attended by over 2000 people. The USGS was recognized for its contributions to the Landsat program in the area of data handling and applications research. The USGS honor was received by the Deputy Assistant Secretary for Water and Science.

- **World Bank Workshop** - Hosted a World Bank workshop at EDC to develop a framework for lesser developed countries to inventory resources, monitor change, and evaluate alternate development plans. The country of Sudan was the test case for the workshop. Participants included Government of Sudan officials, World Bank officials from Washington, World Bank consultants from the United Kingdom and Sweden, U.S. Agency for International Development, and the USGS. The report developed at the workshop provides guidelines and procedures for structuring and implementing a resource information system.

- **Film Award** - Produced a 16-1/2 minute video which was honored with a third place Bronze medal at the 1987 International Film Festival in New York. The video, "Geographic Information Systems: Man & Nature," won the prestigious award in the "Education-Science" category of the international competition.

- **Landsat Data Processing** - Received, processed, and cataloged 42,000 scenes of multispectral scanner (MSS) data and 4,500 scenes of Thematic Mapper (TM) data bringing the U.S. Landsat archive to a total of almost 840,000 scenes. Periodic updates were made to the on-line cataloging and indexing system referencing the U.S. archive and approximately 1,540,000 scenes of Landsat data held by Argentina, Australia, Brazil, Canada, Italy, Japan, Maspalomas, South Africa, and Sweden. More than 4,600 orders for Landsat data were processed resulting in sales revenue of $8,084,291 to EOSAT. Average turnaround time for all Landsat products was seven days. This activity was carried-out with $6.7 million of NOAA funding in FY 1987.

- **Landsat Archive Tapes** - Reached agreement with NASA and NOAA to ship historical Landsat 1, 2, and 3 data tapes and the associated processing system from the Goddard Space Flight Center to EDC where the rest of the Landsat archive resides for long-term preservation. Landsats 1, 2, and 3 collected more than 400,000 scenes worldwide between 1972 and 1978. Of these, only about 45,000 scenes have been processed to usable computer compatible tapes (CCT). NASA and NOAA are funding the packaging and shipping of all data and equipment.

- **NOAA Meteorological Satellite Image Data** - Initiated operation of the Advanced Very High Resolution Radiometer (AVHRR) Data Acquisition and Processing System (ADAPS) began in May 1987. Approximately eight swaths of conterminous U.S. coverage have been acquired daily from NOAA

9 and 10 to support Federal government research activities. ADAPS has also been used to process foreign tape recorded AVHRR data purchased from NOAA to support the AID Africa Grasshopper Project. The ADAPS system was designed, integrated, and installed by EDC engineers. The system components were procured by the USGS with $575,000 in NOAA funding.

- **Satellite Data Procurement** - Established a contract for procurement of civil satellite data products and services from the Earth Observation Satellite (EOSAT) Company and the SPOT Image Corporation and obtained over $4 million in data products for over 20 Federal agencies. This activity has greatly simplified the process of obtaining commercial civil satellite data within the Federal government. These USGS activities are funded via a 5 percent surcharge on data procurement which returned roughly $200,000 to the USGS.

- **Interior Landsat Data Library** - Established a program to facilitate Landsat data sharing between Interior bureaus for data purchased prior to September 1985, the date of commercialization of the Landsat program. Interior bureaus and offices have been contacted and a catalog of all Landsat holdings have been merged into a concise data base. Landsat scenes within this data base can be used without restriction by any Interior bureau or office for the cost of reproduction. The current data base includes over 6,300 Landsat scenes acquired between 1972-1985.

- **National Satellite Data Archive** - Progress in development and implementation of the NOAA/USGS National Satellite Land Remote Sensing Data Archive (the Archive) centered on preparation of a program definition and implementation plan that identifies and describes all components of the Archive system, establishes an initial Archive basic data set and acquisition strategy, and defines a scope and schedule for Archive operations. A $250,000 study on concepts for archive implementation was completed under contract by NOAA with USGS participation. Efforts were made to resolve Archive funding issues.

- **Cooperative Federal Remote Sensing Research** - Prepared an Affiliation Agreement with NOAA to provide a mechanism for Federal agencies to formally join the Research Program. These documents have been approved by the USGS. Cooperative research activities between USGS scientists and NOAA scientists resident at EDC continued in 1987. The Soil Conservation Service plans to affiliate with the program in early 1988, and

several other agencies have expressed interest in formal program participation.

- **NASA Investigations** - Initiated two remote sensing research projects being supported directly by NASA funds secured through a formal competitive proposal process, and three additional proposals have been submitted by EDC scientists in response to recent NASA Announcements of Opportunity (AO). NASA funded $18,000 for a joint EDC/University of Nebraska study that is analyzing historical weather and remotely sensed data to determine and document climatic changes resulting from dramatic increases in surface irrigation in SW Nebraska and to determine the utility of Landsat data to monitor spectral changes associated with increased irrigation. NASA also is providing $14,000 in support to a USGS project that is evaluating the geometric and radiometric characteristics and geologic information content of data collected by the Airborne Visible and Infrared Imaging Spectrometer (AVIRIS) over a well-documented geologic site in Western Utah. Notification is expected in early 1988 on the evaluation of proposals submitted by EDC scientists in response to NASA Announcements of Opportunity for its Remote Sensing Applications/Commercialization Program and its Shuttle Imaging Radar-C (SIR-C) Experiment. A proposal submitted jointly by the USGS, NOAA, USDA, and Purdue University under the Applications/Commercialization Program requests $60,000 from NASA to support a study designed to evaluate NOAA-AVHRR data products for assessing and monitoring agricultural crops. Another proposal submitted jointly under the same program by the USGS and NASA/JPL requests $141,000 from NASA to support a study with the objective to develop and document a systematic and comprehensive approach, based largely on the application of remotely sensed data, to mineral exploration in remote, structurally complex, and vegetated regions of the world. Finally, a USGS/NOAA proposal submitted under the SIR-C Experiment AO requests $150,000 of NASA funding to support a project to determine and evaluate the radiometric and geometric characteristics of SIR-C data and Shuttle X-band Synthetic Aperture Radar (X-SAR) data and to determine the attributes of these sensors for snow pack characterization and mapping.

- **Interior Remote Sensing Coordination** - Chaired the DOI Task Force for Coordination of Remote Sensing which met four times, and discussed a wide variety of topics, including national satellite programs and policies, remotely sensed data sources and availability, and remote sensing research

and applications. One Task Force meeting was held at the EROS Data Center providing Task Force members with the opportunity to tour the Center's facilities. An important effort initiated by the Task Force for completion by mid-1988 is a report to the Secretary of the Interior that will document the extent to which remotely sensed data and related technology are currently used within the Department.

- **Satellite Image Mapping** - Completed 22 image maps. Products included: eleven 1:250,000-scale image maps produced from Landsat MSS data and six from TM data. In addition, four 1:50,000-scale image maps of Jordan were produced for the Office of International Geology utilizing Landsat TM data. A merge of SPOT Panchromatic data and Landsat TM data at 1:50,000 scale was produced for the Pan American Institute for Geography and History. FY 1988 projects in-work include a small-scale mosaic of the conterminous United States using AVHRR data and the merging of SPOT multispectral and Panchromatic data with Landsat TM data for large-scale image mapping at 1:24,000 scale.

- **DLG Digitizing** - Generated 119 1:24,000-scale Digital Line Graphs (DLG's) which were submitted and accepted into the National Digital Cartographic Data Base. This was an increase of 66 percent over FY 1986. The 119 DLG's completed included 60 boundaries, 15 public land surveys, and 44 hydrography layers. Although the Dorothy, New Jersey project contained extremely dense and complex hydrography layers, the project was completed in time to support a WRD commitment.

- **Census Support** - Completed the evaluation and updating of 839 Bureau of Census Feature Change Maps (FCM's) in support of a cooperative Bureau of Census/U.S. Geological Survey program. This cooperative program began in early FY 1985, has been funded at $100,000 a year by Census, and is scheduled to be completed by mid-FY 1988. Through FY 1987, 2,350 FCM's have been completed with 616 FCM's remaining. These 616 FCM's will be completed by March 1988.

- **Photo Lab Reorganization** - Combined the Custom and Photographic Laboratories into one laboratory to consolidate equipment and personnel, improve supply and maintenance support, and provide better utilization of processing and inspection areas. The consolidation provides for improved cross-training, closer supervision of personnel, and shorter workflows for

some product lines. Space requirements were reduced by 18 percent and redundant equipment was eliminated.

- **NAPP Software Development** - Developed and implemented software for the National Mapping Division to manage the National Aerial Photography Program. The software automates the process of inventorying, inspecting, and monitoring photographs for acceptance under the multi-agency program. In addition, procedures were implemented to provide catalog information to the Department of Agriculture, Aerial Photography Field Office (APFO) in Salt Lake City, Utah.

- **DOD Support** - Substantially increased activities to provide products and analytical services to various organizations within the Defense and Intelligence Community in 1987. Reimbursable revenue to the USGS was roughly $600,000. EDC scientists are working closely with scientists from these various agencies to develop techniques for producing enhanced image products, integrated digital image and cartographic data products, and to implement EDC developed analytical software at several installations. Presented several briefings to various agencies and organizations including the Defense Intelligence Agency (DIA), Defense Mapping Agency (DMA), Central Intelligence Agency (CIA), Naval Space Command, U.S. Army Intelligence agencies, COMIREX, and various other interagency committees. These briefings were in response to a growing desire by these agencies to work cooperatively with the Center, to investigate new imaging systems, data processing techniques, and product development.

- **SCIF Implementation** - Started implementation of a Sensitive Compartmentalized Information Facility (SCIF) to be used for activities concerning exploitation of civil satellite remotely sensed data, digital cartographic data, and geographic information systems for classified DOD and intelligence programs. The facility will be equipped with a secure telecommunication system (funded by other agencies).

- **Beta Test Site Activity** - Participated as the beta test site for 3M's digital color imaging system with the capability to input a digital file to disk, write the digital image onto film or paper in full resolution format, and automatically process hardcopy prints in 8-10 minutes. In addition, participated with Sony Corporation in a beta-test program to evaluate Sony's optical disk system. EDC also was the Beta test site for UNIX-based ARC/INFO GIS software and performed extensive testing of the system

prior to the official software releases. EDC installed the first Beta release of the UNIX ARC/INFO system on a SUN 3/160.

- **Map Product Software Development** - Completed two major software activities in support of improved management of map materials at the Mapping Centers and distribution of associated products; the Map Printing and Publications System (MAPPS) for handling and distribution of maps, text products, and professional publications; and the Map Separates Tracking System (MSTS), providing an automated system for management of cartographic source materials. The systems were installed and training was provided at each of the four Mapping Centers of the National Mapping Division.

- **Image Processing Software Implementation** - Completed several new installations of the Land Analysis System (LAS). Cooperatively developed by the EROS Data Center and the NASA Goddard Space Flight Center, LAS provides a broad range of functional capabilities in the areas of image processing and analysis, tabular data processing and analysis, geographic data input and manipulation, and custom product generation. LAS installations were completed at the EROS Alaska Field Office in Anchorage, Alaska; the Western Mapping Center in Menlo Park, California; and the Defense Intelligence Agency in Washington, D.C. Also, a subset of LAS was installed on a SUN Microsystems workstation in the National Mapping Division's GIS Research Lab in Reston, Virginia.

- **Network Expansion** - Expanded communications networking capability, previously limited to a network of terminals for data inquiry and customer order processing, to allow data file transfers and electronic messaging to a national community of scientific institutions and research specialists. Connections were established to access NASA's Space Physics Analysis Network (SPAN), implementation of a ground line and satellite link to access the USGS Geonet network was completed, and the EDC is installing a communications engine to access the new NASA Science Internet (NSINET).

- **Image Processing and Enhancement** - Worked cooperatively with the University of Arizona in the development of image enhancement and geometric correction procedures for remote sensing systems. These procedures model the degradations associated with particular sensor systems and deriving correction functions to eliminate the effects of the degradations.

Prior to 1987, procedures were successfully developed for TM and MSS data. In 1987, procedures for AVHRR and SPOT data were implemented.

- **Data Interface and Translation Development** - Developed a flexible "toolbox" solution to the problem of transferring data among different systems that support the handling of vector data. Building data bases for a specific GIS is difficult because the data that are needed have been acquired and compiled for different purposes at different resolutions and projections and have been stored in different data structures and formats. USGS Open-File Report 87-309 documents EDC's experience in vector data structure conversion.

- **Data Standards Development** - Actively participated in the Digital Cartographic Data Standards Task Force (DCDSTF) development of the Federal Geographic Exchange Format (FGEF) produced by the Federal Interagency Committee for Digital Cartography (FICCDC) and the Spatial Data Exchange Standard (SDES) produced by the National Committee for Digital Cartographic Data Standards (NCDCDS). These efforts have been successful and a proposed Spatial Data Transfer Specification is currently under preparation for submittal to the American Cartographer. Expected publication date is January of 1988.

- **CUSMAP Support** - Entered final phase of a cooperative National Mapping Division-Geologic Division research program directed at the development of Geographic Information System (GIS) technology for application in the USGS Conterminous United States and Alaskan Mineral Resource Assessment Programs (CUSMAP and AMRAP). The 5-year program addresses (1) digital compilation of representative geoscience data bases, (2) design and development of specialized spatial data processing techniques, (3) development and implementation of automated interfaces between tabular, vector, and raster subsystems of the GIS, (4) testing and evaluation of the resultant system, and (5) application of quantitative models describing specific types of mineral resource potential within selected CUSMAP quadrangles. The successful implementation of technology developed in this cooperative effort has produced the first examples of GIS-based mineral resource assessments and has resulted in the acceptance and installation of GIS capabilities within GD to meet newly started and planned CUSMAP/AMRAP requirements.

- **Advanced GIS Cooperation with Geologic Division** - Initiated a new

National Mapping Division-Geologic Division cooperative research and development project addressing applications of GIS technology to three-dimensional analysis and restoration of complexly deformed geologic terranes. In this effort, geologists from Geologic Division's Branch of Central Regional Geology and scientists at the EROS Data Center have been compiling a digital geologic data base that encompasses the Proterozoic Belt Basin of the Pacific Northwest. The data base will be used initially to investigate and develop GIS-based techniques to graphically portray two-dimensional cross sections of the deformed basin and then to model the three-dimensional sequence of structural events that contributed to the present-day configuration of the basin. Anticipated results of this project will provide USGS geologists with automated capabilities to analyze and evaluate structurally deformed terranes from data sets that are commonly available from regional geologic studies.

- **Satellite Stereo Elevation Modelling** - Evaluated the spatial accuracy and feature recognition potential of SPOT stereoscopic imagery. Stereoscopic data have been acquired for three areas in Alaska to evaluate SPOT for map revision at 1:63,360 scale. Dr. Edward Mikhail's (Purdue University) unsolicited cooperative research proposal for "Photogrammetric Modeling and Reduction of SPOT Images" was approved and funded in FY 1987. Platform data, control information, and stereoscopic imagery have been provided to facilitate the work proposed for 1988. Work is currently under way to develop the required algorithms. The next step will be the implementation of resulting algorithms on an analytical stereoplotter. SPOT satellite image maps have been produced at a scale of 1:24,000 and 1:50,000.

- **Image Data Mosaicking** - Implemented techniques for mosaicking multiple digital orthophotos for large scale mapping. EDC's expertise in digital mosaicking and enhancement combined with Western Mapping Center's expertise to rectify imagery provides the capabilities to produce the digitally rectified orthophoto. Research will continue over the next two years with emphasis on determining optimum scanning procedures, resampling/restoration techniques, enhancement techniques, and output medium.

- **Chernobyl Radiation Effects Modelling** - Participated under a $20,000 reimbursable agreement in a U.S. Department of Energy study designed to evaluate radiation-induced damage in vegetation adjacent to the damaged Chernobyl nuclear power plant using commercial satellite image data. Eight

scenes of Landsat Thematic Mapper data acquired between April 22, 1986 and May 11, 1987 were computer-processed and enhanced to produce images that showed the extent and magnitude of radiation effects on pine trees within 15 km of the reactor site. The image of May 11, 1987, acquired approximately one year after the accident, showed detectable injury to pine trees up to 5 km west, 2 km north, and 2 km south of the damaged reactor. Interpretations of the timing and extent of vegetation damaged were used to estimate the radiation doses in the area around the power plant and to indirectly derive the dose rates as a function of time during and after the accident.

- **Alaska Land Cover Mapping** - Worked with Office of Geographic and Cartographic Research, Reston, and Geographic Investigations Office, Menlo Park to produce standardized land cover maps for all of Alaska. Land cover classifications derived from Landsat digital data for various State and Federal agencies are being converted to a statewide land cover legend. To date published land cover maps have been printed for the Valdez and Arctic Alaska quadrangles, and the remaining four quadrangles (Fairbanks, Dillingham, Mt. Michelson, and Meade River) are in printing.

- **Federal Land Information Systems Prototype** - Produced example maps/plots of the Silver City 1:100,000-scale quadrangle in New Mexico as part of the demonstration of a prototype Federal Land Information System (FLIS). The maps/plots depict management and legal restrictions, surface administrative units, and task force restrictions. Color separates for a page-size plate showing the potash area in southeastern New Mexico were prepared. The plate shows availability and favorability for locatables and geothermal resources. This effort demonstrates an automated approach which could be applied to future statewide studies. FLIS work in Alaska was completed in FY 1987 and the state-wide regional data base was transferred to the EROS Field Office in Anchorage for operational use.

- **AID Support for Africa** - Developed and tested procedures for using time-series remote sensing for monitoring potential grasshopper problems in the Sahel of Africa. AID funding to the USGS for this effort was $250,000 in FY 1987. The test sites included Mauritania, Senegal, Gambia, Niger, and Chad. Local area coverage (with a 1-km resolution) spectral data from the Advanced Very High Resolution Radiometer (AVHRR) were georeferenced and a vegetation index computed. Composite field sheets were prepared every two weeks for each country throughout the six-month grasshopper

season. Geographic information system techniques were used to design the field sheets to include a variety of geographic data including major administrative boundaries, roads, and population centers. The sheets were transferred to the field within two weeks after the last satellite overpass. The data were used to locate areas where rainfall had occurred in sufficient quantities to start the grasses growing. These are areas of high potential for grasshopper hatches and were used to plan and carry-out aerial spraying and control operations.

- **Africa Famine and Early Warning System Study** - Conducted a repay project for the African Bureau, Agency for International Development that provided technical assistance to the Famine Early Warning System (FEWS) Program. The FEWS provides early warning of famine and other related disasters, especially for Africa. EDC staff conducted a formal assessment of the current FEWS technology and prepared a conceptual framework for implementing a subsequent $12 million, 5-year project that takes full advantage of remote sensing and geographic information system technologies. Also, assistance was provided to the Government of Sudan in preparing a project plan to assess and monitor natural resources. Site visits to Chad, Niger, and Sudan have been completed in support of the FEWS program.

- **Cooperation with People's Republic of China** - Worked cooperatively with the PRC in developing applications of remote sensing to mapping in accordance with the USGS/China Protocol for Scientific and Technical Cooperation in Surveying and Mapping Studies. EDC scientists participated in the third year activities of the five year Protocol during a month long scientific visit to China. During the visit, Chinese scientists successfully demonstrated jointly developed software used for geometric registration and mosaicking of Landsat and SPOT satellite data. EDC scientists also conducted a field survey within the Ningxiang test site in Hunan Province test site. The Ningxiang test site is being used to evaluate results of remote sensing research. A reciprocal visit by the NBSM scientists to EDC is scheduled for early 1988.

- **Soils Mapping Support** - Worked with the Soil Conservation Service in producing a soil attribute data set of over 150 general soil variables which has been reformatted and used in a geographic information system. A series of interpretive maps has been produced for Nebraska, illustrating the benefit of linking the maps to an attribute data set. The SCS is expected to

complete nationwide coverage of the 1:250,000-scale general soil maps in mid-1989.

- **Monitoring Irrigated Lands** - Completed a cooperative project with the Water Resources Division (WRD), Pacific Northwest District, resulting in satellite data being used to determine crop acreages for input to a groundwater model for the Columbia Plateau. WRD is now planning to use thematic mapper data on a periodic basis to assess crop acreages on the Columbia Plateau.

- **Snow Mapping System Development** - Initiated a cooperative investigation with the National Weather Service (NWS) Office of Hydrology (OH) to examine the potential utility of AVHRR data, and ancillary solar/sensor geometry data, for mapping snow. The NWS currently maintains an operational program to map, in near real-time, the areal extent of snow cover over mountainous areas of the western United States using GOES-VISSR data. The satellite derived snow cover area data are provided to NWS forecast centers and cooperating Federal agencies for use in operational water resources management and water resources research programs. The NWS is establishing an enhanced program for mapping snow, and has recently procured a dedicated image processing hardware and software system, which should be installed and operational by May or June 1988. This new system will have the capabilities for processing AVHRR data, as well as GOES data. EDC will provide NWS with near real-time AVHRR data for the enhanced snow mapping program.

- **Hydrologic Dynamics Study** - Completed the James River GIS Project, which was authorized in the Director's GIS Sweepstakes program for 1986, on schedule and is now in the final documentation phase. The project used automated analysis of digital elevation models to quantify hydrologic parameters for the pothole terrain in the North Dakota James River Basin. The USGS Water Resources Division and the Bureau of Reclamation (BOR) used the parameters to estimate the flood potential for the BOR dam at Jamestown. The software will soon be distributed to the Water Resources Division, the Geologic Division, the Bureau of Land Management, the Army Corps of Engineers, and University researchers.

- **26th International Remote Sensing Workshop** - Conducted the twenty-sixth in a series of International Remote Sensing Workshops in the early fall (August 31 - October 2, 1987). Fourteen scientists representing

seven countries (Indonesia, Italy, Japan, Jordan, Pakistan, Switzerland, and Sudan) participated in the five week workshop. The workshop covered principles of remote sensing, fundamentals of aircraft and satellite data acquisition, and data analysis in land cover and geologic studies. Classroom activities using lectures and extensive hands-on exercises were supplemented with field trip sessions. Increased attention in this workshop was given to digital data analysis systems.

This workshop marks the completion of over 14 years of EDC offered International Workshops; to date over 520 international scientists and resource managers, representing over 90 countries, have participated in the EDC International Workshop series.

FUTURE PLANS AND OPPORTUNITIES

- **Data Production** - Future data sales at the EROS Data Center are expected to increase at a rate of approximately 5 to 10 percent a year over the next 5 years. The advent of the NAPP program, with its larger scale photography should stimulate an increase in aerial photography sales. As the Data Center moves into increased digital earth science data activity, the sales of earth science products should increase. An increase in the production of digitally enhanced products for Federal government customers is expected.

- **Cooperative AID Applications** - Agreements with the Agency for International Development (AID) will require continued technical assistance in support of the Famine Early Warning System (FEWS). The EROS Data Center's efforts will concentrate on developing data base guidelines and standards for a multilevel resource data base of Africa. A major effort in Africa was established by AID to develop a Natural Resource Management System. The resource inventory and information management needs of the program will be discussed during a workshop to be held at the EROS Data Center in March 1988. A variety of efforts are planned, such as developing a project paper for implementing a resource based monitoring system in Sudan; conducting a user needs study for producing products from the Advanced Very High Resolution Radiometer (AVHRR) data on the NOAA satellite for AGRHYMET in Niamey, Niger; training AID staff in the use of remote sensing for Chad resource monitoring; and conducting an evaluation workshop in Dakar, Senegal, on using remote sensing in African grasshopper control programs. In addition, EDC will begin to prepare up to 45 image

maps from thematic mapper and AVHRR data for the central portion of Sudan. The maps will range in scale from 1:250,000 to 1:2,500,000, and will be prepared jointly with the Sudan Department of Surveys and the Regional Centre for Services in Surveying, Mapping, and Remote Sensing in Nairobi, Kenya. Overall AID funding to the USGS in support of this effort should approach $1 million in FY 1988.

- **DOD Support** - Reimbursable revenue to the USGS from support of certain DOD and Intelligence agencies should approach $1 million in FY 1988.

- **Future NASA Space Station Cooperation** - Preliminary meetings have been held with NASA Headquarters and GSFC regarding USGS EROS Data Center responsibility for processing, archiving, and distributing future Earth Observing System (EOS) land or terrestrial data from the Space Station polar platform. NASA is currently wrapping up Phase A study activities and hopes for an EOS new start in FY 1991 and launch of the first EOS platform in late 1995. The major U.S. land sensors planned are MODIS (Moderate Resolution Imaging Spectrometer), HIRIS (High Resolution Imaging Spectrometer), and SAR (Synthetic Aperture Radar). These sensors will provide very high data rates and large volumes of land remote sensing data and will require extensive processing and archiving capabilities. NASA plans to release two 15-month studies ($1.5 to 2.0 million each) by the end of FY 1988 to develop conceptual design and cost estimates for the EOS Data and Information System (DIS).

- **Earth Science Data Distribution** - EDC's activity in the archiving, reproduction, and distribution of earth science data should increase significantly over the next several years. Currently the National Uranium Resource Evaluation (NURE) data are archived and distributed by the Data Center, and negotiations are currently underway to place digital earth science data from the Geologic Division's Rock Analysis Storage System (RASS), the Water Resource Division's Regional Aquifer System Analysis (RASA) data base, and the Geological Long Range Inclined Asdic (GLORIA) data set at EDC. Plans call for the development of a variety of both standard and custom products derived from these data sets.

- **Alaska Natural Wildlife Refuge GIS Work** - The Geologic Division, the Water Resources Division, and the NMD will commence work in 1988 on developing a GIS data base for the Coastal Plain portion of the Arctic

National Wildlife Refuge referred to as the 1002-Area. The Branch of Alaskan Geology has identified approximately 12 data layers of geologic and geophysical data to be digitized and converted to the GIS. The Water Resources Division has identified approximately six data layers of hydrologic data to be entered into the GIS. USGS/EROS Alaska Field Office staff are providing coordination between Federal agencies to update land status and are working within the National Mapping Division to acquire digital elevation model, hydrologic (stream network and lakes), and boundary data from 47 1:63,360-scale maps that cover the 1002-Area and adjacent watersheds.

- **Continued Image Processing Software Development** - The EROS Data Center will continue cooperative development of the Land Analysis System (LAS) with NASA's Goddard Space Flight Center and the Jet Propulsion Laboratory, various Department of Defense installations, and several academic institutions. New developments are underway to insure transportability of LAS under both the VAX/VMS and UNIX operating systems. The Data Center is also investigating the feasibility of porting a version of LAS to PRIME computers under the PRIMOS operating system. New installations of LAS are planned for the Army Engineer Topographic Laboratory and the Defense Mapping Agency, with associated agreements for cooperative research and development activities.

- **Global Change Initiatives** - Remote sensing and GIS capabilities and expertise at EDC comprise a basis upon which important contributions to global change programs could be developed. The cooperation with NASA in processing and archiving EOS land data is one example of an important role EDC could assume in the area of global change. Other possible activities that would expand EDC's role in global change include direct reception of foreign satellite data, implementation of the National Satellite Land Remote Sensing Data Archive and Cooperative Federal Land Remote Sensing Research programs, development of digital and image data products to meet the needs of global science programs, and participation in the development of advanced data systems and networks.

- **Digital Cartography and Mark II** - Activities in support of NMD product generation and distribution should continue to grow as the quantity of available digital cartographic data increases in the years ahead. Center support of the development and implementation of Mark II and Advanced Cartographic Systems (ACS) should also increase in the areas of derivative

and custom products and product distribution. Limited digital data production will continue at the Center as will the production of diapositives, NCIC support, image and special thematic mapping, GIS R&D, software development, and the development of cartographic applications of remote sensing data.