

cmc (vnmnc) file

(prepared for
5th vnmnc,
for Byrne)

THE EARTH RESOURCES OBSERVATION SYSTEMS OFFICE

AN

OVERVIEW

Introduction

The U.S. Geological Survey's Earth Resources Observation Systems (EROS) Office was established in 1966 by order of the Secretary of the Interior. The mission of the EROS Office is to support the Department's natural resource inventory, monitoring, and management responsibilities through the application of remotely sensed data.

Department of the Interior interest in remote sensing originated primarily from two U.S. Geological Survey activities. First was the longstanding use of aerial photography and related reconnaissance data, especially for mapping purposes. The second activity involved the participation of USGS geologists in assisting the National Aeronautics and Space Administration (NASA) in using remotely sensed data to determine the physical properties of the Moon's surface in preparation for planned Apollo mission landings. USGS scientists, realizing the potential benefits of distant, synoptic views of the Earth, were among the first members of America's scientific community to press for the launch of civilian, Earth-surface observation satellites. U.S. Geological Survey initiatives, under the leadership of Director William T. Pecora, greatly influenced NASA's development of the Landsat Program, which officially began in 1969.

The primary functions of the EROS Office fall into two major categories. One includes research, development, and training for the Department in the application of remotely sensed data. The EROS Office contributes significantly to the research literature in the field of remote sensing as demonstrated by the more than 50 reports prepared for publication during the first half of CY 1982 and highlighted by the preparation of chapters on geology, hydrology, forestry, range management and digital cartography for the American Society of Photogrammetry's Manual of Remote Sensing. The other function involves processing, storage, reproduction, and distribution of remotely sensed data for Department of the Interior users, other government agencies, and the general public. EROS archives consist of 1.7 million worldwide Landsat scenes on film and computer tape and five million aerial photographs of primarily U.S. sites. Computer technology is vital to nearly every aspect of EROS work, such as processing incoming Landsat MSS digital data, tracking each of the 100,000 annual orders for individual data products, and enhancing and analyzing data for various applications.

Headquarters for the EROS Office is located in Reston, Virginia. Data handling and primary research facilities are at the EROS Data Center (EDC), near Sioux Falls, South Dakota. An EROS Field Office is operated in Anchorage, Alaska. Approximately 90 civil servants and 300 contract personnel carry out the EROS Office mission.

In FY 1982, approximately one-third of the EROS Office operating budget of \$18 million is derived from data sales and scientific or training services. In FY 1983, it is estimated that nearly one-half of the EROS operating budget will be derived from reimbursable receipts. Details of EROS Office funding are provided on the following page.

EROS OFFICE FUNDING

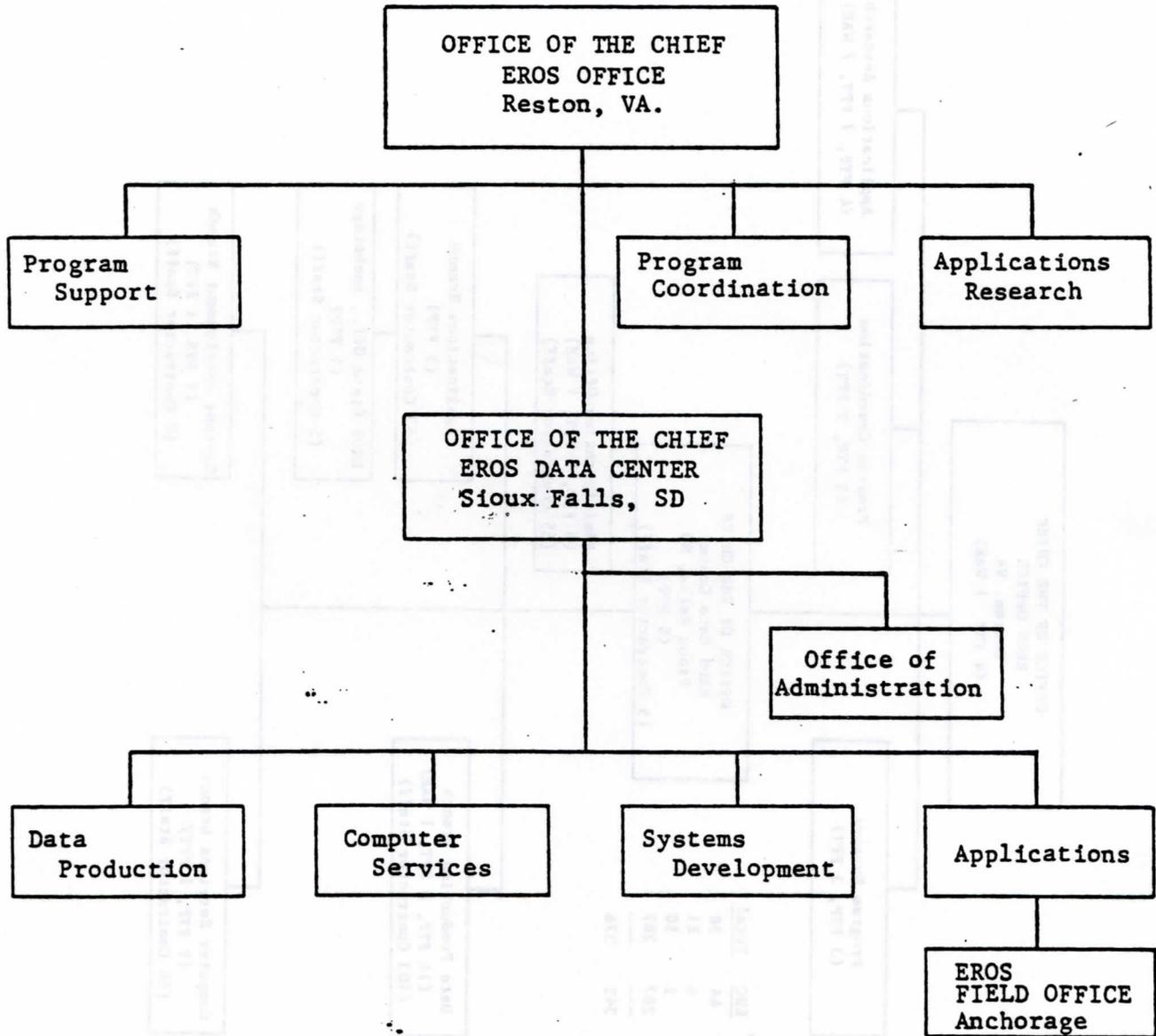
<u>FUNDS AVAILABLE</u>	<u>FY 1982</u>	<u>FY 1983</u>
SIR Appropriation	11,904,000	9,490,000
Non-Federal Sales	3,350,000	1,650,000
Federal Sales	600,000	300,000
Survey Sales	700,000	350,000
Training	130,000	140,000
NCIC	600,000	600,000
NOAA	700,000	4,770,000
Cooperative Projects and Analytical Services		
OESA-SLAR	110,000	
NASA-Pre-EDIPS Microfilming	30,000	
NASA-Magsat Project	20,000	
NASA-Iceland Volcanoes	40,000	
NASA-Europa	7,000	
BIA/BLM/COE-RIPS Procurement	75,000	
IDS Software Support	160,000	
BLM-Vegetation/Terrain Mapping	30,000	
BIA-Range Condition and Trend	30,000	
BIA-Irrigated Lands Inventory	40,000	
COE-Spatial Variation in Digital Terrain Data	15,000	240,000
Alaska Field Office Activities	105,000	
Misc. Analytical Services	10,000	
TOTAL	\$18,656,000	\$17,540,000

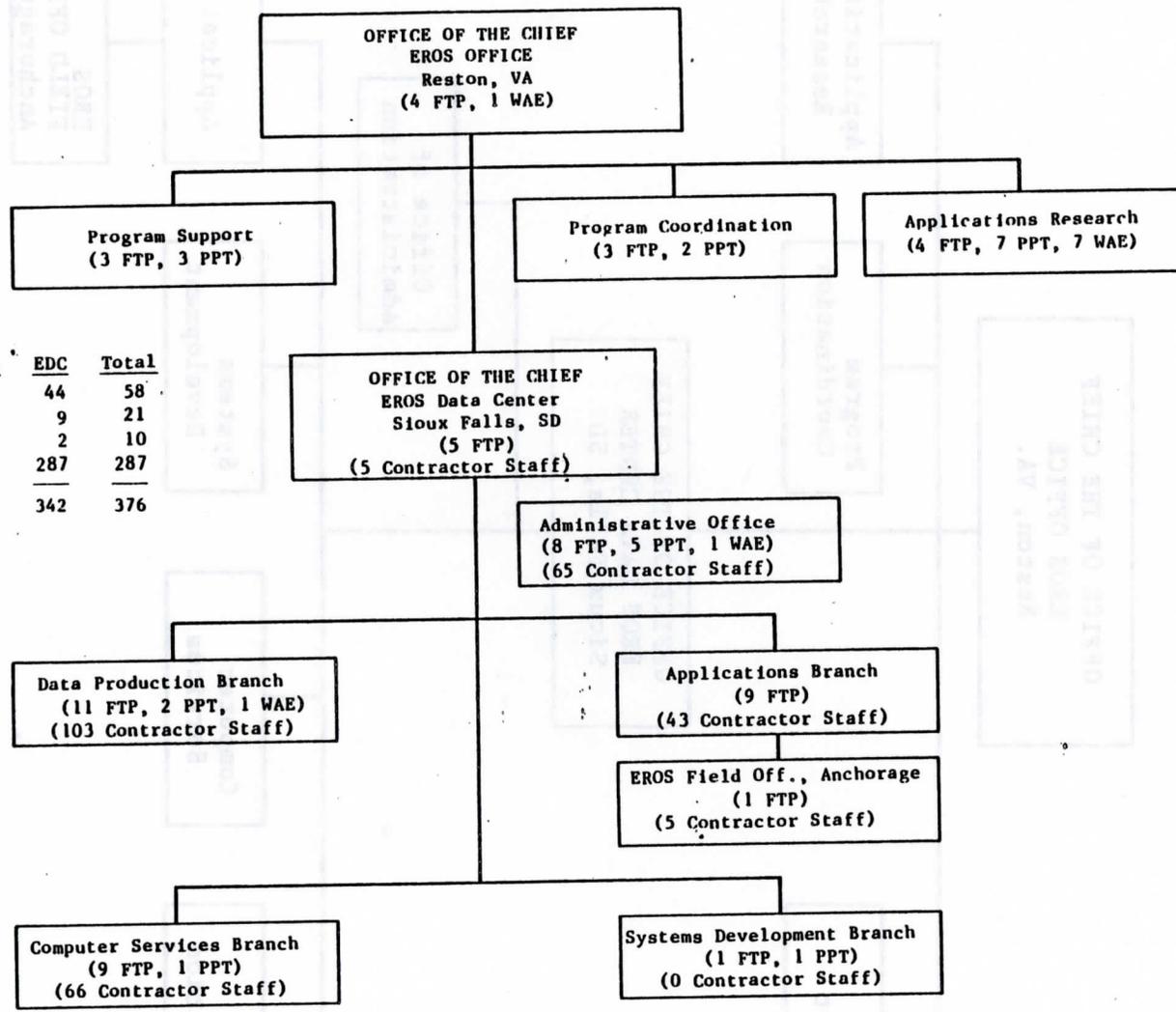
Headquarters for the EROS Office is located in Reston, Virginia. Data handling and primary research facilities are at the EROS Data Center (EDC), near Sioux Falls, South Dakota. An EROS Field Office is operated in Anchorage, Alaska. Approximately 90 civil servants and 300 contract personnel carry out the EROS Office mission.

In FY 1983, approximately one-third of the EROS Office operating budget of \$18 million is derived from data sales and scientific or training services. In FY 1982, it is estimated that nearly one-half of the EROS operating budget will be derived from reimbursable receipts. Details of EROS Office funding are provided on the following page.

Organization

Organizational structure of the EROS Office is provided on the following diagram.





	<u>Reston</u>	<u>EDC</u>	<u>Total</u>
FTP	14	44	58
PPT	12	9	21
WAE	8	2	10
Contractor	0	287	287
Total	34	342	376

**Earth Resources Observation Systems (EROS)
Office of the Chief**

Chief, EROS Office SES	J. Salisbury
Deputy Chief, EROS Office GM-15-1301	W. Rohde
Secretary (Steno) GS-7-0318	H. Seal
Secretary (Typing) GS-6-0318	D. Campbell

Program Support

Physical Scientist GM-13-1301	J. Jones
Physical Scientist GM-13-1301	C. Hall
Administrative Officer GS-9-0341	T. Tillette
Visual Info. Specialist GS-11-1084	R. Hansell (PPT)
Information Assistant GS-7-0303	H. Bowman (PPT)
Secretary (Typing) GS-5-0318	A. Kulyk (PPT)

Program Coordination

Computer Specialist GM-15	O. Kays
Remote Sensing Specialist (Biosciences) GS-14-1301	L. Pettinger
Remote Sensing Specialist (Geosciences) GS-14-1301	D. Black
Secretary (Typing) GS-6-0318	A. Gallihugh (PPT)
Secretary (Typing) GS-5-0318	N. Sherman (PPT)

Applications Research

Geologist GS-15-1350	R. Williams
Geographer GS-13-0150	D. Peuquet
Physical Science Tech. GS-8-1311	S. Southworth
Geographer GS-13-0150	K. Fitzpatrick- Lins (PPT)
Geologist GS-11-1350	J. Ferrigno (PPT)
Geologist GS-7-1350	T. Kent (PPT)
Secretary (Typing) GS-6-0318	B. Powell (PPT)
Secretary (Typing) GS-6-0318	L. Candler (PPT)
Physical Scientist GS-15-1301	W. Hemphill
Remote Sensing Spec. GS-11-1301	A. Thiesen* (PPT)
Physical Scientist Tech. GS-4-1311	N. Tinnin* (PPT)

When Actually Employed (WAE)

Physical Scientist GS-15-1301	D. Carter	Computer Programmer GS-9-0334	L. Kikuchi ^o
Geographer GS-14-0150	R. Wittick	Computer Programmer GS-7-0334	C. Goettsche
Remote Sensing Specialist GS-12-1301	R. Tyson	Computer Clerk GS-4-0335	C. Heath
Physical Scientist GS-12-1301	A. Walker	Clerk-Typist (Summer) GS-2-0322	D. Saxman

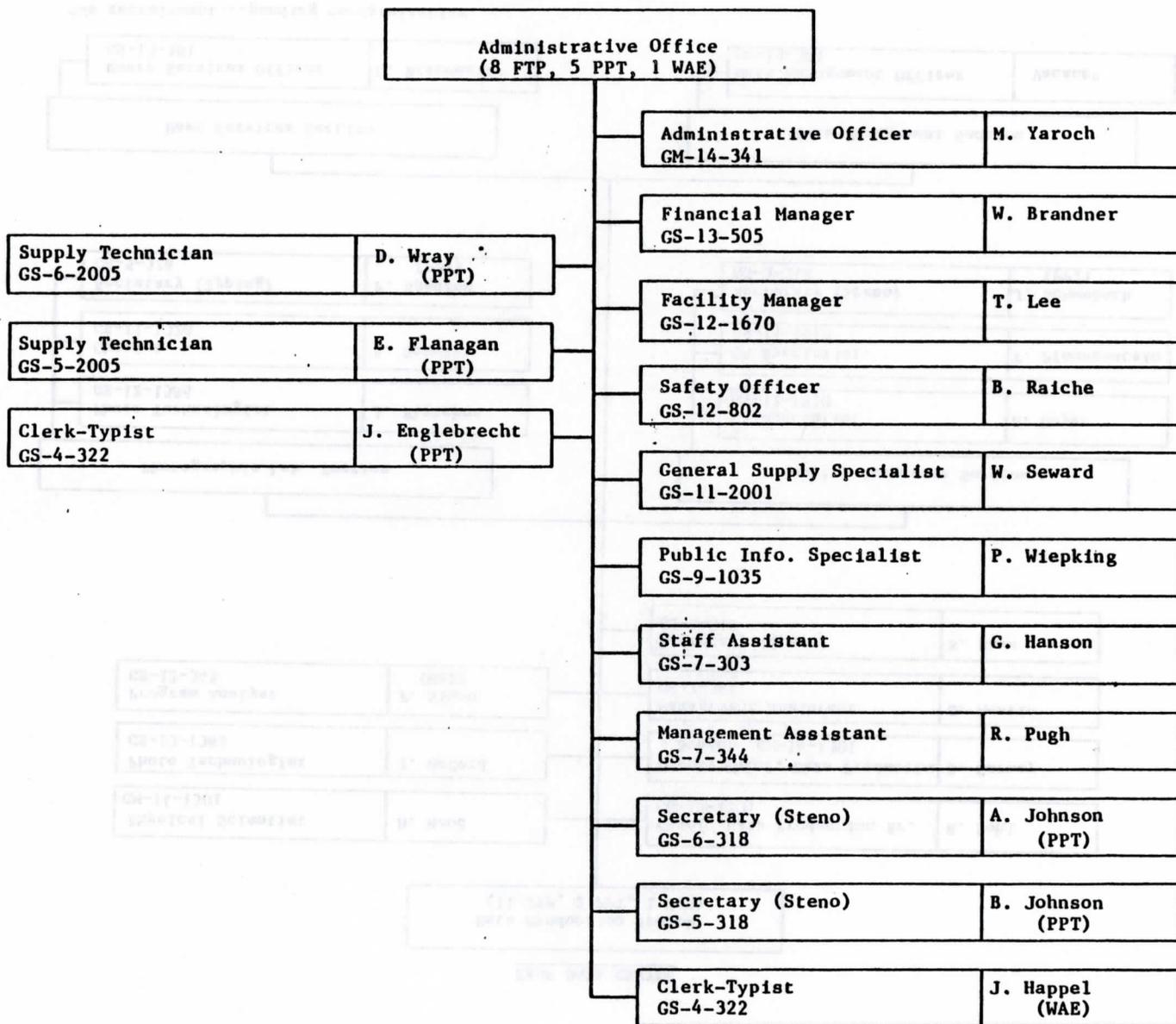
*Located at Flagstaff

EROS DATA CENTER

**Office of the Chief
(5 FTP)**

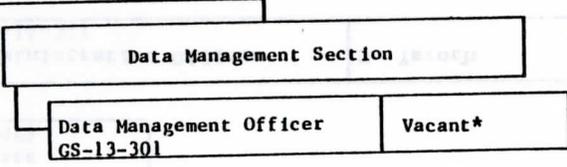
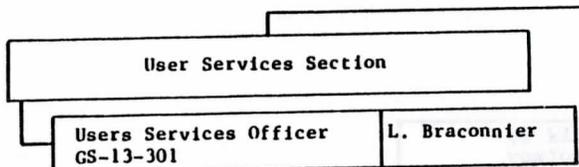
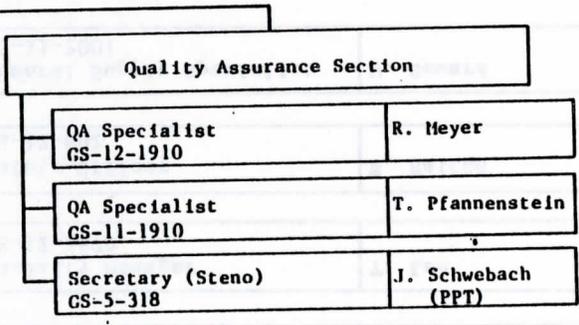
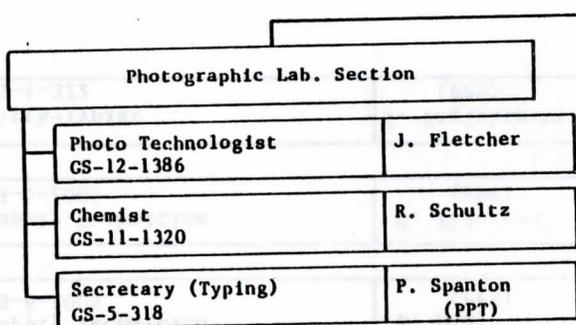
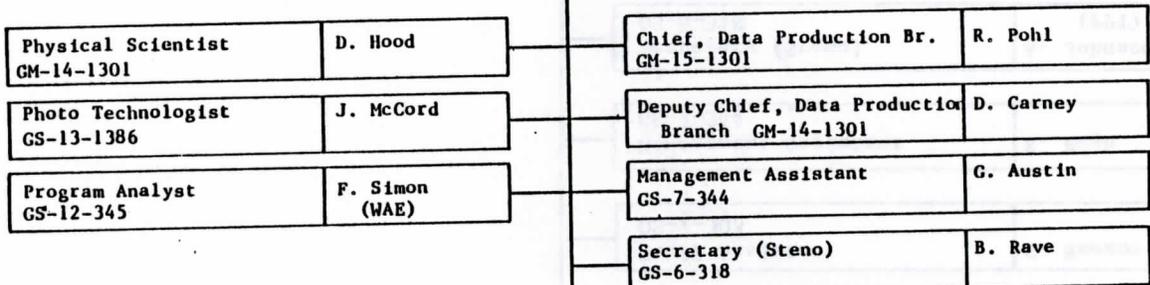
Chief, EDC SES	A. Watkins
Deputy Chief, EDC GM-15-1301	G. Landis
Public Information Officer GS-13-1035	Vacant
Secretary (Steno) GS-7-318	J. Schriever
Secretary (Steno) GS-7-318	R. Tornow

EROS DATA CENTER



EROS DATA CENTER

**Data Production Branch
(11 FTP, 2 PPT, 1 WAE)**



*No recruitment...pending reorganization

EROS DATA CENTER

Applications Branch
(10 FTP)

Chief, Applications Branch
GM-15-1301

D. Lauer

Deputy Chief, Applications Branch
GM-14-1301

D. Orr

Secretary (Steno)
GS-6-318

C. Johnson

USGS/EROS Field Office, Anchorage, Alaska

Chief, USGS/EROS Field Office
GM-14-401

D. Carnegie

Geoscience Applications Section

Chief, Geo. Appl. Section
GS-14-1301

G. Moore

Remote Sensing Scientist
GS-14-1301

B. Bailey

Bioscience Applications Section

Chief, Bio. Appl. Section
GS-14-1301

D. Moore

Data Analysis Laboratory

Chief, Data Analysis Section
GS-14-1301

S. Doescher

Remote Sensing Scientist
GS-13-1301

D. Greenlee

Training and Assistance Section

Chief, Training and Assistance Sect.
GS-14-1301

W. Draeger

EROS DATA CENTER

Systems Development Branch
(1 FTP, 1 PPT)

Chief, Systems Development
Branch GM-15-1301

G. Metz

Secretary (Steno)
GS-5-318

Vacant
(PPT)

EROS DATA CENTER

**Computer Services Branch
(9 FTP, 1 PPT)**

Systems Engineer
GS-13-801 **J. Boyd**

Computer Specialist
GS-13-1550 **S. Paulson**

Computer Specialist
GS-13-334 **Vacant**

Clerk-Typist
GS-4-318 **K. Jones
(PPT)**

Chief, Comp. Serv. Branch
GM-15-330 **R. Thompson**

**Deputy Chief, Comp. Serv.
Branch** GM-14-334 **R. Parsons**

Systems Analyst
GS-13-334 **B. Lowell**

Secretary (Steno)
GS-6-318 **M. East**

Software Section

Computer Systems Analyst
GS-12-334 **J. Thormodsgard**

Operations Section

Computer Specialist
GS-13-334 **E. Constant**

Multiple Data Sets Applications Research and Development

In recent years, the utility of image-type remotely sensed data has been greatly enhanced through digital merging with other available forms of Earth data, such as elevation, aeromagnetism, and soils. Merging spatial, geophysical, or geochemical data sets with Landsat and aircraft data has not only presented promise, but also challenges. For example, many data sets must be converted to digital form before being registered to Landsat data in a computer. Recent EROS activities and projects have dealt with developing necessary techniques for handling and processing large disparate digital data sets.

Hydrologic Information System. Multiple spatial data sets have been compiled into a hydrologic information system for the Black Hills, South Dakota. This work is being done in cooperation with the South Dakota District Office, USGS Water Resources Division. The data sets include Landsat scenes, digital topography, land cover, geology, drainage lines and divides, and precipitation and streamflow indices. Data set formatting and parameter evaluation are completed. Research on the calculation of surface drainage areas and the automated delineation of drainage lines from digital topographic data is underway.

Landsat Applications for Soil/Vegetation Inventory. An inventory of soil and vegetation resources has been mandated by Congress for approximately 100 million hectares of arid and semi-arid lands of the western U.S. Costs of this activity are becoming a serious problem to the Bureau of Land Management (BLM). A digital data base was assembled for the Grass Creek Resource Area (594,000 hectares), Worland District, in northcentral Wyoming. Landsat multispectral scanner data, soils boundaries, digital terrain data, and digitized administrative boundaries were registered to a common 50-meter Universal Transverse Mercator grid base. Preliminary field evaluation of project results indicated: the digital data base concept for mapping ecologically significant soil/vegetation landscapes is valid; misclassification of vegetation did not adversely affect study area delineation; and maps of ecologically important soil/vegetation landscapes can be produced for less than 20 cents per hectare (8 cents per acre). The resulting digital data base also forms an important information source for post-inventory land management activities.

Determination of Irrigation Potential. In cooperation with the Bureau of Indian Affairs (BIA), a multiple digital data base for the Lower Brule and Crow Creek Indian Reservations in South Dakota was developed to determine irrigation potential of the reservations lands and to assist in meeting other resource management needs of the BIA. A multiple data base was made using NMD's digital terrain and digital line graph data, and digital soils, ground water, road network, and ownership boundary maps. Crop water use, energy needs, and energy costs were calculated and entered into the data base. An irrigation model was developed which allowed manipulation of the data with a variety of parameter restrictions to determine irrigability under several sets of conditions. Results of the project were maps showing irrigation potential and other types of resource information useful for management decisions by the BIA. These results are currently being evaluated by BIA personnel and a follow-on effort has been proposed for the Fort Berthold Indian Reservation in North Dakota.

Use of NOAA Data for Wildfire Applications. Polar Orbiter Satellite data are being acquired weekly for portions of Arizona and Idaho through a cooperative arrangement with the National Oceanic and Atmospheric Administration (NOAA). Digital data are being used to estimate standing green biomass within previously mapped wildfire fuels types to determine the date of curing. These inputs are used to determine when and

where dried vegetation exists as a fuel load to wildfires. Individual bands, band ratios, and transforms sensitive to vegetation are being investigated. The fuel-load estimate from NOAA data will be used together with climate data, lightning occurrences, and fuel types to implement the Initial Attack Wildfire System for the million hectares (180-million acres) of BLM lands. These estimates (high, medium, low) will then be incorporated as part of the BLM program for determining where lightning-caused fires are likely to occur. Feasibility of the technique will be evaluated during FY 1982 and, if successful, follow-on investigations in the western U.S. will be conducted during FY 1983.

Mineral Resource Assessment with Digital Geologic Data Bases. A geologic data base for the southern half of the Nabesna Quadrangle, Alaska, was developed to demonstrate the utility of digital processing techniques applied to mineral resource assessment investigations. A spatial analysis model for evaluating porphyry-type copper potential was developed to analyze the digital geologic data base consisting of 16 original data types and 18 derived data sets. Landsat MSS data, digital topographic data, and regional geochemical, geophysical, and geologic data from the Alaska Mineral Resources Assessment Program (AMRAP) were the primary data types used. All data were geometrically rectified and transformed to a 50-meter Universal Transverse Mercator coordinate grid reference. Model parameters were quantified with arithmetic and statistical integration of multivariate data sets. The resultant model has ten parameters which identified three areas of significant porphyry copper potential, two of which are known occurrences. The third, a previously unknown area, was identified as having high potential. Field studies conducted in August 1981 confirmed the results of the geologic model and a comprehensive report on the project is being prepared for publication during FY 1982.

Satellite Glaciology. Satellite Glaciology is a new field of research made possible by data acquired by near-polar-orbiting Earth resources satellites. Data from such satellites permit periodic monitoring of the size and movement of glaciers and of the margins of ice sheets and ice caps. A U.S. Geological Survey Professional Paper, "Satellite Image Atlas of Glaciers," involving 60 U.S. and foreign glaciologists and other scientists, is scheduled for completion in 1983. Current radar altimetry data permit the acquisition of ice surface elevation information. A prototype Landsat image mosaic map of the Amery Ice Shelf, East Antarctica, in which Landsat images are combined with 1- and 5-m contour intervals from Seasat radar altimetry data, will be available in manuscript form by late 1982. The combination of ice area, ice surface elevation, and depth-to-bedrock data (the latter obtained by surface or airborne radio-echosounding techniques) allows calculation of ice volume.

International Cooperation in Fuels Exploration. The signing, by the USGS and the People's Republic of China, of Annex 1 to the Protocol for Scientific and Technological Exchange in the Earth Sciences has formally initiated Project 2A, Application of Remote Sensing Techniques to Petroleum Exploration. Geologists from EROS and from the Scientific Research Institute for Petroleum Exploration and Development of China's Ministry of Petroleum Industry are completing a geologic interpretation of Landsat images for the entire Chaidamu Basin of western China. In addition, they are digitally processing Landsat data from selected areas within the basin to define those techniques which permit interpretation of maximum amounts of geologic information. Chinese scientists will visit the United States for two months during the summer of 1982, and the two groups will jointly review and evaluate the work done to date. Plans will be made to develop a data base consisting of Landsat, geophysical, and geologic data to evaluate the petroleum potential of the Chaidamu Basin.

Renewable Resource Assessment, Alaska. The U.S. Forest Service has worked cooperatively with personnel from the EROS Field Office in Anchorage to develop sampling techniques for inventory of vegetation resources in Alaska. EROS staff members have assisted the Forest Service in demonstrating that digital land cover classifications from Landsat MSS data reduce sampling error when combined with sampling of vegetation type from high- and low-altitude aerial photographs and ground sample plots. Preliminary results from Landsat land cover classifications of 130 square hectometer sample plots coinciding with grid intersections spaced every 5,000 meters in the Susitna River Basin were favorable, thereby setting the stage for an operational test of methodologies in the western half of the Tanana River Basin during FY 1982. Land cover for this region will be classified from Landsat MSS data, and sample blocks measuring 8 square hectometers corresponding to the intersections of a 5,000 meter grid, will be extracted from the classified images. The results will be merged with terrain data to refine classification accuracy and then incorporated with data from three other phases of sampling to make inventory estimates of resources. The data collected will be used by the Forest Service for the National Resource Inventory.

Classification of Land Cover and Terrain, Kenai National Wildlife Refuge. Landsat MSS data acquired in August 1980 were used to classify over 1 million square hectometers of land cover within the Kenai National Wildlife Refuge. Digital terrain data were acquired for the project area and registered to the Landsat data. These terrain data were then used to calculate the elevation, slope, and aspect corresponding to each Landsat picture element. The land cover and terrain data, along with surficial geology data, were combined within a multiple data base to produce resource maps from each data type and from combinations of each data type. This digital data base was produced for the U.S. Fish and Wildlife Service (USF&WS) as a cooperative project by the EROS Office and the National Mapping Division. The resource maps are being used by the USF&WS for comprehensive planning for the refuge as mandated by the Alaska National Interest Lands Conservation Act, 1980. Of particular importance to the USF&WS are the water cover and habitat maps produced from combinations of vegetation cover types and terrain variables. In addition, the Alaska Department of Natural Resources is using the land cover data to produce vegetation maps for their resource assessment program (ADNR). The completed multiple data base will be transferred from EROS to the USF&WS for further manipulation on their own computer systems.

Land Cover and Terrain Mapping, Bristol Bay, Alaska, Subregion. Personnel from the ADNR and the USF&WS have used the computer analysis equipment of the EROS Field Office to produce land cover and terrain maps of the Bristol Bay Subregion, an area of approximately 12 million square hectometers including all or portions of the Togiak, Izembek, Alaska Peninsula, and Becharof National Wildlife Refuges. The land cover maps were produced from geometrically corrected Landsat data that have been reformatted for the 19 USGS quadrangles (1:250,000-scale) covering the area. Digital terrain data from the quadrangles were registered to the Landsat data to produce elevation, slope, and aspect maps. The elevation and slope data, together with winter Landsat scenes, were used to improve classification accuracy of the land cover maps. The winter Landsat scenes were extremely valuable for clearly separating wetland from conifer cover types. The land cover maps were produced at a scale of 1:250,000 and used by ADNR and USF&WS in preparing a comprehensive plan for the subregion, also mandated by the Alaska National Interest Lands Conservation Act. The digital data base, comprised of the land cover and terrain data, was transferred to the Alaska Department of Natural Resources for further manipulation and production of habitat maps.

New Sensor Evaluation

Evaluation of Thematic Mapper (TM) Simulator Data. Studies are being conducted to improve discrimination of sedimentary rocks and detection of surficial effects related to gas and oil occurrences in the Uinta and Piceance sedimentary basins of northeastern Utah and northwestern Colorado. Initial results show that Landsat Multispectral Scanner (MSS) and TM data, acquired by NASA's National Space Technology Laboratories over selected areas in the region, can be digitally processed to significantly improve the interpretation of image products. Ground and aerial measurement of spectral reflectance between .40 and 2.50 micrometers at more than 200 sites within the study area are being used to help design optimal digital processing approaches as well as to calibrate TM simulator data. Landsat MSS and TM simulator data have been registered to a Universal Transverse Mercator map base and will be used with topographic, aeromagnetic, gravity, and geochemical data to develop and evaluate models and techniques for applying multiple data sets to define exploration target areas which have a high potential for the occurrence of petroleum. Results of this study will be reported in FY 1983.

Analysis of Landsat D TM Near-Infrared Response. Beach sands on the east coast of Florida change in composition from primarily quartz to primarily carbonate over a distance of less than 100 miles. These beaches provide essentially monomineralic strips of known size and composition against which to test TM system response in the near-infrared, since carbonates have strong absorption bands and quartz does not. This effort is part of a cooperative program with Geologic Division (for similar spectral response studies) and NMD (for geometric accuracy studies). Complementary laboratory analysis of spectra of soils is also underway to better define the background against which efforts will be made to discriminate different rock and mineral types.

Landsat D MSS/TM Geometric Accuracy Investigation. Experiments with Landsat D MSS and TM data are designed to verify processing system throughput, accuracy, and compatibility necessary to meet expected requirements for generation of user-oriented digital and film products.

Research on Data from NASA'S Magsat. NASA's Magsat has provided the first high quality worldwide geomagnetic data set. These data are being used with information on known mineral resources to improve our understanding of their origin and distribution, which could ultimately be useful in improving our ability to analyze the regional mineral potential of large areas. A preliminary analysis of global magnetic anomalies in selected areas in west Africa and South America has been made as part of a research project being conducted for NASA.

Luminescence Studies. An airborne Fraunhofer line discriminator (FLD) permits imaging of materials on the Earth's surface which have been stimulated to luminesce by the Sun. This technique is several times more sensitive than the human eye, and it is the first viable airborne method for discriminating luminescent materials without the use of range-limited artificial sources such as lasers and flash lamps. The FLD has been used experimentally by the USGS to measure the areal extent and film thickness of marine oil seeps, and to image the distribution of mineral outcrops and impact-shocked rocks. Some materials, such as sedimentary phosphate rock and some uranium minerals commonly exhibit inherent luminescence, and an FLD with improved spatial resolution could have applications in mineral resource exploration. Industrial and residential pollutants also commonly exhibit inherent luminescence; experimental work suggests direct application to the Survey's toxic waste disposal monitoring program, and to the Bureau of Reclamation's reservoir assessment program.

Side-Looking Airborne Radar (SLAR) Project. This effort, begun in 1980, has resulted in the acquisition and entry in the public domain (at EDC) of over 200,000 square miles of SLAR data in Alaska. Because of overlap, these data actually cover a 60,000 square mile area. Research using these data to define the geologic, hydrologic and cartographic applications of the SLAR technology were published as Open-File Report No. 81-1358 in December, 1981. In addition, the Survey is currently involved in negotiations with two potential vendors for data acquisition for six project areas within the contiguous U.S. and Alaska. It is anticipated that this contract will be awarded by the end of July and that acquisition will begin in August of this year. Survey scientists have defined 12 projects to utilize these data and preliminary work on these studies has begun.

Data Processing and Technical Development

Multispectral Classification Procedures. A new procedure, AMOEBA, to cluster and classify Landsat MSS data using their spatial as well as spectral properties has been developed. The procedure locates spatially and spectrally homogeneous areas in an image and calculates cluster centers within these areas. Arbitrary parameters such as location and size of training sets or number of land cover clusters need not be specified by the analyst. The result of the AMOEBA algorithm is a classification of land cover based on both multispectral reflectance and image texture (the spatial variability of reflectance). Tests of the AMOEBA algorithm have shown that the resulting land cover classification can be obtained faster than with most other algorithms and with an accuracy that is comparable to other methods. The AMOEBA algorithm is more efficient than other methods because it does not require a trial-and-error approach to the relationships of image characteristics and cover classes. Work will continue on demonstrating the use of the AMOEBA algorithm in the context of application projects.

Digital Image Mosaicking. As more and better techniques for analyzing Landsat data emerge, larger areas are being incorporated into projects to take advantage of the synoptic coverage characteristics of Landsat. As these larger areas are defined, the requirement for mosaicked digital images covering these areas increases in importance. Also, users require smaller areas that cross individual Landsat scene boundaries. With multi-scene digital mosaicking capability, the area of interest can be selected regardless of scene boundaries. These requirements stimulated development of a contract to install Landsat mosaicking-support software on EDC systems by staff members of the Jet Propulsion Lab. These mosaicking techniques are being installed on EDC systems beginning in 1982, with capability for large mosaics (such as 6 x 6 image-blocks) by early 1983.

Geometric Registration. Increasing use of Landsat data for resource investigations has prompted user demand for such data to be registered to a map base and/or to other Landsat scenes. A system for registering Landsat image data to a map base has been designed and implemented. Testing and the first production requirement have been completed. The initial product set includes three scenes over each of three BLM test sites. BLM indicated that the data were entirely satisfactory and well within accuracy specifications. A second test product of this registration project demonstrates capabilities under development to mosaic small areas of raster (image) data and extract a specified area of interest. Portions of four Landsat scenes covering the Las Vegas 1:250,000 quad map were registered to the map base utilizing the EDC Geometric Registration System. These scenes were then processed through the Generalized Image Processing System to digitally mosaic the data and extract a quad area of interest. The resulting data were color-composited and processed to the appropriate scale by the EDC Custom Photographic Lab. A second phase of the geometric registration project is nearing

completion with the development of software to automatically register temporal Landsat images to each other. Software is also being developed to register digital elevation model and digital line graph data with Landsat data in map quadrangle areas.

Digital Elevation Model/Digital Line Graph (DEM/DLG) Data Processing. Digital topographic data have been increasingly incorporated in digital data bases. Software and procedures were developed to perform custom processing and a system is being developed to support processing of digital elevation model data from the Defense Mapping Agency (DMA) at a scale of 1:250,000 as well as NMD-generated digital elevation model data at a scale of 1:24,000. Key software elements were installed to mosaic quadrangles and to resample the mosaicked data to change the projection and/or the pixel size. Users are made aware of data availability through maintenance of a set of index maps by EDC User Services Section as well as by a procedure for specifying the required product and submitting orders that can be processed and distributed to the user. Use of DLG data is also facilitated by software currently being developed to extract from and/or mosaic available data into a data set covering a project area of interest. Initial developments have concentrated on the processing and use of DLG data from the 1:2,000,000- and the 1:24,000-scale DLG data generated by the National Mapping Division.

Production, Digitizing, and Editing. To develop the required system for digitizing soils, geologic, and other types of map-based data for EROS projects, a coordinated program of hardware and software procurement as well as in-house development of new software has begun. Equipment purchases resulted in installation of a stand-alone Altek digitizer to collect the data, and an M&S interactive system to be utilized as a data-editing station. Editing of topological data will be accomplished by software packages procured and installed on EDC computers. This software will also support analysis and manipulation of the edited data for integration into specific projects. Further contract support is being procured for assistance in the design of the system. In-house software development will be required to interface the acquired software packages and to add routines for converting data files in internal disk format to or from other format types, such as the NMD DLG format.

Format Conversion Software Development. Three software functions have been implemented on the Interactive Digital Image Manipulation System (IDIMS) which converts computer classifications to polygonal formats. Using this technique, ground cover classes can be plotted as polygons, and cartographic generalization can be effected. This technique provides an important bridge from image processing of raster data to spatial analysis techniques employing vector (line) representations. These activities build on and reinforce the production of DEM's and DLG's by the Survey's National Mapping Division, geophysical data by the Survey's Geologic Division (Branch of Regional Geophysics), and atmospheric data by NOAA's National Environmental Satellite Service.

Remote Image Processing Systems (RIPS) Research and Development. Currently, enhancement of Landsat images is performed in sophisticated computer laboratories. The RIPS project is investigating the potential of using small computers in field offices to perform similar functions independently for some tasks and through communication with a large "host" computer for other tasks. An operational RIPS will have numerous processing functions and will be able to interface with many host computers. Thus, RIPS will be able to input and analyze several sources of geographically referenced image data such as meteorological, Landsat, topographic, as well as polygonal cartographic data structures. In FY 1982, a prototype RIPS is being demonstrated, tested, and evaluated in Survey offices in Reston, Denver, and Anchorage. In FY 1983, several units procured from industry will be deployed and supported in selected Survey offices.

Digital Analysis of Multiple Spatial Data Sets. A project to develop user-friendly computer techniques for the compilation and analysis of multiple spatial data sets addresses special problems in petroleum, mineral, and water resource studies. Work has been initiated to (1) develop automated procedures to delineate drainage lines and drainage divides using digital topographic data, (2) develop an adequate procedure for generation of a surface from point data, including the problems of irregularly distributed points and discontinuous surfaces, and (3) develop procedures for analysis of geophysical and geochemical data by regression analysis, factor analysis, and clustering.

Storage of Very Large Spatial Data Sets. Mass digitizing systems have made it possible to produce increasingly large spatial data sets. Increases have previously come through improvements in hardware storage technology, but projections of future volumes indicate that more efficient and economic data structures will be needed. A proposed new data structure which permits processing in both raster and vector modes is being implemented on a minicomputer and will be empirically compared with existing data structures on the basis of storage efficiency, speed, robustness, and range of application.

Spatial Data Research Support System (SDRSS). An SDRSS has been designed to provide an integrated set of system resources to support data acquisition, storage, processing, analysis, and product generation requirements of a broad research program directed toward the integration and application of disparate spatial data types. Hardware for this system is to include existing and new computer resources which will be linked for optimum sharing of resources.

Initial attributes of this conceptual design include the installation of a Burroughs Corp. B6900 general purpose system, a scientific processing system, a data storage/staging system, and special purpose equipment for digitizing map-based information. With the availability of these systems, development and procurement of software for spatial data processing has begun. The management information system on the new B6900 computer will be expanded to serve as an information clearinghouse for all data bases utilized by the network and will support batch-oriented statistical processing requirements. Utilization statistics will be maintained and accounting reports will be generated detailing the use of all network resources.

The EROS Digital Image Processing System (EDIPS) will provide network access to the Landsat high-density digital tape archives via unique tape recorders and will generate high-quality film products through laser beam film recorders. The IDIMS will provide a capability for interactive analysis of spatial data. A new scientific processor (SEL 32/87) will complement these unique capabilities, and software systems to analyze geobased data sets will be added.

As the demand on SDRSS increases, both the on-line and off-line data storage and staging requirements will increase. These systems will be interconnected with a high-speed data bus to support transfer of spatial data sets from one system to another. This data bus connection has been procured from Network Systems Corporation and installation is expected to be completed by fourth quarter, FY 1982.

Data Services Training

USGS Product Inventory and Distribution. As a result of continuing dialogue between NMD/Office of Information and Data Services and EROS regarding the responsibility and requirements for inventory and distribution of USGS publications and map products, a proposal was prepared by EROS to define an automated system that would satisfy these requirements. That proposal was accepted, and FY 1982 funding was transferred

to EDC to support the first phase of development of this project. EDC staff have completed design for the first phase of a software development project that will support and utilize a network of computer resources supporting NMD, EDC, and other divisions that have a requirement for customer accounting, order processing, inventory control, and production control. The initial phase of this project will be implemented in the fourth quarter of 1982 to automate the inventory control functions at the Eastern Map Distribution Center in Arlington, VA, and the Western Map Distribution Center in Denver, CO. Automation of order processing and customer accounting functions for the distribution centers is currently in the design phase and implementation will follow that of inventory control.

Sales. The budgeted reimbursable sales for FY 1982 are \$4,650,000. Both the incoming and shipped data sales as of mid-May were \$2,800,000, which is about 3% (\$90,000) behind the budget. The work-in-process totals some \$176,000. Of the \$2,800,000 of sales, 63% is Landsat, 28% is aircraft, and 9% is other data. The Landsat data sales are 59% photo products and 41% digital data. Turnaround times for all products average under 2 weeks. Current trends, including discussions with customers planning to submit orders this summer in anticipation of the NOAA price increase scheduled for next fiscal year, indicate that the budgeted reimbursable sales of \$4,650,000 will be made. A customer profile breakdown of FY 1982 dollar sales through April is as follows:

	Landsat Imagery	Landsat CCT's	Aircraft
Federal Government	18%	12%	37%
State/Local Government	3%	9%	4%
Academic	7%	7%	8%
Industrial	30%	46%	36%
Individuals	7%	1%	13%
Non-U.S.	<u>35%</u>	<u>25%</u>	<u>2%</u>
TOTAL	100%	100%	100%

Sales of NHAP data from the start of the program through April, 1982 total \$359,922. FY 1982 sales to date for NHAP are \$170,727. NHAP data continue to be of high interest to many users.

Training. EROS Office training and technology transfer activities take place through coursework, Data Analysis Laboratory hands-on training and publication of training exercises, research findings, and application project results. The EROS training program is supplemented by the Don Kulow Memorial Library, with over 28,000 accessions, and an accommodating information and scientific visitor assistance policy.

During the past year, over 470 persons attended the 26 training courses conducted by EROS staff members. Among the Department of Interior agencies represented were the USGS Water Resources, Geologic, and Conservation (now Minerals Management Service) Divisions, the Bureau of Land Management, the U.S. Fish and Wildlife Service, the Office of Surface Mining, and the Bureau of Reclamation. The training courses ranged from three days to four weeks, and varied in content from fundamentals of remote sensing applications to advanced digital image analysis techniques. In general, EROS courses are designed to serve the needs of scientists and managers of natural resources for whom remote sensing can be a valuable information-gathering and analysis tool.

Future Developments

LANDSAT D. The launch of Landsat D is currently scheduled for July 1982. EROS has identified required hardware and software modifications necessary for processing Landsat D data including development of new software and data bases to support handling of user requests for data; new procedures and software for controlling the financial interface between EROS and NOAA; significant hardware refurbishment/upgrade to EDIPS; a new format for Landsat digital products; and changes required by Landsat D WRS path-row numbers and spectral band identification numbers.

The Landsat D Memorandum of Understanding between NASA and the USGS was signed in early April. The necessary Interface Control Documents (ICD's) between NASA's Goddard Space Flight Center (GSFC) and EROS have been developed for governing the specific data and information to be interchanged, the media to be used for interchange, and the operating procedures by which the program will be implemented. Of the eight ICD's required, six have been signed by EROS and NASA/GSFC. Responsibility for the Landsat system is currently scheduled to be transferred to NOAA by January 31, 1983. EDC will produce and distribute data for NOAA through an interagency agreement signed in March 1982 by the Commerce and Interior Departments.

EROS has defined the FY 1983 and FY 1984 recurring costs (\$5.0 million and \$5.3 million respectively) that need to be transferred from NOAA to EROS to perform the Landsat function, plus \$700 thousand in FY 1982 funds needed for capital investment modifications due to changes in Landsat D. Funds have been made available to EROS and modifications have begun. EROS is currently developing a baseline of Landsat-related functions to be performed for NOAA in FY 1983.

NOAA has received Landsat D MSS data requirements from the major Federal agencies and has a planned pricing policy for Federal users that will be placed in effect in 1983. In addition, NOAA has released a price list for Landsat data products and services to the public. The prices established by NOAA implement the Administration's decision that, beginning on October 1, 1982, user fees recover the cost of operating and maintaining the operational Landsat system. NOAA has also begun negotiations with the foreign stations to raise the Landsat access fee, currently \$200 thousand per year, to about \$600 thousand per year.

The Program Board on Civil Operational Land Remote Sensing from Space has been established to provide the continuing Federal coordination and regulation needed by Commerce to manage the operational Landsat system being implemented by NOAA. Board members will be Federal officials, at the Assistant Secretary level, representing their agencies and assisting in the formulation of program goals and requirements from a national viewpoint. Thus far, the board has focused most of its attention on resolution of the issues related to the transfer of remote sensing activities to the private sector.

International Satellite Data Reception. With the launch of Earth-looking remote sensing satellites by other countries, the collection and processing of data acquired over the United States by these satellites could provide additional information to satisfy the requirements of domestic resource-management programs. Launch of an Earth observation satellite (SPOT) by the French Centre National d'Etudes Spatiales (CNES) is scheduled for late 1984. SPOT will carry two multispectral scanners. Unique characteristics of this system include: ground resolution to 10 meters, off-nadir viewing providing revisit capabilities (13 times per 26-day period at 40° North or South) and the opportunity for stereo coverage.

The EROS Data Center is in an ideal location to receive data directly, providing complete coverage of the conterminous U.S. A Request for Proposal for competitive procurement of the design study for SPOT data processing capability at the EROS Data Center has been approved and is ready for issuance on or about July 1. This procurement will result in a study that will document alternatives and associated costs for addition to or augmentation of EDC systems to provide the necessary processing capability.

Mass-Storage Systems. EDC maintains a digital high-density tape archive containing several hundred thousand Landsat images. The cost of maintaining this archive and of processing the image data to extract scenes of interest can be significantly reduced when moderate-cost, reliable, high-density data storage devices become available. Recently, a commercial vendor has revealed details of a prototype device that holds reasonable promise of providing reliable, cost-effective data storage. EDC production applications and the capabilities of the candidate mass-storage device will be analyzed.

Color Recorders. The Landsat false-color compositing process is labor-intensive and time-consuming. The advent of reliable and accurate equipment for recording color film directly from digital data has the potential for reducing or eliminating the need for this manual, high-overhead process. Several companies have indicated availability of color recorders that may meet EDC throughput, quality, and cost requirements. The companies expressing such an interest have been offered a test set of digital images to be converted to color film products. Test products will be returned to EDC with appropriate throughput and cost data for analysis by digital and photographic engineers. If the test products meet EDC's criteria for color film product quality, selection will continue based on unit cost, product throughput, vendor support, and other appropriate criteria.

New Products. A product line of National High-Altitude Photography (NHAP) program diapositives has been developed and brought into production under specification from NMD mapping centers. Tremendous advancements in micro-computer technology have prompted the development of new systems and products for distributing and processing digital image data. With the evolution of the RIPS concept and several similar commercially-developed micro-processing hardware systems for use in Landsat interpretation, the need for Landsat and other data in compatible digital format has evolved. Whereas these data product requirements originally surfaced as a result of research efforts in micro-computer Landsat image processing, the demand for products of this type will in fact extend beyond Landsat data. Development has resulted in a limited-throughput system to allow generation of floppy disks of user-selected areas. As a result of this effort, limited quantities of floppy disks of selected sub-areas of Landsat scenes and/or digital elevation model data, resampled to arc-second format, are currently offered to Department users. Additional hardware is being procured to increase production throughput. Future development will address data products utilizing high-density tape cassette and fixed-disk technology.

Image Maps. An inter-divisional (OESA, NMD, GD) project to use Landsat 3 return beam vidicon (RBV) images as a map base is nearing completion. Two experimental image map products will be published by the USGS. In late 1982, a 1:100,000-scale Landsat 3 RBV image map of the New Bedford Quadrangle will be ready for public sale. In 1983, a 1:100,000-scale Geologic map of Cape Cod on a Landsat 3 RBV image base will also be ready for distribution. The 1:100,000-scale image map could serve as a prototype of an image map series of the U.S. The 1:100,000-scale geologic map

could also serve as a prototype for a faster and less expensive means of publishing 1:100,000-scale geologic maps of the U.S. At the same time, strong interest is being shown by other agencies in digitally stitched image maps at a scale of 1:250,000 utilizing multispectral scanner data.

been approved and is ready for submission on or about July 1. This procurement will result in a study that will document alternatives and associated costs for addition to or augmentation of EDC systems to provide the necessary processing capability.

Fast Storage Systems. EDC maintains a digital high-density tape archive containing several hundred thousand Landsat images. The cost of maintaining this archive and processing the image data to extract scenes of interest can be significantly reduced when moderate-cost, reliable, high-density data storage devices become available. Recently, a commercial vendor has revealed details of a prototype device that holds reasonable promise of providing reliable, cost-effective data storage. EDC production applications and the capabilities of the candidate mass-storage device will be analyzed.

Color Recovery. The Landsat false-color compositing process is labor-intensive and time-consuming. The advent of reliable and accurate equipment for recording color data directly from digital data has the potential for reducing or eliminating the need for this manual, high-overhead process. Several companies have indicated availability of color recorders that may meet EDC throughput, quality, and cost requirements. The company's equipment and an interest level were offered a test set of digital images to be converted to color film products. Test products will be returned to EDC with appropriate instructions and cost data for analysis by digital and photographic engineers. If the test products meet EDC's criteria for color film product quality, selection will continue based on cost, product throughput, vendor support, and other appropriate criteria.

New Products. A project line in the High-Altitude Photography (HAP) program has been developed and brought into production under specification from QED mapping centers. The program's development in micro-computer technology has prompted the development of new systems and products for distribution and processing digital image data. With the evolution of the RPS concept and several similar commercially developed micro-processing hardware systems for use in Landsat investigations, the need for Landsat and other data in compatible digital format has evolved. Whereas these data product requirements originally resulted as a result of research efforts in micro-computer Landsat image processing, the demand for products of this type will in fact extend beyond Landsat data. Development has resulted in a limited-throughput system to allow generation of floppy disks of user-selected areas. As a result of this effort, limited quantities of floppy disks of selected sub-scenes of Landsat scenes and/or digital elevation model data, reoriented to arc-second format, are currently offered to Department users. Additional hardware is being produced to increase production throughput. Future development will address data products utilizing high-density tape, cassette and fixed-disk technology.

Image Maps. An inter-divisional (OESA, NMD, GD) project to use Landsat 3 return beam vision (RBV) images as a map base is nearing completion. Two experimental image map products will be published by the USGS. In late 1983, a 1:100,000-scale Landsat 3 RBV image map of the New Bedford Quadrangle will be ready for public sale. In 1983, a 1:100,000-scale geologic map of Cape Cod on a Landsat 3 RBV image base will also be ready for distribution. The 1:100,000-scale image map could serve as a prototype of an image map series of the U.S. The 1:100,000-scale geologic map