PRECISION CORRECTIONS

Experts have been concerned with the geometric accuracy of Landsat data since the launch of Landsat 1. It is known that optimum band-to-band and scene-to-scene geometric registration is tied closely to the utility of Landsat products, and for this reason efforts to introduce greater precision in the correction techniques applied have been ongoing.

Early attempts to apply precision corrections to the data were impeded by the experimental nature of Landsat, a lack of familiarity with user needs, and the slowness of available processing systems. Thus, the geometric correction method that evolved is a relatively straightforward system-dependent procedure that makes use of spacecraft attitude and ephemeris data and is used for the "system-corrected" data that are currently available.

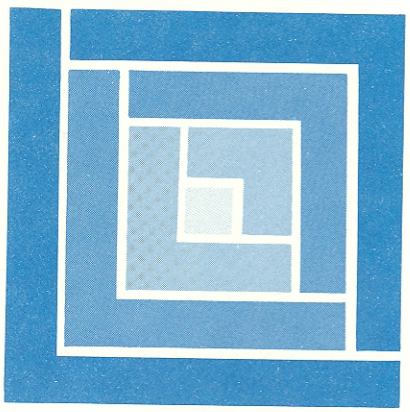
Improved geometric corrections will be applied to data processed by the new digital data handling systems at NASA/Goddard and the EROS Data Center through the use of known ground control points and matching them to individual scenes. The accuracy of the map used to locate the control points thus determines the accuracy of the band-to-band, scene-to-scene, and image-to-map registration that can be obtained. The subsequent spatial corrections that are applied to an image are correspondingly more accurate.

The general concept and philosophy of this precision correction technique will apply to both MSS and RBV imagery. However, currently only MSS data are being addressed. Use of ground control points for RBV imagery will be delayed until priorities can be established relative to the current schedule for MSS data.

To perform a scene-dependent correction of this type, a set of ground control points must be defined for each Landsat Path-Row area for which corrected images are required. Definition of ground control points and subsequent scene correlation is a time-consuming process requiring three distinct phases of activity. First, the ground control points for one Path-Row must be selected from the best available maps, and the respective geodetic location of each point must be digitized. This step has been done for the lower 48 United States and is well underway for Alaska and various land areas around the world.

Second, the defined set of control points must be correlated to a Landsat reference image. For each point, a 32-by-32-pixel "window" must be defined with the center of the window corresponding to the control point located on the map. The window forms a digital signature for that point. This process was started in February 1979 upon acceptance of the Master Data Processing system at NASA/Goddard; an average of three scenes per day are currently being input.

Third, the control point signatures must be digitally matched to the corresponding signatures found on each new scene to be corrected, thus allowing the correction algorithm to be accurately and uniformly applied. This matching is accomplished as an in-line processing step as each new scene is processed, assuming the ground control points for a given Path-Row area are available.



Landsat Data Users NOTES

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EROS DATA CENTER
Sioux Falls, S. Dak. 57198

Although this complicated procedure will result in a much better product for the user, it must be remembered that until the ground control point selection and entry is complete for a given Path-Row, only the standard system-corrected data will be available for scenes covering that Path-Row. Considering the current entry rate of three scenes per day, it may be some time before corrected data for selected areas can be made available. Scene-corrected data for the Eastern United States, for example, may not be available until early 1980.

The status of ground control point selection and entry will be reported in future issues of the Landsat NOTES.

DIGITAL PRODUCTION STATUS

As of February 1979, the new digital image processing systems at EDC and NASA/Goddard were producing fully processed (both radiometrically and geometrically corrected) MSS imagery in limited quantities. Delays in realizing full-production processing have been due to the limited amount of data available to EDC for such processing.

The processing referred to involves converting high-density tapes of the Landsat MSS data currently being acquired to master reproducible film chips and computer-compatible digital products. In the next few months it is planned to commence similar digital processing of RBV data as well. Only data acquired from February 1, 1979, will be available within this time frame. Furthermore, these data will be standard, fully processed data only.

Later this year, perhaps by early summer, partially processed data (radiometrically corrected only) and fully processed data to which non-standard geometric corrections and resampling techniques have been applied will become available. Users will be able to request such products for any data acquired since November 1976.

The availability of digital products for Landsat data acquired *before* November 1976, however, has been a subject of intense discussion at both the EROS Data Center and NASA/Goddard. As announced previously, it is planned to make CCT's available in two basic formats for a limited period (1-year): the old swath-oriented, band-interleaved-by-pixel tape format (known as the X-format) is to be made available concurrently with the new CCT format that was implemented with the start of digital image processing operations in February. But the Master Data Processor (MDP) at NASA/Goddard cannot currently process any pre-November 1976 data in the new format. For one thing, Landsat data acquired from 1972 to April 1974 lacks the spacecraft performance data needed to allow the MDP to adapt it to the new format. In addition, data acquired from April 1974 to November 1976 are of such a nature that processing to the new format would require major MDP software modifications — a move that is under consideration but not yet approved.

In view of these problems, and with current plans to discontinue all production of old X-format tapes after a limited period of time, serious questions have arisen concerning the future availability of Landsat digital products for data acquired prior to November 1976. Particularly in the case of 1972-74 data (some of which has never existed as CCT's in any format), the limitations of the MDP at Goddard would seem to warrant conversion of as many of the early data as possible to X-format CCT's in the short-term future. The EROS Data Center would then have the option of providing customers with these data in the same X-format or of converting the data to new-format CCT's, as required.

One upshot of this situation has been a request to NASA by the Department of the Interior to extend the time limit for production of X-format data beyond 1979. The requested extension would ensure availability of X-format tapes until at least mid-1980.

The revised schedule will provide users with more time during which to convert their own software to the new format. It will also permit the many questions and variables surrounding this issue to be carefully ironed out.

CENTRAL SOURCE OF LANDSAT DATA

The EROS Data Center has recently concluded agreements with NASA, the USDA Agricultural Stabilization and Conservation Service, and the National Oceanic and Atmospheric Administration that have resulted in EDC becoming the central source of Landsat data products for these facilities and the general public.

This step was made possible by recent changes in data handling systems at both NASA/Goddard and EDC. A communications satellite link for relaying Landsat data between the two facilities and new digital image processing systems will help reduce turnaround times for Landsat data production.

SYMPOSIUM

The 13th International Symposium on Remote Sensing of Environment will be held in Ann Arbor, Michigan, April 23-27, 1979. Part of a series of unique symposia conducted on an international level, this symposium will address state-of-the-art techniques and new or innovative concepts in scientific research and development leading to a more thorough understanding of remote sensing technology and its effective application in various earth resources and environmental monitoring programs.

Further information can be obtained from Dr. Jerald J. Cook, Environmental Research Institute of Michigan, P.O. Box 8618, Ann Arbor, Michigan 48107, phone: (313) 994-1200, TWX: 810-223-7019.

TASK FORCE SOLICITS PRIVATE SECTOR VIEWS

The following announcement was issued in the Commerce Business Daily *and the* Federal Register. *It is reprinted here for the readers who have not seen it. Organizations considering submissions to the Task Force should contact Mr. Gray at (202)755-8433.*

The Federal government has been investing in the development of systems for remote sensing from space for the past several years. It is now interested in determining how to increase the involvement of the private sector in such activities. At the request of the President, an Interagency Task Force co-chaired by NASA and the Department of Commerce is developing a plan of action on how to encourage private investments and direct participation in civil systems for remote sensing of the Earth from space. This plan of action will be submitted to the Space Policy Review Committee for consideration and action. Expressions of interest in such systems may be extended to include sensing of the oceans and/or atmosphere, if desired. Interest may involve the ownership and/or operation of the total system or any segment of it, e.g., spacecraft, space-to-ground communications links, data processing, data dissemination and storage, analytical services, etc.

The views of interested parties are solicited for consideration in developing recommendations for a plan of action. The information desired includes:

1. Incentives believed required from the Federal government, if any. Actions recommended to the government to attract greater private participation and investment in this field.
2. Desirable institutional or corporate arrangements.
3. Desirable and undesirable government regulation, if any.
4. A description of the remote sensing system of choice and its capabilities; including area of coverage, resolution, sensor frequency bands, frequency of coverage.
5. Preferred, proposed, or required data products, both as to type and quantity.
6. Estimate of the markets for and uses of data products; overall market size as well as markets of special interest (both domestic and foreign); market growth potential.
7. Estimates of the private investment deemed necessary for the level of involvement envisioned; the availability of investment capital.
8. Consideration of possible foreign competition and its effects.
9. Time frame in which private participation is considered feasible.
10. Any other information or views that should be considered.

SYMPOSIUM

An international view of problems, promises, and accomplishments will be the topic of a symposium on *Remote Sensing for Natural Resources* next September 10-14, 1979. The symposium is being coordinated through the Office of Continuing Education, University of Idaho, Moscow, Idaho 83843.

PRESIDENT'S SPACE POLICY

The President recently announced a space policy that will set the direction of U.S. efforts in space over the next decade. The policy is the result of a 4-month interagency review requested by the President in June 1978.

The following information has been extracted from the President's space policy for inclusion in the NOTES because of its criticality to remote sensing from space and the Landsat program.

1. Remote Sensing Systems - The United States will continue to provide data from the developmental Landsat program for all classes of users. Operational uses of data from the experimental system will continue to be made by public, private, and international users. Specific details and configurations of the Landsat system and its management and organizational factors will evolve over the next several years to arrive at the appropriate technology mix, to test organizational arrangements, and to develop the potential to involve the private sector.

2. Integrated Remote Sensing System - A comprehensive plan covering expected technical, programmatic, private sector, and institutional arrangements for remote sensing will be explored. NASA will chair an interagency task force to examine options for integrating current and future systems into an integrated national system. Emphasis will be placed on defining and meeting user requirements. This task force will complete its review before the FY 1981 budget cycle.

3. The Private Sector - Along with other appropriate agencies, NASA and the Department of Commerce will prepare a plan of action on how to encourage private investment and direct participation in civil remote sensing systems. NASA and Commerce will be the contacts for the private sector on this matter and will analyze proposals received before submitting to the Policy Review Committee (Space) for consideration and action.

EDC TRAINING SCHEDULE

The EROS Data Center's Applications Branch staff will conduct or participate in several training courses and workshops in the coming months.

Apr. 3-Apr. 6 *Water Resources Workshop* (Sioux Falls, South Dakota). Open enrollment, preference given to U.S. Federal agency personnel. Contact: Branch of Applications, EROS Data Center, Sioux Falls, South Dakota. 57198.

Apr. 30-May 25 and Sept. 10-Oct. 5 *International Remote Sensing Workshop* (Sioux Falls, South Dakota). Open to non-U.S. scientists. Contact: Office of International Geology, U.S. Geological Survey, National Center (917), Reston, Virginia 22092.

May 7-May 11 and May 21-May 25 *Introduction to Remote Sensing Applications* (Phoenix, Arizona, and Boise, Idaho). Open to Bureau of Land Management personnel only. Contact: William Bonner, BLM Scientific Systems Development, Denver Service Center, Bldg. 50, Code D-140, Denver, Colorado.

Jun. 4-Jun. 8 *Basic Geology Workshop* (Sioux Falls, South Dakota). Open enrollment, preference given to U.S. Federal agency personnel. Contact: Branch of Applications, EROS Data Center, Sioux Falls, South Dakota 57198.

Jun. 18-Jun. 22 *Vegetation Remote Sensing Workshop* (Ann Arbor, Michigan). Open enrollment. Contact: Dr. Charles Olson, Remote Sensing Program, School of Natural Resources, University of Michigan, Ann Arbor, Michigan 48109, phone: (313) 764-1413.

Jun. 18-Jun. 22 *Terrain Analysis: Interpretation of Aerial Photographs and Images* (Sioux Falls, South Dakota). Contact: Lisa Underkoffler, Graduate School of Design, Gund Hall L-37, Harvard University, Cambridge, Massachusettes 02138, phone: (617) 495-2578.

Jun. 25-Jun. 29 *Coal Surface Mining Remote Sensing Workshop - Abandoned Mines* (Sioux Falls, South Dakota). Open to OSM program participants. Contact: Branch of Applications, EROS Data Center, Sioux Falls, South Dakota 57198.

Oct. 15-Oct. 19 *Advanced Geology Workshop* (Sioux Falls, South Dakota). Open enrollment, preference given to U.S. Federal agency personnel. Contact: Branch of Applications, EROS Data Center, Sioux Falls 57198.

ADDITIONAL TRAINING IN REMOTE SENSING

May 14-May 18 *Advanced Topics in the Analysis of Remote Sensing Data* (Lafayette, Indiana). Contact: Prof. Phillip H. Swain, Purdue/LARS, 1220 Potter Drive, West Lafayette, Indiana 47906, phone: (317) 749-2052.

May 7-May 11, Jun. 4-Jun. 8, and Jun. 18-Jun. 22 *Short Course on Remote Sensing Technology and Applications* (Lafayette, Indiana). Contact: Douglas B. Morrison, Purdue/LARS, 1220 Potter Drive, West Lafayette, Indiana 47906, phone: (317) 749-2052.

May 14-May 25 *Remote Sensing Techniques and Applications in Arid Lands* (Tucson, Arizona). Contact: Phillip N. Slater, Committee on Remote Sensing, Building 94, University of Arizona, Tucson, Arizona 85721.

May 28-Jun. 29 *Advanced Training in Geologic Interpretation* (Flagstaff, Arizona). Open to non-U.S. scientists. Contact: Office of International Geology, U.S. Geological Survey, National Center (917), Reston, Virginia 22092.

Jun. 18-Jun. 22 *A Short Course on Remote Sensing and Image Interpretation* (St. Paul, Minnesota). Contact: Eugene L. Anderson, Office of Special Programs, 1420 Eckles Ave., University of Minnesota, St. Paul, Minnesota 55108, phone: (612) 373-0725.

Aug. 19-Aug. 24 *Aerospace Technology and the Forest Environment - An International Short Course and Conference* (Arcata, California). Contact: Donna B. Hankins, Remote Sensing Technology Transfer Project, Humboldt State University, Arcata, California 95521, phone: (707)826-3731.

Oct. 8-Nov. 9 *Advanced Training in Land Use Planning and Environmental Applications* (Flagstaff, Arizona). Open to non-U.S. scientists. Contact: Office of International Geology, U.S. Geological Survey, National Center (917), Reston, Virginia 22092.

Feb. 11-Mar. 7 *Advanced Training in Digital Image Processing* (Flagstaff, Arizona). Open to non-U.S. scientists. Contact: Office of International Geology, U.S. Geological Survey, National Center (917), Reston, Virginia 22092.

Monthly: *Remote Sensing Short Course* (West Lafayette, Indiana). Contact: Douglas B. Morrison, Purdue/LARS, 1220 Potter Drive, West Lafayette, Indiana 47906, phone: (317) 749-2052.

LANDSAT MICROFICHE SYSTEMS

Two important microfiche reference systems have been available from the EROS Data Center for several months. Developed by EDC with support from the National Cartographic Information Center, these systems provide complete reference information for determining the availability of Landsat data.

The microIMAGE system is a replacement of the 16-mm "browse" microfilm previously produced by NASA/Goddard. It incorporates band 5 images (photo-reduced) of all Landsat scenes acquired since March 1978. Users thus can study a representative scene before ordering full-size photographs or computer-compatible tapes.

The microCATALOG system incorporates several thousand computer printouts resulting from geographic inquiries. It permits users to view individual Landsat records for purposes of research.

Both systems are keyed to the Path-Row notation of the Worldwide Reference System (WRS). The 251 Paths, or ground tracks of the satellite, form the basis for identifying 10 "regions" covering the major land masses of the world. The 124 Rows, or lines of latitude intersecting the Paths, are divided into three major "zones" for the north, south, and polar areas of the Earth. The microCATALOG and microIMAGE fiche can be ordered for any zone or region individually, or any combination thereof.

MicroIMAGE

The microIMAGE fiche are 4-by-6-inch film chips each with a title area along the top border and a data area below containing 60 "microframes." Each microframe is dedicated to one Path-Row nominal center. Within each microframe is a quality reproduction of an MSS band 5 image acquired over that center.

The microIMAGE fiche are indexed by date as well as Path-Row. For every pass of the satellite over a particular Path-Row point, an MSS image is recorded on microfiche. Users can compare successive images of one geographic area, assess the cloud cover, or verify ground coverage.

Landsat data are acquired daily, necessitating daily additions to the microIMAGE system. A subscription service is available from the EROS Data Center by which a user can be assured of obtaining all new fiche as they are produced. Users can subscribe for microfiche of the world, a zone, or a region. A complete collection of all fiche to date (for a region, zone, or the world) can be obtained at any time with a single order.

MicroCATALOG

The microCATALOG fiche are also 4-by-6-inch film chips with a descriptive title area and a 60-microframe data area. In the microCATALOG, the microframes contain computer listings of all Landsat data available over a given Path-Row point. These listings are sometimes lengthy, so the fiche are broken into groups of convenient date ranges.

The microCATALOG information is retrospective, that is, the descriptive listings collectively treat all acquisitions since the launch of Landsat 1. Additional fiche are necessary from time to time to incorporate new acquisitions, so updates are produced periodically. Updates for heavy coverage areas such as North America are produced monthly; updates for other regions and zones are made quarterly. Orders for the microCATALOG may specify world, region, or zone coverage, or any combination thereof, for a single order for all fiche to date or for a subscription order for periodic updates.

All inquiries and orders for either the microIMAGE or the microCATALOG Landsat reference systems should be directed to the User Services Section, U.S. Geological Survey, EROS Data Center, Sioux Falls, South Dakota 57198, phone: (605)594-6511.

The microCATALOG system is also available in hardcopy from the National Technical Information Service, 5285 Port Royal Road, Springfield, Virginia 22161.

PRICE LIST

	ZONE				REGION									
	WORLD	North	South	Polar	U.S., Central America	Alaska, Hawaii	South America	Central & South Africa	Australia, Southeast Asia	Europe, North Africa	India, Burma, Pakistan	Middle East	China, Japan	Asia
MicroCATALOG														
Annual Subscription	$ 750	$ 350	$ 200	$ 200	$ 95	$ 95	$ 25	$ 45	$ 35	$ 35	$ 25	$ 20	$ 40	$ 95
Current Edition	$ 260	$ 140	$ 70	$ 50	$ 40	$ 40	$ 7	$ 10	$ 10	$ 12	$ 10	$ 10	$ 10	$ 25
Micro/Image														
Annual Subscription	$1100	$ 720	$ 360	$ 30	$ 260	$ 100	$ 40	$ 90	$ 60	$ 105	$ 65	$ 65	$ 100	$ 275

NEW ALASKAN PHOTOGRAPHY AVAILABLE

More than 7,000 frames of black-and-white and color infrared aerial photographs of Alaska have been received from the Ames Research Center. These data represent the beginning of a 3-year program to acquire coverage of the entire State.

It is the first time that color infrared photography has been included in a series of aerial photography missions this extensive. The effort is a result of the need by numerous Federal and State resource-management agencies to acquire more detailed information about Alaska's land cover, terrain, and other resources. Vegetation mapping, mineral exploration, wildlife estimates, and hydrology studies are among the application for this new imagery.

The coverage obtained so far has been entered into the EDC data base in geographically retrievable format. Characteristics of the imagery are as follows:

Scale:	1:120,000 and 1:60,000
Format:	9 1/2 inch (241 mm)
Focal length:	6 inch (152 mm)
	12 inch (305 mm)
Camera:	RC-10 Metric Framing
Flying height:	60,000 feet (18,300 m)

RBV DATA BEING STUDIED

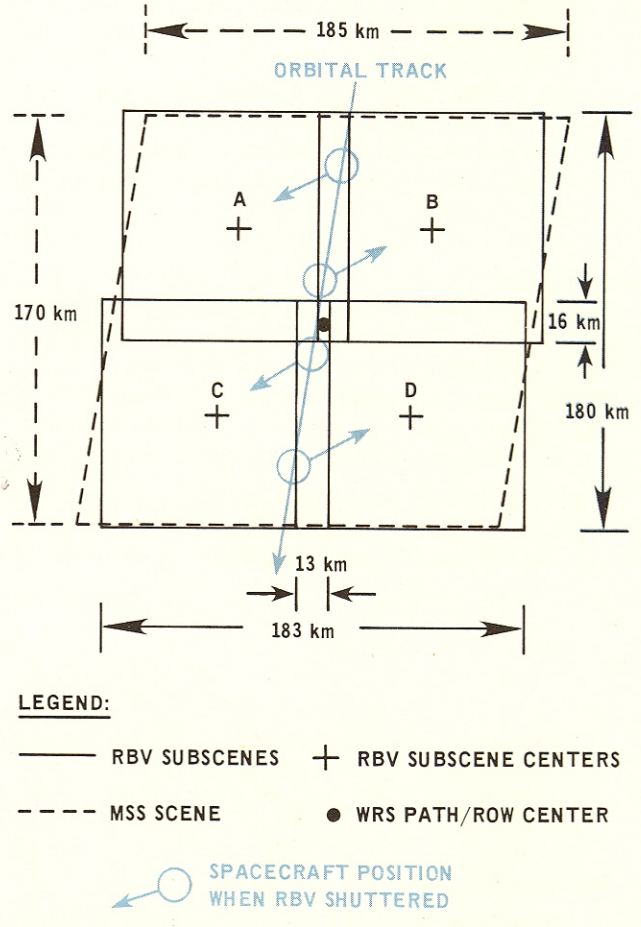
In addition to multispectral scanner (MSS) data, Landsat 3 provides imagery from a return beam vidicon (RBV) camera system. The system consists of two RBV cameras onboard the satellite, each capable of imaging an area approximately one-fourth the size of an MSS scene. Mounted side-by-side and operating alternately, the RBV's acquire four "subscenes" to provide the same ground coverage as one MSS scene. (See diagram.)

One broad spectral band (0.505 to 0.750 μm) is covered by the RBV system. The EDC digital image processing system can record the RBV data on 1:500,000-scale original film negatives or on digital computer-compatible tapes. The ground resolution, or "instantaneous field of view," of the RBV imagery (38 by 38 m) is considerably sharper than that of the MSS (which is 79 by 79 m). This advantage of RBV data does not diminish the value of the better spectral information obtainable from MSS imagery; both types of imagery used in combination may well be the answer to many new applications.

Currently, very few RBV data are available, and the EROS Data Center does not expect to receive any in quantity for a few months. Also, some calibration problems with the two cameras are being experienced that, while not serious, may have some effect on subscene-to-subscene data saturation levels.

In the accompanying photographs, RBV imagery can be compared with both MSS and conventional aerial mapping photography. These photographs are of an area around Cadillac, Michigan, and are printed at a scale of 1:80,000. The first is a part of a black-and-white Geological Survey aerial mapping photograph. Next is part of an RBV image, and after that, parts of four MSS images are arranged vertically, one for each band. The aerial photograph was acquired May 9, 1976; the satellite images were acquired by Landsat 3 on April 26, 1978.

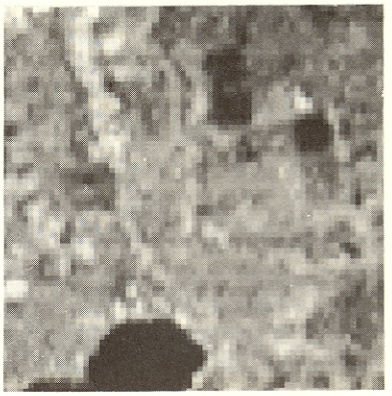
The differences in ground resolution are obvious. The aerial mapping photography was printed at contact scale directly from the film negative archived at EDC. The five satellite images were extracted from computer-compatible tapes and digitally enlarged to a scale of 1:80,000 before being recorded on film. (Digital enlargements compare favorably with photographic enlargements of the same area.)



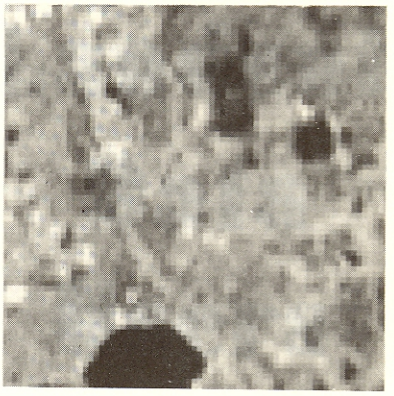
MSS and RBV Coverage Areas Superimposed

Other experiments either underway or being planned at EDC will involve: (1) generation of false-color composites that have the spectral qualities of MSS imagery and the spatial resolution of RBV; (2) comparison of RBV images to published maps in order to investigate potential uses; and (3) studies of the geometric characteristics of RBV imagery.

In addition to ongoing work at EDC, the Topographic Division of the Geological Survey has prepared exhibit panels comparing RBV imagery with aerial photographs of Monomoy Island on Cape Cod, as well as a side-by-side comparison of MSS band 5 and RBV for an area around Dulles Airport in Virginia. This work has been published in U.S. Geological Survey Open-File Report 78-1107.



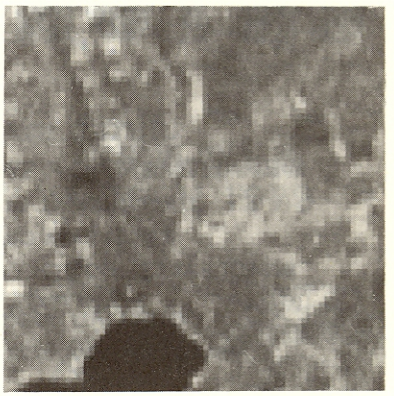
LANDSAT MSS
Band 4
Scale 1:80,000



LANDSAT MSS
Band 5
Scale 1:80,000

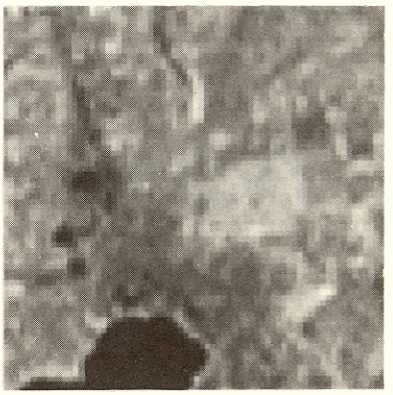
AIRCRAFT PHOTO
Scale 1:80,000

about 2-1/4 mi.



LANDSAT MSS
Band 6
Scale 1:80,000

LANDSAT RBV
Scale 1:80,000



LANDSAT MSS
Band 7
Scale 1:80,000

* * *

The Landsat Data Users NOTES is published bi-monthly in order to present information of interest to the user community regarding Landsat products, systems, and related remote sensing developments. There is no subscription charge; individuals and organizations wishing to receive the NOTES should contact the User Services Section, U.S. Geological Survey, EROS Data Center, Sioux Falls, South Dakota 57198, U.S.A., telephone: (605)594-6511.

Comments, corrections, and other inquiries should be directed to:

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