FINAL REPORT

on

SURVEY OF USERS OF EARTH RESOURCES REMOTE SENSING DATA

to

NASA USER AFFAIRS - OFFICE OF APPLICATIONS

TASK UNDER APPLICATIONS - NEW INITIATIVES CONTRACT
NASw-2800, Task 6

March 31, 1976

by

G. E. Wukelic, J. G. Stephan, H. E. Smail, L. Landis, and T. F. Ebbert

Approved by: George E. Wukelic
G. E. Wukelic - Task Manager

Arnold C. Robinson
A. C. Robinson - Project Manager

BATTELLE
Columbus Laboratories
505 King Avenue
Columbus, Ohio 43201

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

LIST OF FIGURES

LIST OF FIGURES (Continued)

LIST OF TABLES

LIST OF TABLES (Continued)

SURVEY OF USERS OF EARTH RESOURCES REMOTE SENSING DATA

by

G. E. Wukelic, J. G. Stephan, H. E. Smail, L. Landis, and T. F. Ebbert

Battelle Columbus Laboratories

BACKGROUND

In response to a request by the Space Applications Board (SAB) of the Assembly of Engineering (National Research Council of the Academy of Sciences), the Director of NASA User Affairs - Office of Applications requested that Battelle's Columbus Laboratories (BCL) undertake a study/survey to clarify and document the application and effectiveness of the use of Earth resources survey (ERS) data by the user community. The Office of Management and Budget (OMB) expressed an interest in the survey and assisted in preparing the survey questionnaires.

The scope of the study was limited in "data used" to only high-altitude aircraft (>60,000 ft: RB 57 and U-2 type aircraft) and satellite (primarily LANDSAT) data; but, in terms of "data user", the scope was to be comprehensive and include all data user communities (i.e., industry, government, educational, and non-U.S. or foreign users). Further, study emphasis was placed on the private sector/industrial user (see Figure 1). The study involved approximately a one person-year of effort over a 6-month period.

In order for the survey results to be of maximum value, specific primary and secondary objectives were established. The primary objective was descriptive in nature, and included identifying who is using ERS data, how they are using the data, and the relative value of current data use. Secondary objectives were in essence exploratory, and involved efforts to obtain user views as to possible ways of strengthening future ERS data use. Thus, the study was not a market survey to identify new markets but rather a user survey to determine current ERS data use/user status and recommendations for strengthening use. The survey results documented in this report should be of interest to the SAB and the OMB and provide relevant decision-making information for NASA Office of Applications appropriate for developing future programs of maximum benefit to all end users of satellite Earth resources survey data.

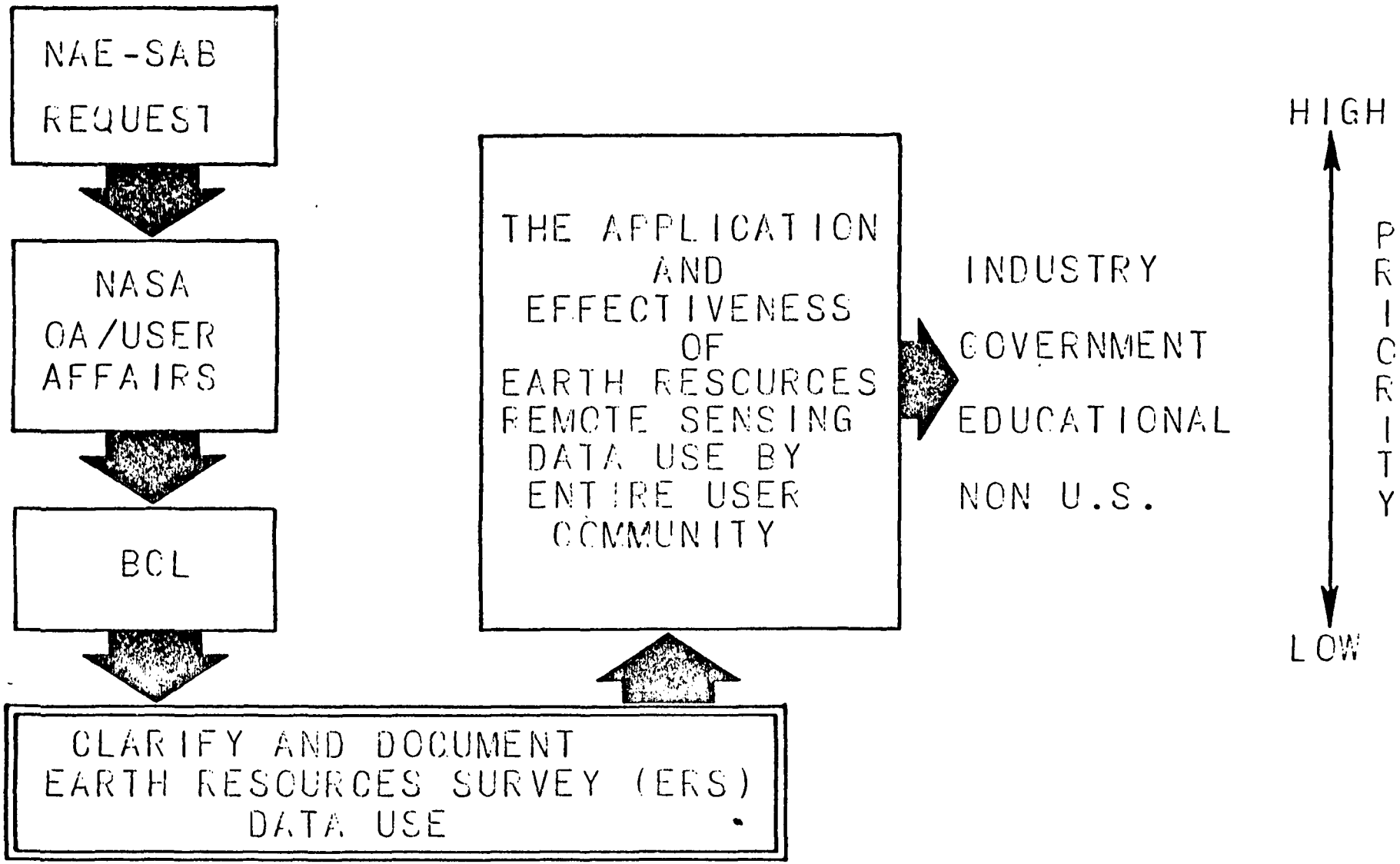


FIGURE 1. SURVEY BACKGROUND AND SCOPE

SURVEY METHODOLOGY

The Earth resources data use survey basically involved a two-phased research procedure (see Figure 2). The first phase of the survey focused on identifying, obtaining, and reviewing information from both direct and indirect sources that related directly and explicitly to ERS data use/user status. Direct information sources included (1) information obtained during visits to three ERS data centers (EROS Data Center, Souix Falls, South Dakota; USDA Data Center in Salt Lake City, Utah; and, the NOAA Satellite Data Services Branch in Suitland, Maryland, (2) structured and unstructured personal and telephone interviews, (3) tailored and comprehensive questionnaire surveys, and (4) selected ERS user presentations/publications. Indirect sources of relevant information included primarily (1) other contemporary surveys (E.G., General Accounting Office, LANDSAT Principal Investigator Survey), (2) interviews with NASA personnel, (3) NASA and NASA contractor reports, (4) attendance at remote sensing symposia, (5) selected domestic and foreign remote sensing publications, and (6) special ERS studies (e.g. Space Applications Board).

The second phase of the survey involved the aggregation and analysis of the information and data according to the following user groups: (1) industrial users, (2) state, regional (substate) and local government users, (3) federal government users, (4) Academic/Educational users, and (5) non-U.S./foreign users. Within each user group an effort was made to determine who are the current users, how they are using the ERS data, what is the current significance of their ERS data use, and lastly, how can ERS data use be strengthened. An ERS data use summary and outlook assessment for each user community as well as for the total study were prepared using all direct and indirect information sources.

To obtain the best inputs possible, all participants were promised that the confidentiality of sources would be maintained throughout the survey. Accordingly, a high confidence level can be assigned to the survey's extensive information base. However, the reader is reminded that this is only a survey of representative ERS data users and, as such, does not constitute a complete inventory of ERS data use. Also, because of the dynamic nature of remote sensing technology, the status of ERS data use and users is constantly changing.

Specific survey activities conducted and results obtained are described in the sections that follow.

INFORMATION COLLECTION AND ANALYSIS		RESULTS, ANALYSIS AND IMPLICATIONS ASSESSMENT
DIRECT SOURCES (STUDY GENERATED)	INDIRECT SOURCES (OTHER)	▲ AGGREGATION OF RESULTS RE
● DATA CENTERS	● OTHER SURVEYS	● ERS DATA USER STATUS
● USER INTERVIEWS	● NASA PERSONNEL	● ERS DATA USE STATUS
● QUESTIONNAIRE SURVEYS	● NASA AND NASA CONTRACTOR REPORTS	● ERS DATA USE EFFECTIVENESS
● USER PRESENTATIONS AND PUBLICATIONS	● ERS CONFERENCES	● RECOMMENDATIONS FOR STRENGTHING USE
	● SELECTED LITERATURE	▲ SUMMARY AND IMPLICATIONS OF RESULTS (PER EACH USER GROUP)
	● SPECIAL STUDIES	▲ TOTAL STUDY SUMMARY AND RECOMMENDATIONS

FIGURE 2. SURVEY METHODOLOGY - OVERVIEW

SPECIFIC ACTIVITIES ACCOMPLISHED - SURVEYS CONDUCTED

A concentrated effort was initiated to become as informed as possible relative to all potentially relevant information/data sources which could help establish the ERS data use/user status and assist in interpreting the significance of the survey results generated. Highest priority was given to developing survey mechanics and conducting the actual user surveys. Three separate, but structurally related, surveys were conducted: (1) Houston ERS Symposium survey, (2) user interviews, and (3) mail survey. Table 1 provides an overview of the statistics for all surveys conducted by user group.

HOUSTON ERS SYMPOSIUM SURVEY (ALL PARTICIPANTS)

Because of the coincidence of the timing of this activity with the first comprehensive symposium on the practical application of Earth resources survey data (held by NASA in Houston, Texas in June, 1975), it was considered opportune to conduct a questionnaire survey of all conference attendees. Hence, a simple one-page (both sides), primarily multiple-choice questionnaire*, developed in concert with NASA, SAB, and the OMB, was included in the ERS Symposium packet distributed to all participants. The questionnaire contained six major information categories, viz., User Description, ERS Data Description, Data Use Description, Data Evaluation, User Recommendations and Symposium Effectiveness, and over 20 subcategories. Of the 1337 registered participants, 373 (or $\cong$ 28%) completed and returned the questionnaires. The user community distribution, for those questionnaires returned relative to user attendance distribution, is shown in Figure 3. A graphic summary of the overall results of this particular survey is contained in the addendum. Only selected results associated with current ERS users are included in the report findings.

---

* Sample questionnaire contained in the addendum to this report.

TABLE 1. TOTAL SURVEY CONTACTS

	HOUSTON SYMPOSIUM SURVEY		MAIL SURVEY		QUESTIONNAIRE TOTALS		INTERVIEWS		TOTAL CONTACTS
	USER	NON-USER	USER	NON-USER	USER	NON-USER	USER	NON-USER	
FEDERAL	63	14	106	24	169	38	55	18	280
STATE/REG. &LOCAL	39	11	66	41	105	52	83	47	287
UNIVERSITY	95	14	72	11	167	25	36	9	237
INDUSTRY	98	15	62	17	160	32	107	24	323
NON-U.S.	24	0	--*	--	24	0	10	--	34
TOTAL	319	54	306**	93**	625	147	291	98	1,161 **

USERS of ERS data were identified as individuals who are currently using the data.

NON-USERS were defined as individuals who are not currently using the data, but who may become a user in the future; they also represent past ERS data users, such as NASA-funded investigators.

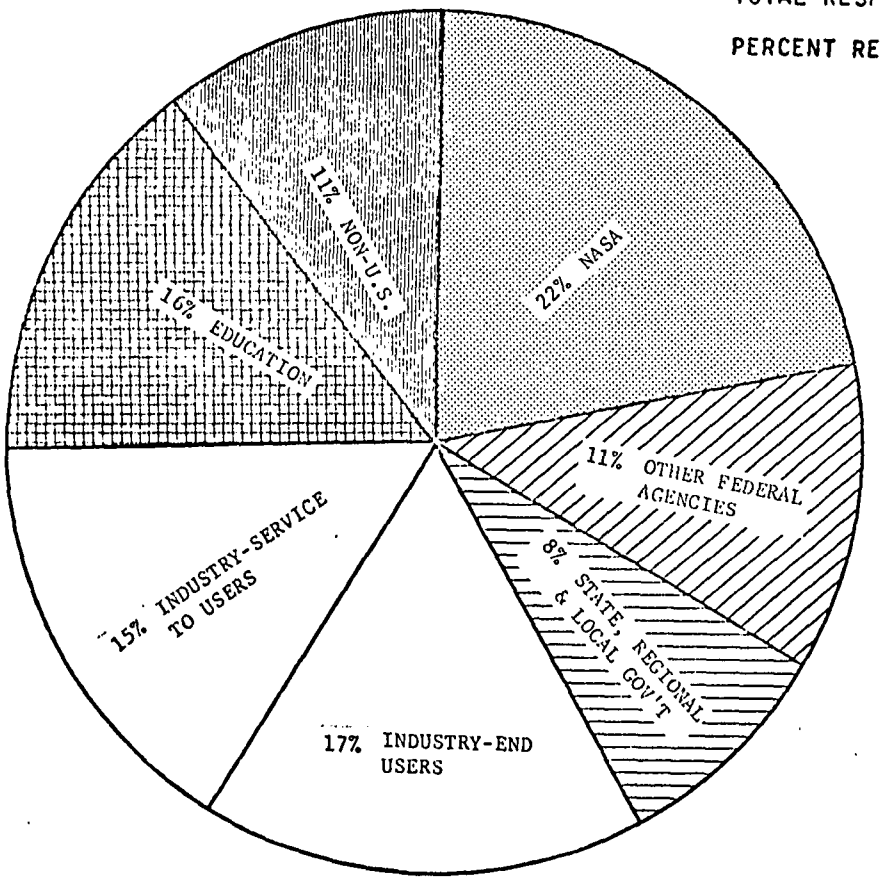
* No questionnaires distributed to Non-U.S. users at NASA's request.

** An additional 126 questionnaires were received too late to be included in the statistical tabulations used in this report, but these responses were reviewed for relevant user comments.

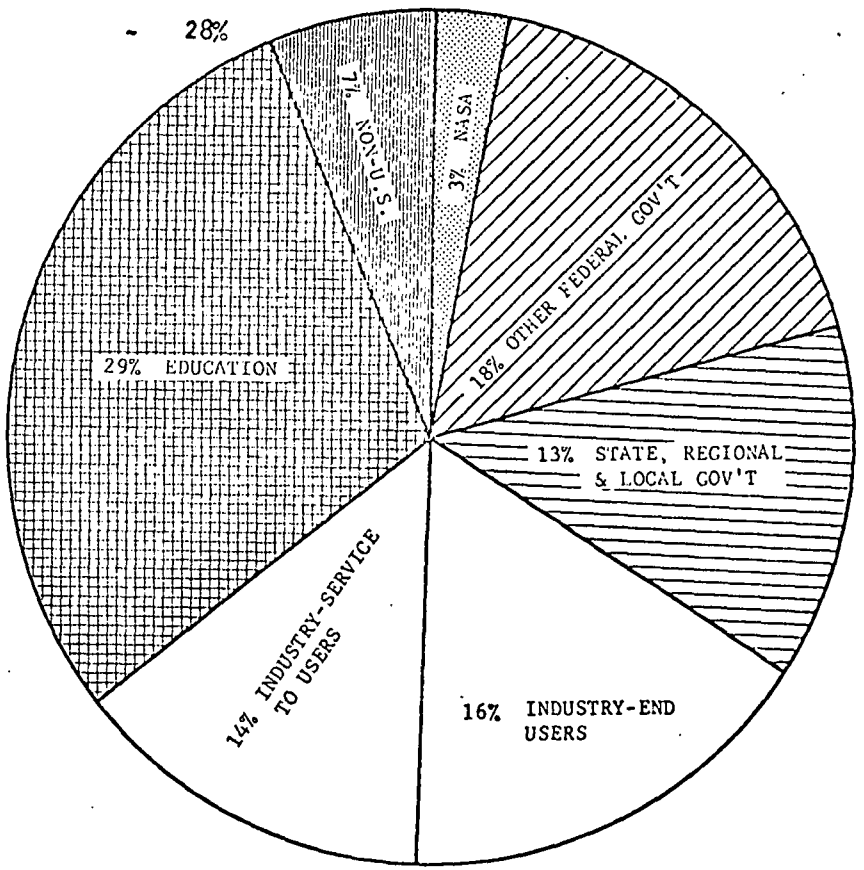
QUESTIONNAIRE INFORMATION CATEGORIES:

MAJOR CATEGORIES	SUBCATEGORIES
I-USER DESCRIPTION	OVER 20
II-ERS DATA DESCRIPTION	
III-ERS DATA USE DESCRIPTION	
IV-LANDSAT DATA EVALUATION	
V-USER RECOMMENDATIONS	
VI-SYMPOSIUM EFFECTIVENESS	

ERS SURVEY STATISTICS: TOTAL (REGISTERED) ATTENDANCE - 1337
TOTAL RESPONSES - 373
PERCENT RESPONDING - 28%



% ATTENDANCE BY USER GROUP



% QUESTIONNAIRE RESPONSES BY USER GROUP

FIGURE 3. HOUSTON ERS SYMPOSIUM SURVEY

USER INTERVIEWS

Much of the effort expended during this survey activity related to conducting interviews with the more frequent/experienced ERS data users. User "interview targets" were carefully and systematically selected from the following information sources, in descending order of priority:

- Most frequent users of ERS Data Centers
- Questionnaires returned on which respondents explicitly identified themselves as users
- NASA and NASA contractor reports of prior surveys of users and potential users (e.g., Ambionics and NASA TAC studies). Unfortunately, extensive personnel changes have occurred since these earlier surveys.

The number of actual interviews conducted in each of the higher priority user communities was a function of the quality of the information provided by those contacted and not a pre-established, statistical quota. That is, interviews concentrated on "informed" experienced user opinions rather than on a broader statistical, somewhat random survey. Thus, interview findings are considered to have more qualitative than quantitative significance. Quantitative results were provided by the broader questionnaire surveys. Approximately 400 user interviews were conducted between July and December, 1975. The distribution among user groups was as follows: industrial sector - 131 contacts (34% of total); state, regional, and local governments - 130 contacts (33% of total); federal government - 73 contacts (19% of total); and educational and foreign users - 55 contacts (14% of total), (see Figure 4).

In all cases, the interviews were semi-structured in that basic questions common to all users were asked. In addition, other general questions were tailored to the specific user community involved. Generally, the length of each interview varied from 15 to 45 minutes. The extent of detail discussed during the interviews depended upon the familiarity and interest of the interviewee. As a minimum, the following information was explicitly solicited during the interview and subsequently recorded: user status, discipline area(s) of application, ERS data bases utilized, user data relevance assessment and evaluations, user ERS data analysis cost and capability information, geographical area of operation or interest, and general comments relative to user needs and recommendations. Information obtained from interviews was considered to be of higher information value than that contained in questionnaire responses, and accordingly had more impact on conclusions drawn and recommendations made in this report.

Type of Interviews

- Telephone and Personal - Very Selective
- Semi-Structured

  Four Basic Questions
  Plus Especially Tailored Questions/User Group

- Concentration on Informed Users
- Concentration on Industry & State, Regional & Local Gov'ts.
- Qualitative Not Quantitative Survey

Interview User Distribution Statistics: Total Interviews - 389

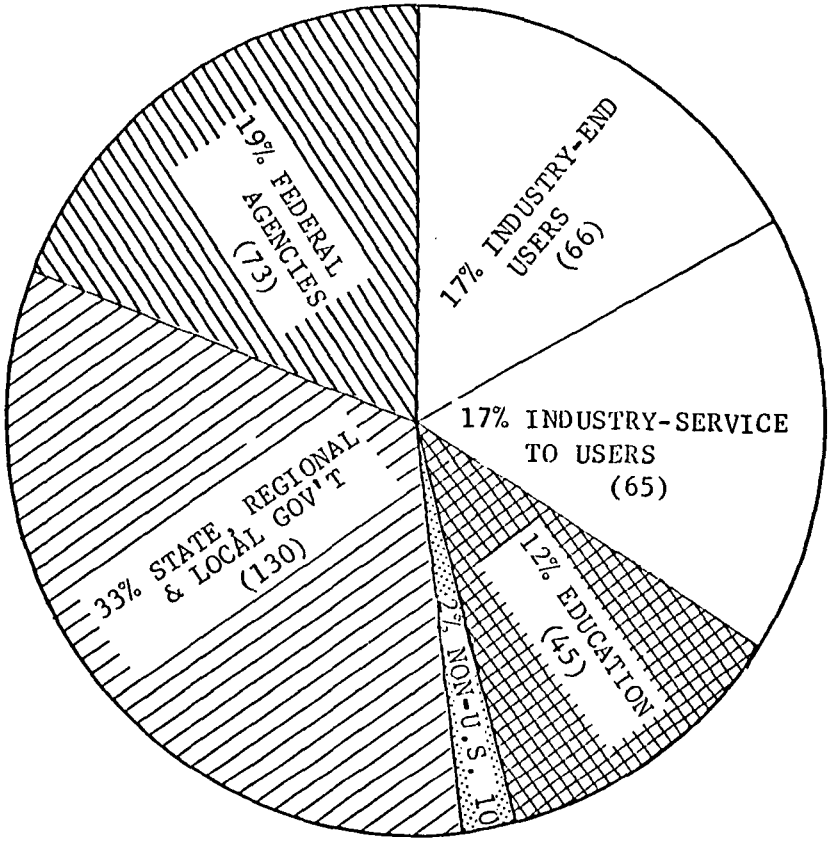


FIGURE 4. USER INTERVIEWS

MAIL QUESTIONNAIRE SURVEY

The third survey conducted was planned to be extremely broad and was aimed at soliciting inputs from the total user community, both current as well as potential. For this broader survey, the Houston ERS questionnaire was modified to include more information relative to potential data use relevance and benefits.*

In this survey questionnaires were mailed to attendees of recent remote sensing symposia, LANDSAT I and II investigators, members of professional remote sensing societies, individuals identified from NASA Headquarters, JSC, and GSFC mailing lists, and others from ERS Data Center Information.

Individuals who returned questionnaires from the Houston ERS symposium and non-US users were not included in the mail survey. Statistics relating to the number of questionnaires distributed and returned during the mail survey are shown in Figure 5. In brief, some 1200 questionnaires were mailed and 389 were returned for a 32.5 percent response rate, which is quite acceptable for a mail survey.** Returns were fairly evenly distributed among user groups.

Because interviews and questionnaire surveys concentrated on current ERS data users, the sample results obtained during this survey <u>are considered representative of current users</u> within each public and private sector user community. In contrast, although, some twenty percent of the survey contacts are non-current users and/or potential users only, survey findings <u>are not</u> considered representative of this group. Actually, statistical data summarized are based on results contained in <u>current users only</u> questionnaire responses. Non-user questionnaires were analyzed for relevant comments only.

---

* Sample questionnaire contained in the addendum to this report.

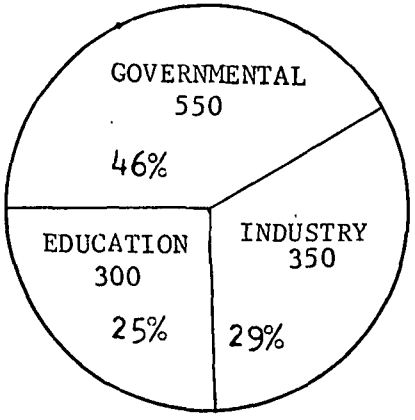
** An additional 126 questionnaires were received too late to be included in the statistical tabulations used in this report, but these responses were reviewed for relevant user comments.

Mail Survey Questionnaire

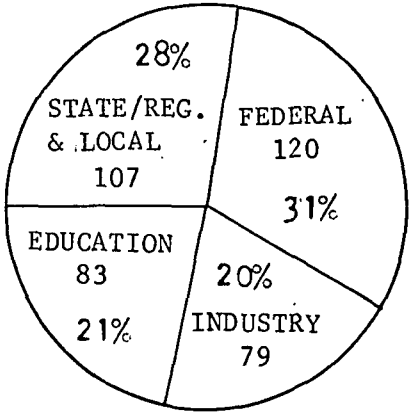
- Modified/Expanded Houston Survey Questionnaire with more emphasis on user assessment of ERS data relevance/benefits
- Mailing List Sources (Minus Houston Survey Respondents)
  - Recent ERS Symposia (Tenth International Symposium on Remote Sensing of Environment, Michigan, Pecora Memorial Symposium, etc.)
  - LANDSAT I & II Investigators
  - JSC, GSFC, and NASA Headquarters Mailing Lists
  - ERS Data Center Information
  - Professional Society Listings
- Mail Survey Statistics
  - Total Questionnaires Mailed - 1200
  - Total Responses - 389
  - Percent Responding - 32.5%

(Approximately one hundred twenty-six additional questionnaires were received too late for statistical analysis.)

Questionnaire Distribution Statistics



Questionnaires Mailed



Questionnaires Returned

FIGURE 5. USER MAIL QUESTIONNAIRE SURVEY

SPECIFIC ACTIVITIES ACCOMPLISHED - NON-SURVEY ACTIVITIES

To assist in developing and executing the surveys and to provide background information for interpreting survey results, a critical list of other activities was established and subsequently accomplished (see Figure 6). Foremost on this list was the requirement to interact with the three existing national ERS data centers to acquire as much user-oriented information as possible, especially that relating to identifying the most routine/frequent ERS data users. Information obtained during visits to each of the three existing national ERS data centers (EROS, USDA, and NOAA) proved extremely useful for establishing user interview priorities, providing ERS data use/user status, and providing trends on ERS data use information as viewed from the perspective of those currently involved in direct interactions with the ERS data user community. Other non-survey activities, viz., interviews with selected NASA personnel, analyses of other ERS related study results and surveys, and attendance at selected remote sensing symposia (especially the first William T. Pecora Memorial Symposium) were useful primarily in interpreting the significance of the survey findings. Several of these non-survey activities require some discussion because the results are indirectly utilized in this report. First, an analysis of the Houston ERS Symposium presentations was made and statistics compiled relative to (1) the user community representation per application/discipline category, (2) the level of application/use described, and (3) type of data used. Secondly, the computerized GSFC collection of NASA identified and evaluated LANDSAT I significant findings arranged according to their scientific, economic, technological and applications impact was analyzed to obtain insight as to the historical user status in the various application areas. This information, along with information available from other user surveys, interviews, and contemporary studies, helped to establish the conclusions and recommendations resulting from this survey itself.

ACTIVITY		PURPOSE
• VISIT ERS DATA CENTERS		• TO IDENTIFY MOST FREQUENT USERS AND DATA USER TRENDS
• INTERVIEW SELECTED NASA AND NASA CONTRACTOR PERSONNEL		• TO ESTABLISH OTHER KNOWLEDGEABLE VIEWS RE DATA USE/USER STATUS
• ATTEND SELECTED ERS SYMPOSIA		• TO GET "FIRST HAND" VIEW OF STATUS AND ATTITUDES OF USER PARTICIPANTS
• REVIEW NASA EARTH RESOURCES SURVEY SYMPOSIUM INFORMATION		• TO DETERMINE DOCUMENTED DISTRIBUTION AND LEVEL OF DATA USE WITHIN USER COMMUNITIES
• REVIEW LANDSAT-I SIGNIFICANT FINDINGS		• TO ESTABLISH DIRECTION AND SIGNIFICANCE OF PAST ERS DATA USE ACTIVITIES BY USER GROUP
• REVIEW OTHER ERS SURVEY FINDINGS		• TO TEST CONSISTENCY OF SURVEY FINDINGS AND EXPLAIN DIFFERENCES

FIGURE 6. ACTIVITIES OTHER THAN SURVEYS

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

SUMMARY

From the historical perspective, the experimental LANDSAT program in less than 4 years has acquired and placed in the public domain repetitive data covering almost the entire Earth's land surface. Much progress has been made in this short time period in the identification, evaluation, and development of practical applications for ERS data.

When progress is viewed from any perspective (i.e., discipline, user community, or geographical area), the result is an extremely favorable impression, considering the broad scope and sophistication of the technologies involved. The LANDSAT program is now in the transition from an experimental to a quasi-operational/demonstrational status. Once data collection systems and data analysis procedures and methodologies are refined, many operational LANDSAT programs will be implemented. The extent of LANDSAT program progress becomes even more evident when compared to historical accounts of other technological innovations (see Table 2 for 10 sample innovations) which have averaged close to 20 years from initial conception to realization of public use of the technology.

As impressive as the current record is, contrasting concerns continue to be expressed that:

(1) ERS data users and applications are not as extensive as claimed

(2) The ERS programs are moving too slowly, considering user needs and technologies available

(3) ERS programs are progressing too rapidly to permit complete understanding and effective adoption and implementation of practical applications, etc.

This survey has documented the current status of ERS data use as viewed from the perspective of the user, and has attempted to provide some insight as to how users feel about the possibilities of increasing ERS data use in the future.

TABLE 2. DURATION OF THE INNOVATIVE PROCESS FOR TEN INNOVATIONS[19]*

Innovation	Year of First Conception	Year of First Realization	Duration, years
Heart Pacemaker	1928	1960	32
Hybrid Corn	1908	1933	25
Hybrid Small Grains	1937	1956	19
Green Revolution Wheat	1950	1966	16
Electrophotography	1937	1959	22
Input-Output Economic Analysis	1936	1964	28
Organophosphorus Insecticides	1934	1947	13
Oral Contraceptive	1951	1960	9
Magnetic Ferrites	1933	1955	22
Video Tape Recorder	1950	1956	6
Average Duration			19.2

* References at end of text.

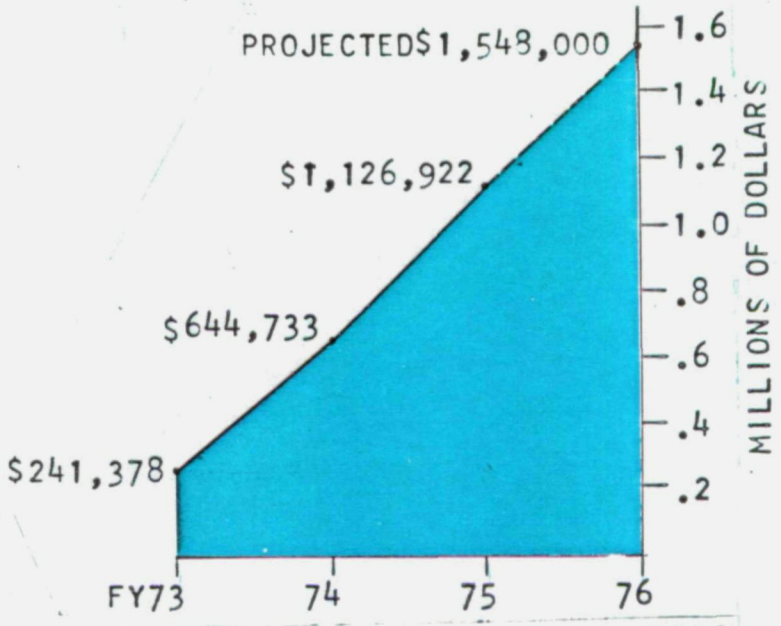
A fairly accurate representation of the extent of current ERS data use can be obtained by aggregating the business statistics from the three operational ERS data centers in the United States. Figure 7 depicts these statistics, which indicate a fairly substantial annual dollar volume increase since FY 1973, and projected through FY 1976 (a total dollar volume of over 3 million dollars). These figures indicate that the purchase of both LANDSAT frames and tapes continues to increase. For FY 1976, it is estimated that 280,000 LANDSAT frames and 2250 magnetic tapes will be purchased. This would make a total of over 700,000 LANDSAT frames sold since FY 1973.

Figure 8 shows the overall results of the survey in terms of ERS data users and data applications. The survey indicated the existence of a substantial number of current ERS data users. During this survey alone, over 700 users of several thousands estimated were identified. Lists of principal data users in the industrial, governmental, and academic communities have been included in the text of this report. These ERS data users include current experimental and routine data users, not planned and/or potential users. Based on federal data center LANDSAT sales (FY 73-FY 75) of slightly over $2 million and 500,000 LANDSAT frames, industrial (private sector) users are the largest single user group (in terms of both dollars and items), followed very closely by non-U.S./foreign data users. Federal governmental agencies and academic/educational users are about equal but considerably less than that of the industrial sector. Very, very small in relative comparison is the apparent degree to which state, regional (substate) and local governmental units are participating directly in the purchase of ERS data. However, their actual purchasing record at the federal ERS data centers may not be representative of their actual involvement, as university and private consultants provide substantial support to state agencies in using ERS data. Also, data center records indicate that approximately 25 percent of ERS data center use is by individuals of unknown organizational association.

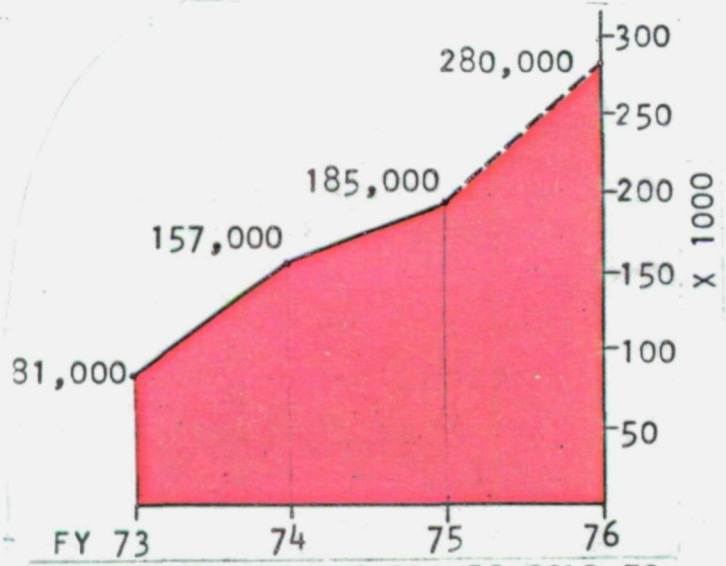
Types of ERS data currently being used are also indicated in Figure 8. User questionnaires indicate that more users are involved with LANDSAT imagery than with any other type of ERS data. The use of high-altitude aircraft data follows a close second. LANDSAT digital data and Skylab data are being used in about the same relative proportion (that is, by little less than 50 percent of users surveyed). Ground-based measurements are being conducted primarily by federal government and academic users.

LANDSAT DATA PURCHASE TREND

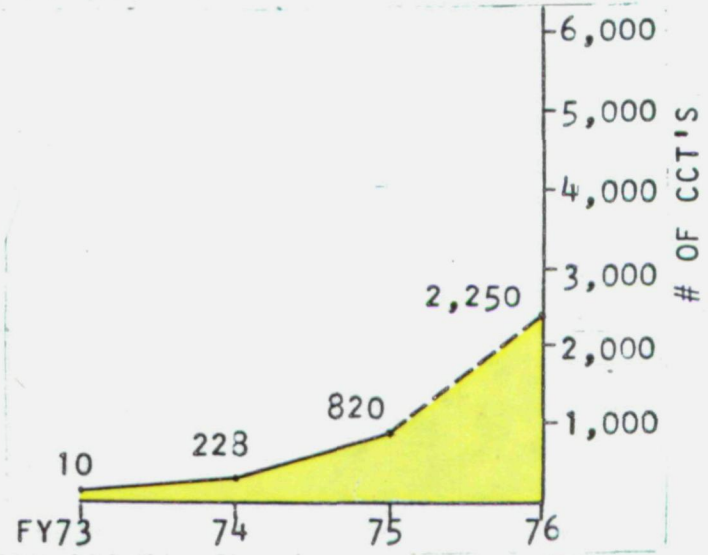
- RATE OF ANNUAL DOLLAR VOLUME INCREASE FOR LANDSAT IMAGERY USED (ALL DATA CENTERS) IS PROJECTED TO HOLD AT LEAST THROUGH FY76
- BOTH NUMBER OF LANDSAT FRAMES AND TAPES PURCHASED CONTINUES TO INCREASE



ANNUAL DOLLAR VOLUME SPENT BY ALL USERS FOR LANDSAT DATA BETWEEN FY-73-FY-75 PLUS PROJECTED VOLUME FOR FY-76(ALL DATA CENTERS)



ANNUAL NUMBER OF LANDSAT FRAMES SOLD TO ALL USERS(ACTUAL AND PROJECTED) DURING FOUR YEAR TIME PERIOD (EROS DATA CENTER ONLY)



ANNUAL NUMBER OF CCT'S SOLD TO ALL USERS (ACTUAL AND PROJECTED) DURING FOUR YEAR TIME PERIOD (EROS DATA CENTER ONLY)

Figure 7. DATA CENTERS' RECORDS OF EXTENT OF ERS DATA USE(1)

EARTH RESOURCES DATA SURVEY SUMMARY

MAJOR FINDINGS

DATA USERS

EXPLICIT NUMBER OF ERS DATA USERS EXISTS-

- THOUSANDS USING DATA CENTERS; HUNDREDS ON FREQUENT BASIS
- >700 USERS SURVEYED

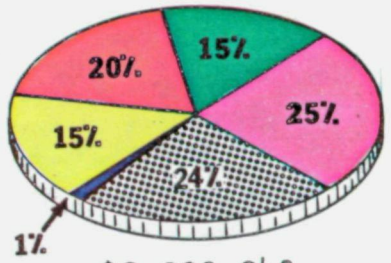
EXTENT OF USE VARIES AMONG USER GROUPS

- INDUSTRY LARGEST SINGLE USER GROUP
- STATE AND LOCAL GOVERNMENT USERS SMALLEST

DATA USED

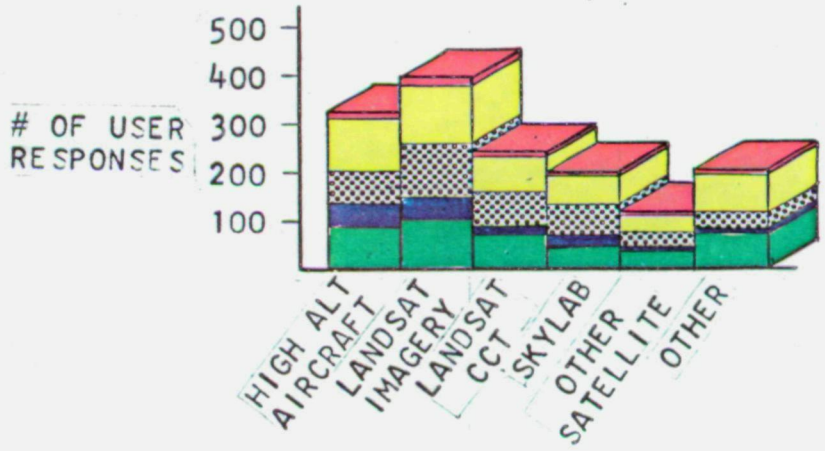
- LANDSAT IMAGERY USE SLIGHTLY LARGER THAN HI-ALT A/C IMAGERY USE
- ABOUT 1/2 USERS SURVEYED USE LANDSAT CCTS AND SKYLAB EREP DATA
- RELATIVE USE OF LANDSAT IMAGERY AND TAPES ABOUT EQUAL FOR INDUSTRIAL, FEDERAL, AND EDUCATIONAL USERS

INDUSTRIAL
OTHER
STATE
NON-U.S.
FEDERAL
EDUCATIONAL



$2,013,043
FY 73-FY 75

% OF TOTAL USER DOLLARS SPENT
ALL DATA CENTERS
(LANDSAT SALES ONLY)



TYPE OF ERS DATA USED

Figure 8. SUMMARY OF DATA USERS AND DATA USED[1-4]

As shown in Figure 9, current data applications among the various disciplines are fairly uniform with the exception of the peaks occurring in land use and geological applications. The more extensive ERS data use in land use and geological applications is most likely related to current national priorities and the high compatibility of current ERS data characteristics with discipline applications requiring a regional perspective. Likewise, environmental applications have lagged due to a combination of waning national interest and insufficient data detail to meet environmental monitoring and regulatory requirements.

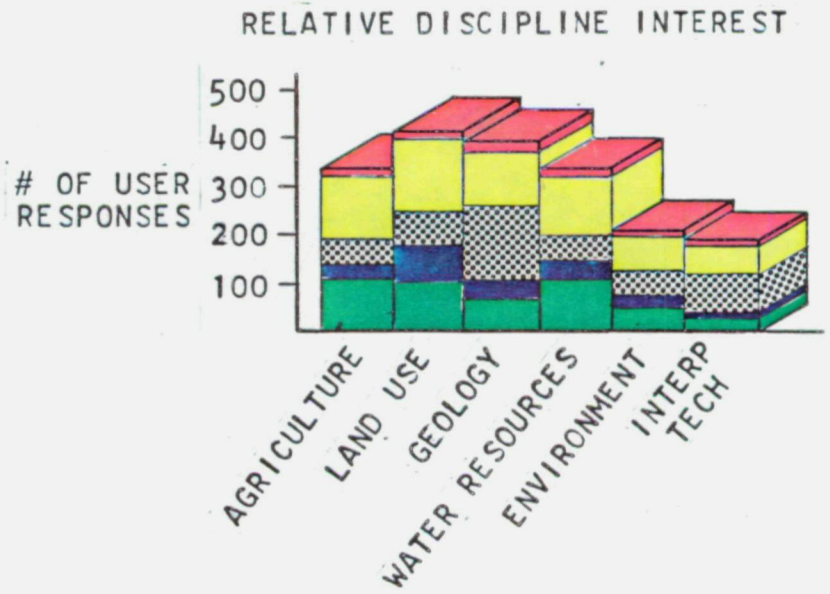
ERS data use for geologically related applications by the private sector accounts for the largest single data use category. Estimates are that industrial use of ERS data for mineral and fossil fuel exploration may be 10 times greater than other current applications. This type of use does not require much repetitive coverage, however. Secondary industrial applications include: land use/land cover studies; agricultural, forestry and other resource inventories; and facility siting assessments. Federal governmental agencies are actively pursuing all application disciplines, with the most substantial effort occurring in land use, agricultural, water/marine resource and geological applications. Because of the availability of funds and expertise, this user group represents the key to the effective transfer of ERS technologies to other governmental user communities. State, regional (substate) and local governmental users have been slow in developing operational ERS data programs, primarily because of a combination of funding and capability limitations, inadequate spatial resolution of LANDSAT imagery, and institutional arrangements and policies which adversely affect the technology transfer process. To date, the most progress made by this user group has been land use/land cover inventorying and mapping applications. Academic users are providing some of the leadership in developing techniques for using ERS data. Often the academic user is the means whereby geographically associated governmental and private organizations are being made aware of the application potential of ERS data. Foreign users are currently involved at all stages of data use from specialized, problem-solving experiments (such as general range condition monitoring in Lesotho, South Africa) to completely operational programs (viz., sea ice monitoring in Canada). U.S. training and user assistance programs, private industry involvement, and international support (UNDP and World Bank) are contributing factors to the growing impact of ERS data on developing countries.

EARTH RESOURCES DATA SURVEY SUMMARY

DATA USE

DISCIPLINE/APPLICATION INTEREST-

- FAIRLY UNIFORM LANDSAT DATA DISCIPLINE USES
- GEOLOGY/MINERAL APPLICATIONS AND LAND USE STRONGEST DATA USE AREAS
- AGRICULTURE/FORESTRY AND WATER/ MARINE RESOURCE SECOND
- ENVIRONMENTAL APPLICATIONS SMALLEST CURRENT USE CATEGORY
- INDUSTRY GEOLOGY/MINERAL DATA USE LARGEST SINGLE DATA USE CATEGORY



UTILITY ASSESSMENT

- LARGEST NUMBER OF USERS CONSIDER ERS DATA TO BE OF HIGH UTILITY
- UTILITY VIEW FAIRLY UNIFORM AMONG ALL USERS
- INADEQUATE SAMPLE EXISTS FOR FOREIGN USERS

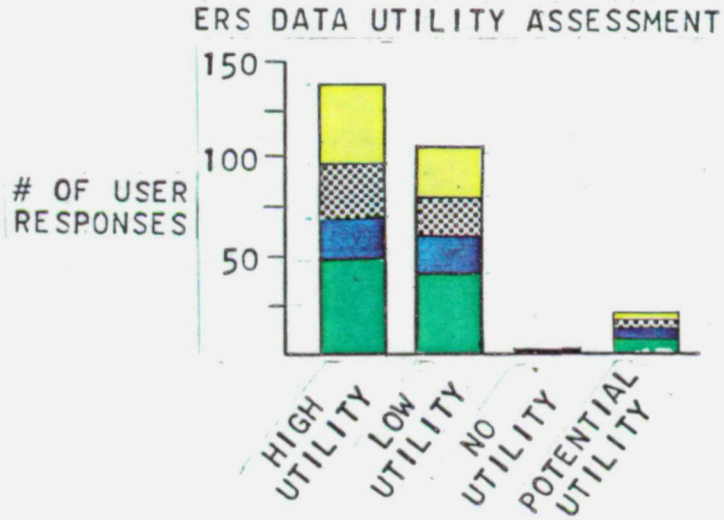


FIGURE 9. SUMMARY ERS DATA USE/UTILITY (ALL USERS)[2,4]

In general, survey results indicate that most ERS data users consider ERS data to be of high utility. As shown in Figure 9, the largest number of questionnaire respondents indicating low data utility were federal government users. In direct interviews, this user group also tended to be more critical than other groups of the lack of data responsiveness to many of their data/information needs. Figure 10 shows the results of more detailed user responses as to the current and potential value of ERS-type data according to individual discipline applications. Most users surveyed consider current ERS data and data products in general to represent a complementary data source which have the potential of becoming an important data source. Users feel that current ERS data products are of the greatest benefit to them because they represent a unique/new data source and a cheaper data source. Also, most users believe that ERS data systems have the potential of providing better data for most application areas. User assessments by discipline show that current ERS data products are most relevant to geological applications, land use activities and water resources interests. Most users feel that ERS data products will eventually be of most value to land use, agriculture/forestry, and water resources. Future ERS data were also considered to have high potential for providing unique data for environmental needs.

Although questionnaire responses from all user communities showed strong agreement that most current LANDSAT data capabilities could be considered as adequate, with the exception of data delivery (See Figure 11), interviews with representative ERS data users did not substantiate this assessment. A more accurate representation of current user views relative to the adequacy of current LANDSAT capabilities and corresponding user recommendations for improving LANDSAT data use are summarized in Table 3. Strongest user concerns and recommendations related to the need to improve data delivery and spatial resolution.

Battelle's evaluation of user recommendations and their probable impact on each user group is summarized in Tables 4 (LANDSAT 1 and 2) and 5 (future ERS systems). According to this assessment, the highest overall impact on current LANDSAT data use would occur by improving data quality on user products, providing more high-altitude aerial photography to be used in concert with LANDSAT data, and providing more user assistance/training programs. For improving data utilization of future LANDSAT-type systems, the greatest user impacts would result from significant improvement in data delivery (including a quick-look capability), more extensive spectral coverage, higher spatial resolution, development of specialized satellites, and acquisition of user data on an "as-needed" basis.

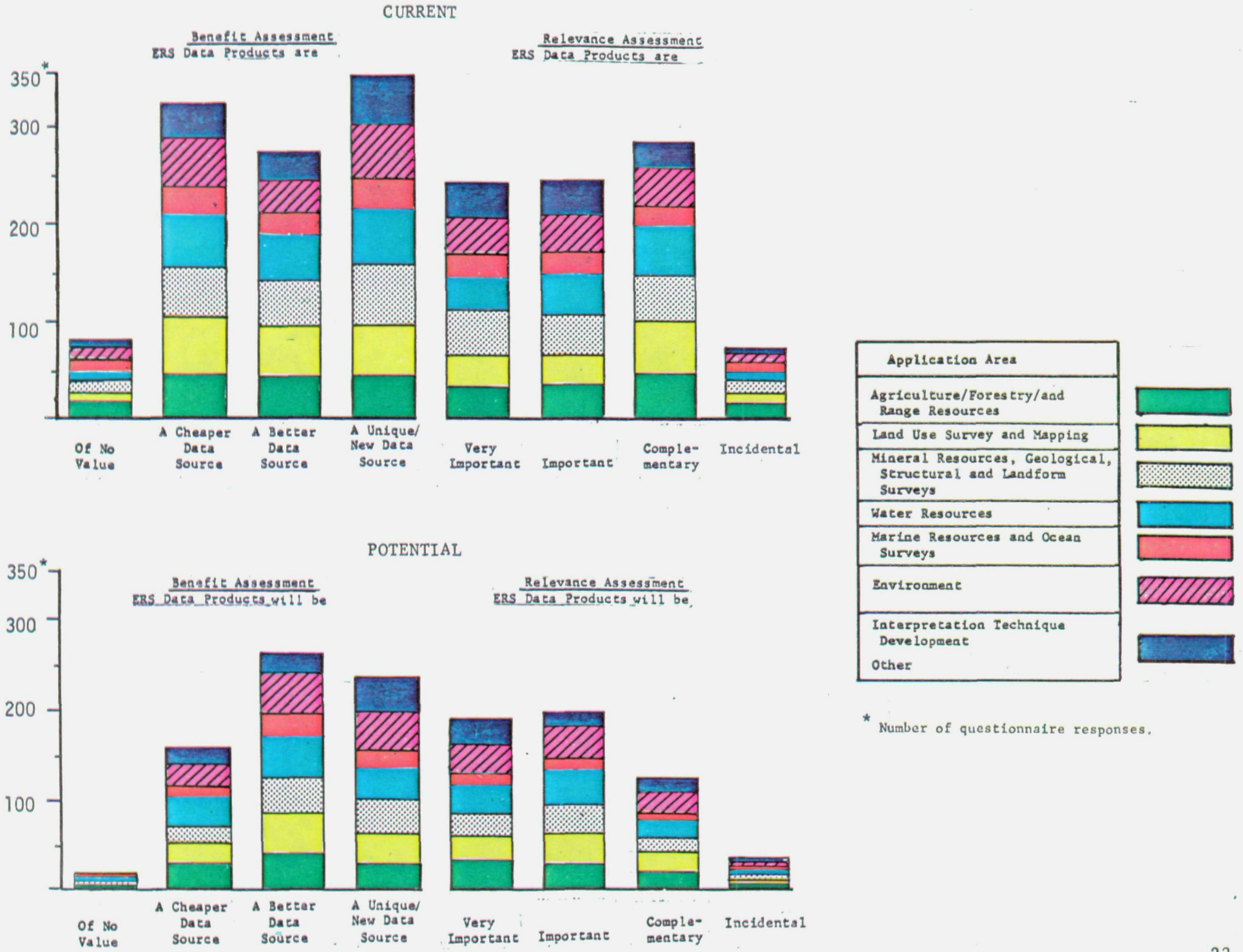
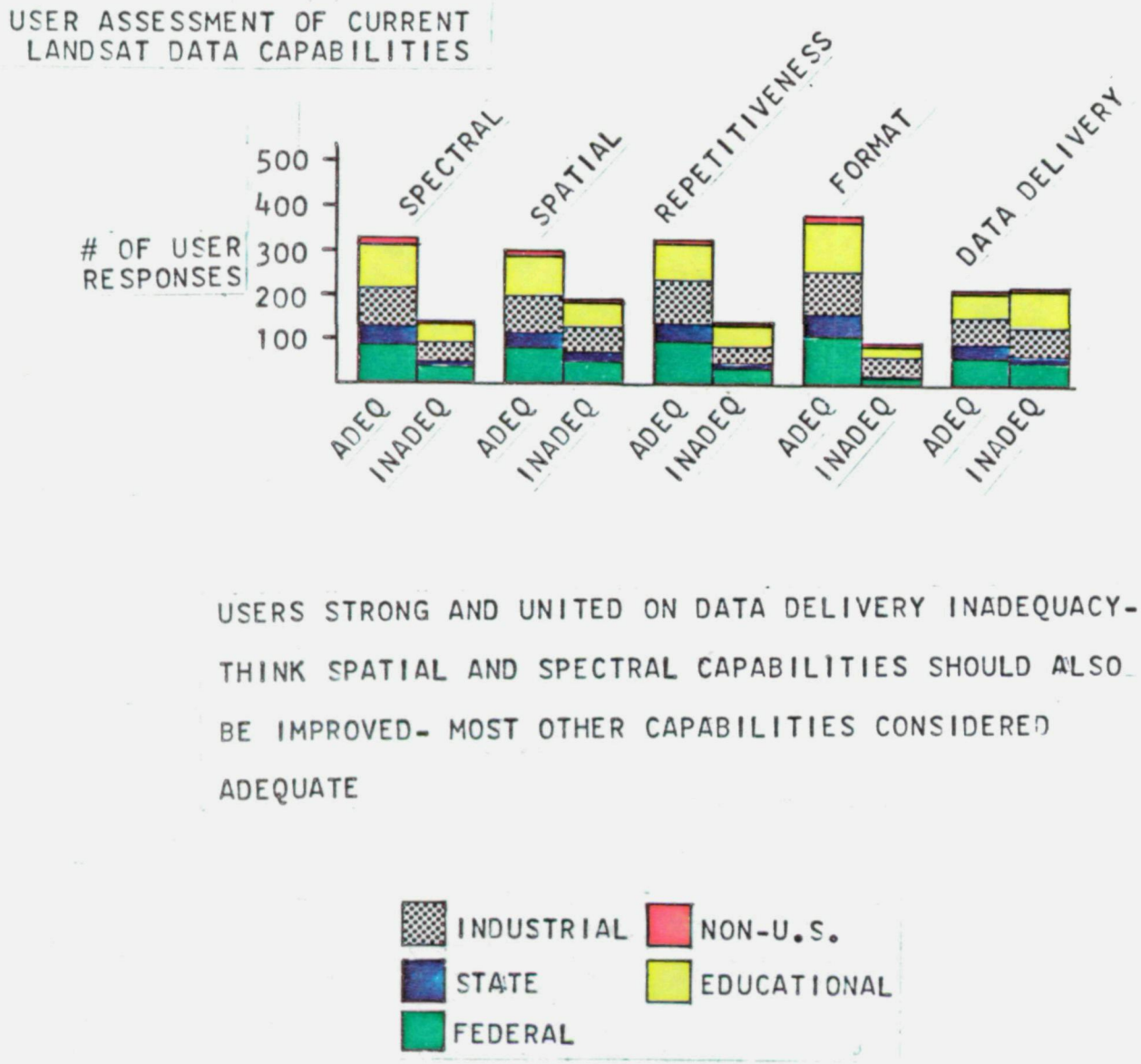


FIGURE 10. USER ASSESSMENT OF CURRENT AND POTENTIAL VALUE OF ERS DATA[4]

EARTH RESOURCES DATA SURVEY SUMMARY



USERS STRONG AND UNITED ON DATA DELIVERY INADEQUACY- THINK SPATIAL AND SPECTRAL CAPABILITIES SHOULD ALSO BE IMPROVED- MOST OTHER CAPABILITIES CONSIDERED ADEQUATE

FIGURE 11. SUMMARY OF USERS' ASSESSMENT OF LANDSAT DATA (ALL USERS)[2,4]

TABLE 3. USER ASSESSMENT OF CURRENT LANDSAT DATA CAPABILITIES AND RECOMMENDATIONS FOR STRENGTHENING DATA USE[2-7]

USER VIEWS	USER RECOMMENDATIONS
• Spectral Coverage - majority of users satisfied but many strong views as to limitations	• Most recommendations are for (1) extending spectral coverage into thermal and microwave regions, (2) providing additional visible and near IR bands, and (3) narrowing existing bands.
• Spatial Resolution - Majority of questionnaire responses indicated current spatial capabilities adequate for experimental and large area uses. User interviews (with exception of exploration users), however, showed strong views as to data utility limitations imposed by 80 meter resolution.	• Most users commonly recommended 20-40 and 10-20 meter resolutions. Some users (especially state and local users) desire spatial resolutions in the 1-10 meter range. In contrast, geologists want to retain large area (synoptic) perspective.
• Repetitive Coverage - Most users content with current LANDSAT data coverage except those concerned with environmental monitoring, snow mapping, flood drainage assessment programs, etc. and areas with extensive cloud cover.	• Strong recommendations related to other than repetitive coverage. Industry (and foreign users) in particular want more coverage of remote domestic and foreign areas and stereo viewing opportunities.
• Format Options/Product Quality - Strong user agreement on adequacy of current data quality.	• Most recommendations relate to providing more product options and better quality control.
• Data Delivery - Strongest area of user dissatisfaction in both questionnaire and interview results especially in considerations involving operational use.	• User recommendations were many and very strong on need to significantly improve this function. Desires for quick-look capability and 2-3 days turn around time were stressed.

TABLE 4. BCL ASSESSMENT OF RECOMMENDED OPTIONS FOR STRENGTHENING USE OF DATA FROM CURRENT LANDSAT SYSTEMS
(By User Community)

	INDUSTRY	STATE/LOCAL GOVERNMENT	FEDERAL GOVERNMENT	EDUCATIONAL/ ACADEMIC	NON US
DATA ACQUISITION AND PROCESSING					
• Shorten Data Delivery Time Between GSFC & EROS	H	L	M	M	L
• Improve Data Geometric and Radiometric Quality	H	H	H	H	H
• Provide more Data/Product Options (Special made Photoscales, Composites) and enlargements/enhancement of portions of frames)	H	H	M	H	M
• Provide more High Altitude A/C Data	H	H	H	H	NA
DATA UTILIZATION/TECH TRANSFER					
• Provide more Education/Training including "Hands on" opportunities	M	H	H	H	H
• Prepare family of user guides (to data availability, hardware/software available and application documentation.	H	H	M	L	H
• Provide more regional centers and browse files to assist users	M	H	L	M	NA
• Provide more funds for application development and verification	L	H	M	H	NA
• Commit federal user involvement	L	H	M	L	NA
• Insure LANDSAT program continuity	M	H	M	L	L
• Establish center for cataloging and loaning software developed for analyzing LANDSAT CCTs	H	H	M	M	H
• Organize more cooperative programs (viz. state and federal, federal and private, state and universities, etc.)	M	H	M	H	NA
• Adopt economic/social descriptors for ERS data use(s) rather than academic disciplines	L	M	M	L	H

Impact Scale
H = High Impact
M = Moderate Impact
L = Low/Little Impact
NA = Not Applicable

TABLE 5. BCL ASSESSMENT OF RECOMMENDED OPTIONS FOR IMPROVING USE OF DATA FROM FUTURE ERS SYSTEMS
(By User Community)

	INDUSTRY	STATE/LOCAL GOVERNMENT	FEDERAL GOVERNMENT	EDUCATIONAL/ ACADEMIC	NON U.S.
• Improve Data Delivery (to 2 to 3 days) and Provide Quick-Look Capability	H	M	H	L	H
• Provide More Foreign and Remote-Area Coverage	H	L	M	L	H
• Improve Spatial Resolution:					
2X (40 meters)	H*	M	M	M	M
4X (20 meters)	H*	M	M	M	M
1-10 meters	H*	H	M	M	H
• Improve Spectral Capabilities:					
Thermal	H	H	H	M	H
Microwave	H	M	H	M	H
Blue Band	M	L	H	M	L
Narrow Bandwidths	H	M	H	M	H
• Increase Frequency of Data Collection	L	M	H	L	M
• Provide Stereo Coverage	H	M	H	M	M
• Provide Specialized Earth Resource Satellites (e.g., sea ice monitoring, Geosat, Agsat, etc.)	H	H	H	L	H
• Acquire User-Requested Data on Near Real-Time Basis	H	H	H	L	H

* Other industrial non-exploration users.

Impact Scale
H = High Impact
M = Moderate Impact
L = Low/Little Impact

CONCLUSIONS

- An Extensive and Increasing Number of Explicit and Identifiable ERS Data Users Do Exist. They include (1) users purchasing and analyzing ERS data routinely using their own resources (selected private industry and most foreign-country users, (2) users developing and testing systems for routinely using ERS data for large-area, small-scale resource inventorying, monitoring, and modeling applications (mostly federal, state, and regional governmental cost-shared programs), and (3) users analyzing the data experimentally to evaluate the feasibility of additional ERS discipline applications and/or analysis possibilities (research and educational programs supported by all user communities, but largely federally supported).

- The Extent of ERS Data Center Use Varies Significantly Among the User Communities. The primary current ERS data user group is private industry, with both end-users and service-to-users participating (major use within the private sector relates to mineral and petroleum exploration interests). The second largest user community of ERS data is non-U.S./foreign users who are, in most cases, assisted by U.S. technology. Federal governmental agencies and the academic community are roughly tied for third place in extent of ERS data use, which involves all application interests. In last place are state, regional (substate) and local users, who appear to be more involved than data center records indicate.

- Relative Discipline Use of ERS Data is Fairly Uniform. Although land use and geological applications of ERS data appear to represent the largest current discipline application interests, overall data use among most ERS discipline/application areas (by all users) is fairly uniform. The exception is environmental use which has considerably less current user interest than the other disciplines.

- ERS Data Utility Varies Among Users and Uses. Most mineral and oil companies are of the opinion that current data use varies from important to very important in both domestic, and especially in foreign exploration, decision-making activities. They could not, however, provide specific dollar benefits, but many expressed a willingness to provide written statements testifying to the need for continuing acquisition of ERS data (with either current and/or improved LANDSAT systems). In contrast, most other users, although positive, were not as strong or consistent in their views as to the effectiveness and value of current ERS data products. User assessments by discipline show that land use and geology applications are the most relevant current uses of ERS data, but land use, agriculture/forestry and environmental applications will increase in importance in the future. In terms of overall benefits, users conclude that land use and water resources areas will benefit the most from ERS data.

- Significant Increase in ERS Data Users, Uses, and Value Will Result From Planned and Possible Improvements in Future LANDSAT System Capabilities. Extensive progress has been made in (1) linking users and user problems with ERS data capabilities, (2) identifying and conducting experiments to assess technical and economic application possibilities, (3) developing demonstration/quasi-operational systems (LANDSAT II and ASVT programs) for using the data routinely, and (4) identifying and developing improvements to upgrade operational uses of future systems. Planned, short-term improvements (e.g., LANDSAT C) will result in some use/user increase, but more extensive improvements in data acquisition, data processing (on-ground and on-board), data delivery and end-user experience and capabilities will be required before extensive, user-financed, ERS data use occurs on an operational basis.

RECOMMENDATIONS

Based upon information collected and evaluated during this survey, the following recommendations are offered:

(1) NASA should accelerate plans and programs to develop satellite ERS systems capable of providing improved data which can be more effectively utilized (technically and economically) by a larger cross section of private and governmental end users.

(2) NASA should develop and implement specialized technology transfer scenarios/plans to improve ERS data utilization within each user community and within each discipline area. Establishment of regional application training centers and specialized user workshops should receive high priority.

(3) NASA should adopt economic and social use descriptors in describing remote sensing applications (rather than technical/academic disciplines) in order to plan future programs more clearly with the end user in mind, and, equally important, to justify such programs according to user need.

(4) NASA should implement a combination of user surveys to help strengthen existing uses of ERS data and market-surveys to detect and promote new use/users of ERS data. Representatives from all user groups should actively participate in both types of surveys.

(5) NASA should make more information available to existing and potential satellite data users that will make them more cognizant of space plans, capabilities, and specific data participation opportunities. In remote sensing applications; the following information aids are very much in demand:

- More newsletters of the GSFC LANDSAT NEWSLETTER type
- A users guide to availability of remote sensing data (high-altitude A/C data as well as satellite data)

- A users' dictionary of remote sensing terms
- A users' guide to hardware/software for ERS data analysis
- A users' guide to remote sensing research and service industries and contractors
- A users' information hot-line so users can contact NASA relative to data application inquiries
- User handbooks for individual ERS data application areas

(6) NASA should take another hard look at the technical, cost, and application implications of developing specialized satellites (e.g., ice monitoring/navigation, geological exploration, environmental monitoring, etc.), especially in view of upcoming Shuttle and Spacelab opportunities.

(7) NASA should review on-going technology development programs and plans relative to their significance to future ERS systems and ERS data use. Programs having the highest potential for significantly improving ERS data use relative to user requirements should be discerned, and a determination made of the implications of accelerating their completion.

SURVEY RESULTS

PART 1. INDUSTRIAL USERS

PART 1. INDUSTRIAL USERS

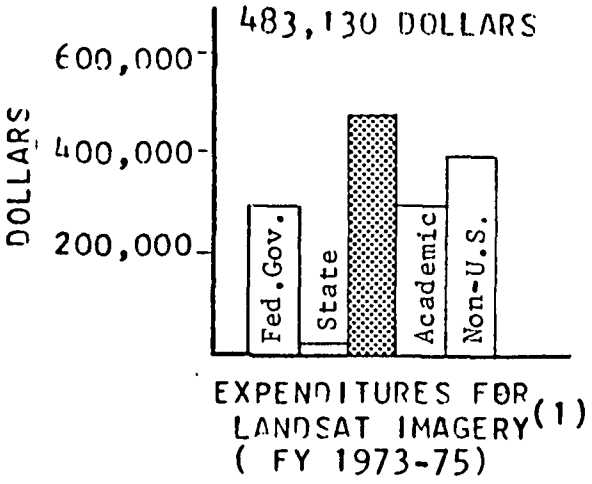
General Description

Private industrial users of ERS data primarily include mineral, petroleum and natural resource exploration companies, consulting firms, and data analysis equipment manufacturers. Private industry is currently the most prominent user of LANDSAT data. During a 3-year period (FY 1973 through FY 1975) industrial users purchased over 100,000 frames of LANDSAT imagery from the three ERS data centers at a cost of almost 0.5 million dollars.[1]* Figure 12 gives a private industry profile for ERS data use.

The most prominent industrial users of the data, however, are major and independent mining and petroleum companies, consulting firms, and services and equipment suppliers. These companies and other identified private-sector LANDSAT data users are shown in Table 6. Companies prefixed with an asterisk are considered to be the most frequent users, based on ERS data center user records, telephone interviews, or user questionnaires indicating a current standing order or frequent user status. Infrequent data users or companies only currently indicating a potential/ planned user status were not included in the table.

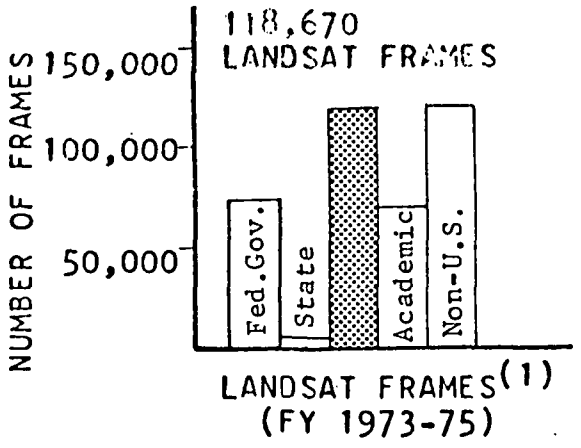
During FY 1973-75, over 2000 industrial users of the three data centers requested 24 percent of all LANDSAT data by item and dollar value. If industrial requests for other Earth resources data (such as Skylab and high-altitude aircraft imagery) are included, then requests by this user group alone account for 34 percent by item and 30 percent by dollar value. It is known that the industrial users utilize the data predominantly for exploration purposes. The intensity of activity in the oil and mineral exploration area at this time may be appreciated from the fact that nearly 50 percent of all ERS data from the EROS center is being used for mineral and fossil fuel exploration and geologic mapping activities.[1]

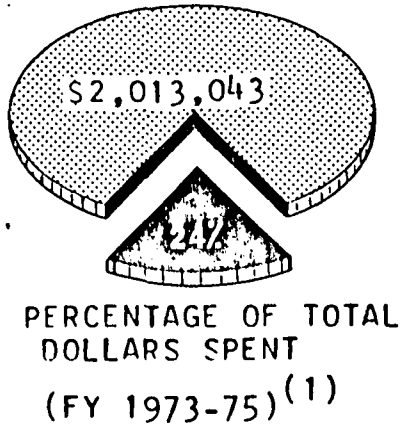
*References at end of text.



INDUSTRIAL USERS(1,2,4)

- Most Prominent Data User (Number of Items and Costs)
- Majority are Petroleum and Mining Companies
- Purchased 24% of LANDSAT Frames and 30% of all ERS Data Sales Over a 3-Year Period
- Number of Frequent and Infrequent Data Orders About Equal





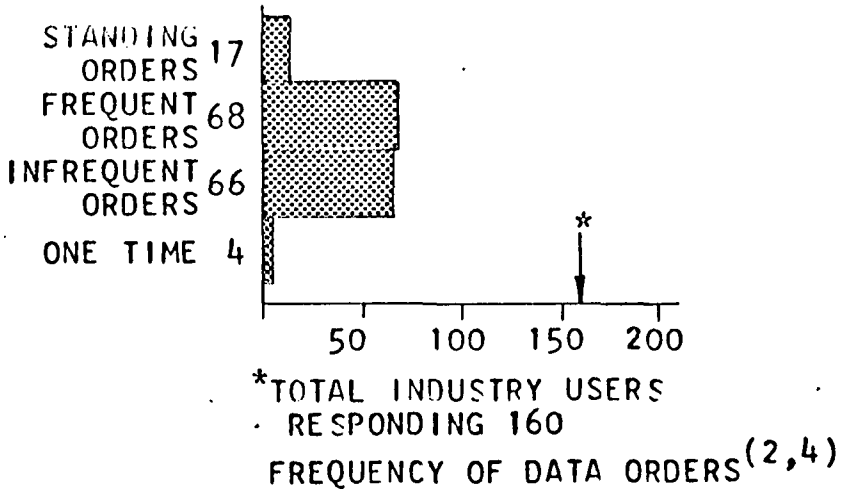


FIGURE 12. PRIVATE INDUSTRY EARTH RESOURCES SURVEY DATA USER PROFILE(1,2,4)

TABLE 6. PRIVATE INDUSTRY USERS OF LANDSAT DATA[1-4]

AAAS

American Smelting and Refining Company

* American Society of Photogrammetry

* AMOCO, including: Chemical Corporation, International Oil Co., Minerals Company, Oil Company, and Production Company

Anaconda Company

* Anderson Clayton

* Argus Exploration Company

* Atlantic Richfield Company

* AVCO Systems Division

* Battelle-Columbus

* Battelle-Northwest

Bausch and Lomb, Inc.

* Bechtel, Inc.

* Bechtold Satellite Technology Corporation

* Bendix Aerospace Systems Division

* Burk and Associates, Inc.

* California Earth Science

Cargill, Inc.

* Casual Living, Inc.

Century Oil Management, Inc.

* Chevron Oil, including: Chevron Overseas Petroleum, Chevron Oil (Field Research), and Chevron Chemical Co.

* CH_2M Hill

* Cities Service Oil Co.

* Cities Services Minerals

Coastal Mining Co.

* Columbia Gas System Service Corp.

* Computer Science Corporation

* Continental Oil Co. (CONOCO)

Cook Industries

H. E. Cramer Co., Inc.

* Cyprus Georesearch Co.

Daedalus Enterprises, Inc.

Dames & Moore Engineering

* DBA Systems, Inc.

Dicomed Corporation

Dow Chemical Company (Oil and Gas Division)

C. S. Draper Laboratory

Dresser Industries (Olympia Division)

Duval Corporation

* Earth Satellite Corporation

Eason Oil Company

* EDCE D'Appolonia, Consulting Engineer

EG and G, Inc.

* Environmental Research Institute of Michigan

*Most frequent industrial users.

TABLE 6. (Continued)

* Environmental Research and Technology, Inc.

* ESL Incorporated

ESSO Production Research Co.

* Exxon Company USA (Exxon Production Research Co.)

* Forest Oil Corporation

French American Metals Corp.

Garrand Corporation

General Crude Oil

* General Electric

Geoscience - A Division of Geosource International

Geo Space Corporation

* Geospectra Corporation

Getty Oil Co.

Goodyear Aerospace

* Grumman Corp., including: Grumman Aerospace Corp., and Grumman Data Systems Corp.

* Gulf Oil

Honeywell, Inc.

Houston Light and Power

* Hunting Surveys and Consultants, Inc.

HRB-Singer, Inc.

Institute for Storm Research

International, Inc.

International Business Machine Corp.

Itek Corporation

* Kennecott Exploration, Inc.

Kerr McGee Corporation

KSTP Weather Service

Law Engineering Testing Co.

Lindsay Earth Exploration and Mineral Resources Co.

* Lockheed Aircraft Corp., including: Lockheed Missiles and Space Co.

Lucias Pitkin, Inc.

* Martin Marietta Corporation

Mead Technology Laboratories

* Metrics, Inc.

Mineral Resources Co.

Minerals Corporation

Mitre Corporation

* Mobil Oil Corporation

Mobil Research and Development

Motorola Aerial Remote Sensing

Murphy Oil Company

National Grain and Feed Association

NUS Corporation

Occidental Petroleum Corporation

Oceanographic Services, Inc.

The Oil Shale Corporation

* Operations Research, Inc.

* Overseas Petroleum, Inc.

* Peabody Coal Company

Phelps Dodge Corporation

* Phillips Petroleum Company

Public Relations Associates

Karl Pugh and Associates

*Most frequent industrial users.

TABLE 6. (Continued)

* Rand Corporation

Raytheon Company

RCA

Real Estate Development Company

Research and Development Company

Research Triangle Institute

Resources and Chemical Corporation

Resources Development Association (Los Angeles, California)

R. M. Towill Corporation

* Rocky Mountain Energy Company

Saint Joe Minerals Corporation

* Science Applications Laboratory

Seiscom Delta, Inc.

Shell Oil Company

Southern Industries, Inc.

Southwestern Exploration Assoc,

St. Regis Paper Company

* Standard Oil Company of California

* Superior Oil Company

* System Planning

TASC

Tech/Ops., Inc.

Tensor Industries

Terra Resources, Inc.

Tetra Tech, Inc.

* Texaco, Inc.

* Texaco, Inc. (Tyler Division)

* Texas Instruments

Trollinger Geological, Inc.

* TRW Systems

Union Carbide

* Union Oil Company

* Union Oil Company of California

* Union Oil of Canada

Utility Data Corporation

UV Industries, Inc.

Van Houten Associates

VTN Consolidated, Inc.

Western Scientific

Westvaco Corporation

* Woodward-Clyde Consultants

Wright Water Engineers

*Most frequent industrial users.

In terms of frequency of data orders, questionnaire surveys showed that most companies have standing ERS data orders or frequently request ERS data. Users having standing and frequent orders are, again, mostly in the geology (mineral and oil exploration) application area. Very few industrial users are only one-time data requesters.[2,4]

Industrial users are currently using ERS data for:

- Exploration for minerals and fossil fuels
- Power plant sitings
- Land use inventories
- Agricultural and forestry inventories
- Construction industry activities (e.g., soil mapping, hazardous geological areas, etc.).

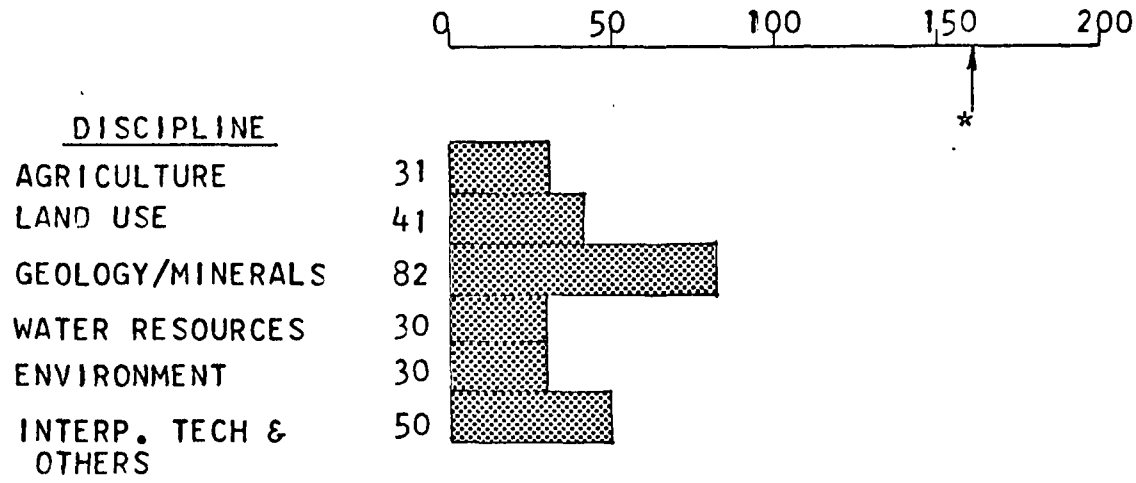
As shown in Figure 13, over half of the industrial users surveyed were analyzing LANDSAT data for geologically related applications. On an average, each user was involved in more than a single discipline use. Almost all companies use LANDSAT imagery, and nearly half are using high-altitude aircraft, LANDSAT CCT's (computer compatible tapes), and Skylab EREP (Earth Resources Experiment Package) data. Only a small number of industrial users make corroborative ground based measurements. Use of ERS data is mostly categorized as being for research and planning in connection with routine operations. As expected, most ERS data use in private industry is self-funded, with some government support for experimental programs, see Figure 14.

Evaluation of Specific Data Use

Private industry in the U.S. is currently the most efficient user of LANDSAT imagery and digital tapes. Unlike other user sectors, the private industrial user has utilized the data in a no-nonsense approach for problem-solving, decision-making and planning. Industry has done so using primarily its own resources.[1-6]

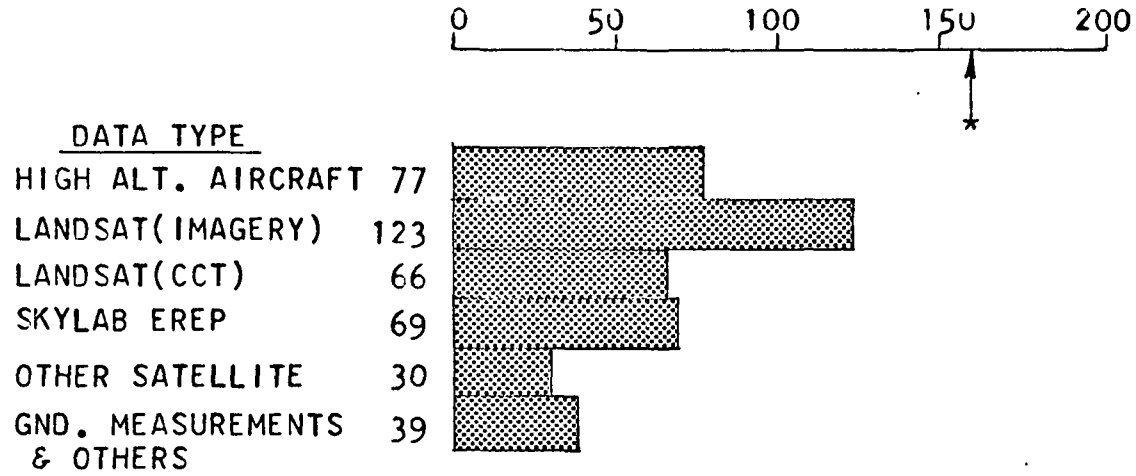
RELATIVE DISCIPLINE INTEREST[2,4]

- About One-Half of All Industrial Users Involved in Geology Discipline Area
- Fairly Uniform Interest Exists Throughout Other Discipline Areas
- Each User Involved in More Than One Discipline/Application Area



RELATIVE TYPE OF DATA USE[2,4]

- Almost All Private Sector Uses Involve LANDSAT Imagery
- High-Alt. A/C, LANDSAT CCT, And Skylab/EREP Data Are in Use by Nearly Half of Industrial Users
- Less Than One-Fourth of Industrial Users Making Ground-Based Measurements.

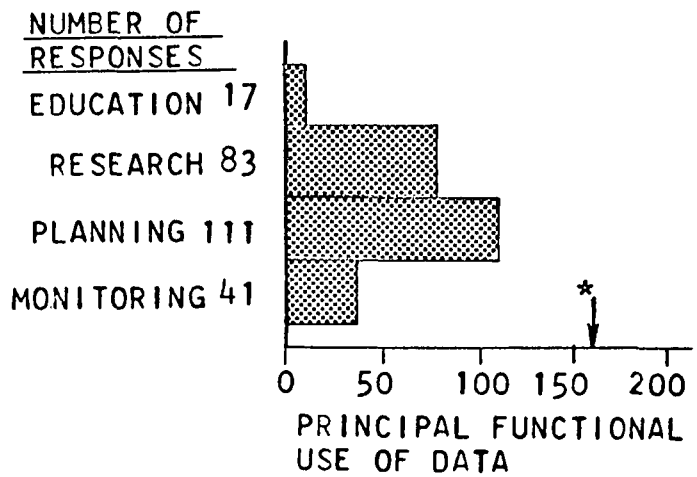


*Total Industry users responding - 160.

FIGURE 13. INDUSTRY - GENERAL DATA USE STATUS

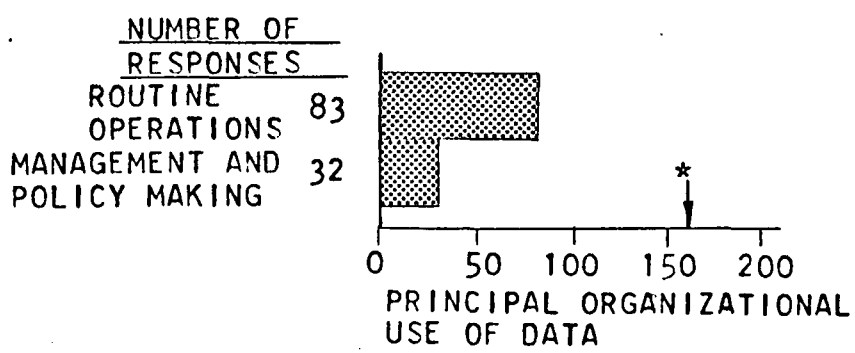
RELATIVE FUNCTIONAL USES OF ERS DATA[2,4]

- Major Private Sector Use of ERS Data is For Planning
- Research is Second Largest Data Use Area



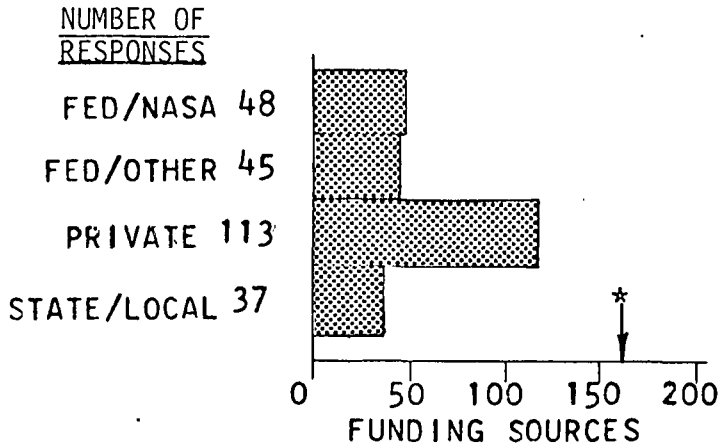
RELATIVE ORGANIZATIONAL USES OF ERS DATA[2,4]

- Over Half of Private Sector Users Use Data Routinely in Support of Their Functional Activities
- Management and Policy Making Uses Are Much Less



FUNDING SOURCES[2,4]

- Most Routine ERS Data Use Self-Funded
- Considerable Support From Federal Agencies For Experimental Programs



* Total Industry Users Responding - 160.

FIGURE 14. INDUSTRY - TYPES OF USES AND FUNDING SOURCES

There are basically two types of users of LANDSAT data in industry:

(1) End users who use in-house capabilities or consulting firms for locating and/or monitoring natural resources, such as minerals, fossil fuels, crops, timber, water, etc. Predominantly represented in this group are mineral and petroleum exploration companies.

(2) Service-to-users who assist end users (in private industry, government, and foreign countries) by developing hardware and software for analyzing LANDSAT data. Service-to-users provide services for analyzing and interpreting the data, usually through digital processing techniques. This group is strongly represented by aerospace and data processing companies who have traditionally been active in remote sensing and data processing techniques.

To more accurately define the scope and level of ERS data use within the industrial sector, direct interviews were made with over 100 users representing a cross section of both end users and service-to-users. The following discussion includes first a synopsis or overview (Table 7) of who was contacted (by general industrial class, i.e., exploration companies, agri-business, etc.) and findings relative to proposed level of and effectiveness of ERS data use to date. Secondly, a more detailed discussion is provided which summarizes users' comments as to how specifically the data are being used. Included in this discussion are sample excerpts which more accurately reflect the views and attitudes of the current industrial ERS data users.

In this analysis, three levels of ERS data use were considered and are defined as having the following meanings:

(1) Experimental Use - Evaluation of use/application possibilities (involves technical, economic and institutional assessments)

TABLE 7. INDUSTRIAL USER - INTERVIEW SYNOPSIS

Type of Organization	Type of Contact	Interest	Estimate of Data Use: Planned Potential	Experimental	Quasi-Operational	Routine/Operational	Evaluation of Data Use
• Oil companies (major and independent) such as: Mobil Oil CONOCO Phillips Texaco Standard Oil EXXON Chevron Union Oil General Crude Oil plus branches	Sr. geologists, engineers, researchers, top management personnel	Exploration for gas, oil, and minerals				X	• Private sector with strongest data use • LANDSAT data have complemented, not replaced, traditional aircraft and/or ground-based surveys • Data considered cheap, available complement, especially in foreign areas where aircraft coverage is not readily available
• Exploration companies • Consulting services and expertise for exploration to oil companies		Consulting geological services					• Data good for regional surveys, not good for classification schemes in detailed mineral exploration
• Utility companies • Paper companies • Agribusinesses	Researchers, engineers, management	Site selection, land use analysis, crop and forest inventory		X			• Data have provided good leads, and savings of 1:2 to 1:3 in exploration industry
• Aerospace, data reduction, computer hardware, research companies (Bendix, Earth Satellite Corp., GE, Texas Instruments, etc.)		ERS data analysis, development of hardware and software for ERS data			X		• Data are used primarily in photographic, secondarily in digital formats

(2) Quasi-Operational/ Demonstrational Use - Development and demonstration of a methodology and/or system for routinely using satellite ERS data

(3) Routine/Operational Use - User-financed employment of a methodology and/or system for routinely using satellite ERS data.

Data Use by Exploration Companies[3]

The industrial user uses LANDSAT data to augment decision-making processes and monitoring techniques traditionally based on aircraft and ground surveys. The most successful use of the data is being made by companies which search for and market minerals and fossil fuels. Use of the satellite data has become routine within this group.

The reason for this use is that the satellite provides a unique perspective for geologists never enjoyed before. It enables 34,000 square kilometers to be viewed in a single photo, in four spectral bands. Geologic features can be traced uninterrupted for tens and hundreds of kilometers, and comparisons can be made of geological features hundreds of miles apart in a single or in a few photographs. Users of the LANDSAT data have stated in direct interviews:

- "We have observed lineaments which we did not know were there." (Research Specialist, Major Oil Company)
- "LANDSAT data have been fully satisfactory----good beyond expectation." (Senior Geologist, Major Oil Company)
- "LANDSAT data provide the broader perspective of a geological scene." (Senior Geologist, Remote Sensing, Major Oil Company)
- "We are using the data primarily for domestic exploration (and) would make use of the data even more strongly if we were involved in foreign exploration." (Senior Geologist, Oil Company)
- "LANDSAT data are very useful to us - and definitely not ancillary to our effort." (Research Scientist, Major Oil Company)
- "We consider LANDSAT data so important that we are willing to provide written testimony to help insure program continuation." (Earth Scientist in International Exploration, Major Oil Company)

- "LANDSAT data is adequate for present regional reconnaissance. For detailed classification the spectral resolution is poor." (Senior Research Associate, Major Oil Company)
- "We consider the LANDSAT resolution more than adequate." (Senior Engineering Associate, Major Oil Company)
- "We consider LANDSAT data as a windfall for our clients."
  "We use LANDSAT data routinely for power plant site selection purposes."
  "Use of the LANDSAT data for geo-technical purposes saves us a lot of time; previous efforts took a lot more time. We are happy with the data as it is."
  (Project Manager, Consulting Company to Exploration Company)
- "Our company is using LANDSAT data for operational exploration."
  (Research Associate, Major Oil Company)
- "LANDSAT program is of great benefit and is widely used in exploration."
  (Senior Research Associate, Major Oil Company)
- "LANDSAT is the greatest thing to happen to exploration in the last fifty years".
  (Geologist, Remote Sensing, Service and Consultant Company to Petroleum and Mineral Exploration Company)
- "We use the data quite extensively for exploration - it is important to us."
  (Management, Oil Company)
- "We are in an early stage of analysis capability development to use LANDSAT data for exploration." (Senior Research Geologist, Major Oil Company)
- "We consider LANDSAT imagery important to our operation; we have obtained quite a few leads from it." (Senior Geologist, Major Oil Company)
- "Our company uses LANDSAT data for preliminary exploration." (Vice President, Exploration and Service Company)
- "The data are essential to us over foreign areas where little aircraft coverage is available." (Research Associate, Major Oil Company)
- "We are using LANDSAT data domestically for refining regional data, in areas of extensive faulting and fracturing." (Geologist, Major Oil Company)
- "In areas where we find gas, we realize a cost saving of 1:2 to 1:3 over conventional surveys." (Research Engineers, Major Gas Exploration and Supply Co.) (Above quotes made by separate individuals.)

These views represent typical comments expressed in personal contacts and interviews with senior-level research and management staff of industrial end users primarily in the exploration industry or consultants to that industry.

End users in exploration make use of the LANDSAT data for:

- Regional surveys to identify and map large-scale linear and circular geological features for locating mineral and fossil fuel deposits. Such surveys have been conducted domestically in Alaska, Arizona, California, Nevada, and Pennsylvania. Abroad, such surveys have been conducted in East Africa, South America, Iran, and Yemen. Since anomalies in the Earth's crust are typically 1 to 200 meters in width, the resolutions obtainable with LANDSAT I and II were considered by many end users in the exploration industry as being adequate, and even desirable, for delineating these anomalies in the Earth's crust. Geologists were quite concerned that a possible increase in spatial resolution might result in a possible reduction in area coverage by the LANDSAT scanner.
- Geological mapping, especially of foreign areas where little, or only poor, photographic and cartographic information is available. LANDSAT data have, in most cases, improved the geological map data currently available. They (1) provide a quick and inexpensive means to map and locate remote and foreign areas of significance in exploration, (2) provide additional geological detail not delineated from aircraft sensors, and (3) augment the interpretation of gravimetric and aeromagnetic data.
- Providing a short-term data base essential for timely leasing decisions of areas suitable for the exploration of oil, gas, or minerals.

Case Study: Industry. The successful and vigorous application of LANDSAT data is typified by one prominent petroleum company which is currently using the data in the exploration for fossil fuels and minerals: In the mid-sixties the company became aware of the potential declassified versions of military thermal and microwave sensors. Initial contracted surveys provided positive results. Consequently, the company developed its own airborne survey and data analysis facility. By the time LANDSAT data became available, the company's research and exploration staff had a significant experience in the application of remote sensing techniques as applied to geo-exploration. Initial experimentation involved mostly the LANDSAT imagery analysis. After having established viable photographic analysis techniques, the company has more recently begun to utilize the LANDSAT digital data. Not having a digital processing facility, the expertise and equipment of prominent data analysis companies were contracted. The company is now considering building its own hybrid data analysis system, using the best equipment available on the market. However, the philosophy of the company is to provide the field personnel with the LANDSAT data for analysis in the field, rather than having a centrally located analysis laboratory provide such interpretation exclusively. To support remote sensing data use within the company, a worldwide, in-house indexing system for LANDSAT data has been established. The file is compiled by interrogating the EROS master index tape and plotting the LANDSAT center points on worldwide maps. Data are sorted by cloud cover quality and season. Current utilization of the data includes regional surveys, the plotting of large geological features, geological mapping and trafficability studies. To date, only in-house resources were used in all efforts by the company to utilize the data. The combination of user need, user experience, and sufficient data responsiveness has resulted in the development of a beneficial, user-supported program for routinely using satellite Earth resources data. To inform other users of the potential of LANDSAT data, the company's management has released publications on its findings.(3)

Other End-User Applications(3)

To a lesser degree, industrial end users have made use of LANDSAT data for agricultural and forest inventories, land use planning, water resource and environmental quality monitoring. In many of these applications, users have a need for higher spatial resolution. Also, the complexity

and cost of data analysis procedures (usually digital processing) required to use LANDSAT data effectively are greater. Of these, power plant site selection activities seem to be the most advanced and most routine.

Data Use by the Service-to-User Industry[3]

This category of industrial users has adopted satellite data as a logical means to broaden its product line and services. Since the launching of LANDSAT I, the service-to-user industry has made an extensive effort to either modify existing or develop new hardware and software for analyzing LANDSAT data. Multispectral cameras, additive color viewers, density slicing viewers, digitizers, digital processing equipment, etc., have gained wide acceptance in the general user community. It is difficult to imagine that LANDSAT data would have been accepted as readily without the existence of data analysis equipment. Some of the most sophisticated and advanced techniques for analyzing satellite data have been generated by the service-to-user community, which is strongly represented by aerospace and data processing companies, who have been traditionally active in remote sensing and data processing activities.

The service-to-user community also provides analysis services in a wide range of disciplines, such as:

- Land use
- Exploration
- Agricultural and forest inventories
- Water resource and environmental monitoring
- Analysis technique development.

Funding of the service-to-user community comes from Federal, state, industrial, and private in-house sources.

Comments were solicited from service-to-user representatives to determine the optimism with which they view current and future LANDSAT data use. Most believed that LANDSAT data would be increasingly used, and that there existed good opportunities in developing hardware and processing techniques, domestically and in foreign markets. Frequently, service-to-user representatives felt that their own technology (hardware and software) was capable of turning out a better LANDSAT product than provided by NASA GSFC or the EROS Data Center. Most felt that the technology pool in the U.S. will not be readily copied or duplicated by foreign competitors for many years, the western European countries excepted.(3)

Selected user comments which represent existing attitudes of this user group include(3):

- "We regard LANDSAT I and II as a starter system - to put up more than two without improving the service payload does not make sense." (Research Engineer, Remote Sensing Research and Service Company)
- "The use of orbital data is still at a very uneducated place---but much better than it was 3 years ago." (Senior Researcher, Data Acquisition and Analysis Company)
- "Oportunity for providing technical service is less than adequate at this time, but hardware sales, particularly on an international basis, flourish." (Manager, Market Development, Equipment and Sensor Company)
- "We see the development of LANDSAT technology and uses as a long, drawn-out R&D exercise." (Manager,Market Development, Equipment and Sensor Company)
- "Most foreign markets are applications oriented, not technology oriented." "We want timeliness, reliability, consistency, and future systems which provide four times better resolution, 20 m instead of 80 m, as well as two thermal bands." (Senior Researcher, Data Acquisition and Analysis Company)
- "We want a guarantee that the data will continue to flow." (Research Engineer, Research and Service Company)
- "LANDSAT data have been the catalyst for an increased use of remotely sensed data and the hardware for analyzing such data. We anticipate a steady increase in the need for services in this area. (Research Engineer, Photogrammetry Analysis Equipment Division of Optical Hardware Company, Also Sales Representative, Aerospace Company)

How Industrial Users View ERS Data[2-4]

Data Use Assessment

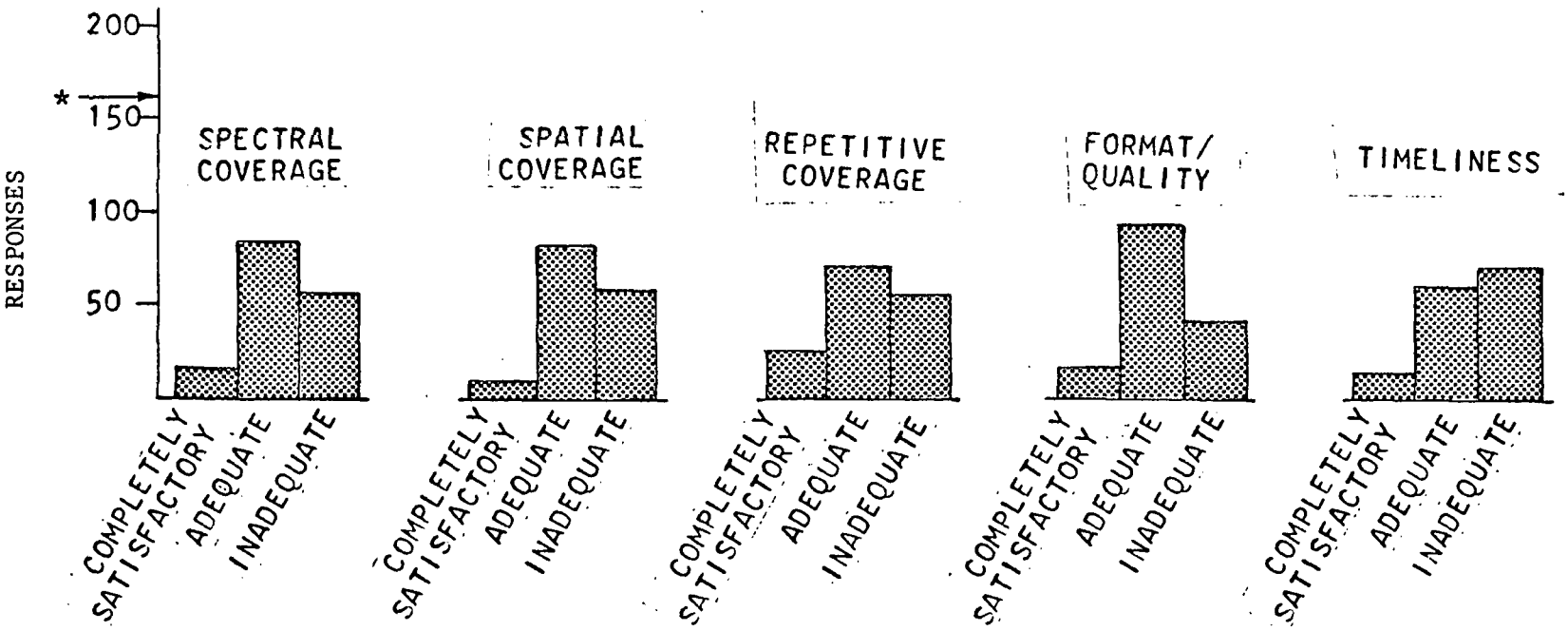
As supported by other sources, industry questionnaire responses indicated a strong benefit and relevance assessment for current ERS data products in the geology/minerals discipline area. Impact on all other discipline interests was assessed fairly uniformly by the industrial users. Most industrial users believe current ERS data products are better and cheaper than conventional sources. Also, industrial users consider future ERS data will be a better data source to the environmental and agricultural/forestry areas. Whereas most industrial users consider current ERS data products to be relevant to their needs in that they complement existing data sources, they are projected to become important data sources in the future, especially for agricultural and environmentally related applications.[4]

LANDSAT Data Evaluation

Through questionnaires and personal interviews, industry users commented on various aspects of LANDSAT data. The most frequently mentioned items were related to:

- LANDSAT MSS spectral characteristics
- LANDSAT MSS spatial resolution
- LANDSAT MSS image quality
- Timeliness of data delivery
- Frequency of data collection
- LANDSAT data collection over remote and foreign areas
- Stereo coverage
- Browse file availability.

Spectral Characteristics. One of the most frequently voiced criticisms of LANDSAT data by the industrial user was that sensor coverage was chosen only in the visible and near infrared portions of the electromagnetic spectrum. The geoexploration industry complained that LANDSAT I and II were essentially "agricultural satellites", and that the bands were not picked to maximize geologic applications. Among other reasons, spectral resolution is considered a problem in mineral exploration where rock color is an important means of locating and identifying minerals. Users in industry also felt that the present spectral bandwidths were much too wide for optimum use. Others felt that, given the present spectral bands, one band should cover the blue band so that natural color, not false color, composites can be made, again to aid in mineral exploration. Although questionnaire responses showed that more than 50 percent of the industrial users view LANDSAT spectral coverage as "adequate" (see Figure 15),



- FEW COMPLETELY SATISFIED WITH CURRENT LANDSAT CAPABILITIES
- MAJORITY OF USERS RESPONDING TO QUESTIONNAIRE SURVEY INDICATED MOST CURRENT LANDSAT DATA CHARACTERISTICS ARE ADEQUATE EXCEPT DATA DELIVERY/TIMELINESS
- IN INTERVIEWS, INDUSTRY USERS WERE MORE CRITICAL OF CURRENT LANDSAT CAPABILITIES

* Total Industry Users Responding - 160

FIGURE 15. INDUSTRIAL USERS' ASSESSMENT OF CURRENT LANDSAT DATA [2,4]

personal interviews and user publications clearly show that widespread dissatisfaction with the spectral coverage of LANDSAT I and II does exists. This opinion is not only held by the geo-exploration industry, but by other end users and service to users as well.(2-6)

Spatial Resolution. Responses to the adequacy of LANDSAT MSS (multispectral scanner) spatial resolution were a function of user need. End users in the exploration industry generally conceded that the spatial resolution was adequate, and sometimes even desirable, if the application involved geological mapping and regional surveys. It was described as inadequate when detailed geological or mineral data were sought. End users conducting agricultural and land use surveys expressed dismay that the data could only be applied for general (Level I) classification purposes.

Although questionnaires revealed that over 50 percent of the end users and service-to-user industry representatives view the spatial resolution of LANDSAT data as adequate (see Figure 15), other information indicated that most users desire an increase in resolution of at least 2X. However, industrial users, especially geologists, do not want this increase at the expense of area coverage.

LANDSAT MSS Image Quality. Many industrial users suspect that the imagery provided by data centers and NASA does not do justice to the original MSS data quality. Some feel that the data processing equipment used by NASA, especially the film recorder, is inadequate for the job. Other users feel that the radiometric and geometric qualities of the data are inadequate. Specifically:

- Precision for locating the principal point in each MSS scene is inadequate.
- Sensitometric quality of MSS data is such that imagery has to be reprocessed at the customer's expense.
- Image quality is graded by NASA on the basis of image quality, as reproduced by NASA, and not on the basis of atmospheric conditions affecting the image. An example cited was the presence of "desert bloom", whereby the brightness of a foreign desert area is so intense as to blot out any meaningful information for geoexploration.
- Some users do not believe that problems showing up in NASA imagery are due to original data collection limitations, but rather to inadequate software.

Generally speaking, industrial users who have profited from LANDSAT MSS data preferred having the data as is, rather than not at all. Users who have not used the data successfully continue to rely on aircraft data.(1-7)

Timeliness of the Data. Although questionnaire response indicate industrial users to be equally divided as to adequacy of data delivery (see Figure 15), all other inputs indicate that industry users are virtually unanimous in their expression that delivery time for LANDSAT imagery is inadequate, and the delivery time for digital tapes impossible.(1-7)

Frequency of Data Collection. Users most dissatisfied with the frequency of data collection were industrial users in agriculture. Most users were satisfied with the frequency of data collection, and, given good data collection conditions over areas of interest, they would be satisfied with annual or seasonal coverage. Since many areas of interest, especially abroad, feature frequent cloud cover, a majority of users suggested that data should be taken as frequently as possible in order to achieve necessary coverage at least once satisfactorily. The major exceptions are pipeline and exploration companies who own and operate ships in arctic ice areas; they need much more frequent coverage to support such operations.(1-7)

LANDSAT Data Collection Over Foreign Areas. Interest in LANDSAT coverage over foreign areas is very high, and many users want more coverage over Africa, South America, and the arctic regions.(2-6)

Stereo Coverage. Users in the geoexploration field expressed frequent disappointment that LANDSAT data do not provide stereo coverage, or at least not programmed stereo coverage. Although the desire for stero coverage is large, users are skeptical about computerized treatment of LANDSAT data to produce a stereo effect and fear that such treatment introduces artificial data into the imagery.(3,6)

Browse File Availability. Industrial users feel that browse files are not located "where the action is", requiring that personnel be dispatched to browse files at unnecessary time and expense. Another concern is that some browse files are attached to other NASA-sponsored investigators and users feel that they are intruding in an ongoing activity. Users also claim that browse files are not being kept current.(2-4)

Although not satisfied with certain aspects of the data or data delivery, the general consensus of industrial users in that the data are useful, better, and cheaper in many cases than what was available before. This opinion, of course, is most commonly expressed by the geoexploration industry.(2-6)

Industrial User Recommendations

Industrial users generally agreed on recommendations for upgrading future LANDSAT capabilities. Listed here are typical comments provided by industry representatives.(2-4)

Spectral Coverage

- Add to current spectral coverage, or modify current coverage to provide additional coverage in the following thermal (infrared) bands:

  $\sim 1 - 2$ μm (micrometers)
  $8 - 14$ μm (micrometers).

- Narrow or peak visual, near IR, and thermal infrared coverage to fit specific applications or disciplines.
- Add microwave sensor in subsequent satellite systems.

Spatial Resolution

- Improve spatial resolution 2X to 4X without sacrificing area coverage.

Area Coverage

- Provide more coverage over foreign and remote areas. (Users in geoexploration want more coverage over remote and foreign areas. While more repetitive coverage is not really helpful to them as it would be for someone monitoring constantly changing events, foreign coverage is obtained so intermittently, and frequently obstructed by adverse atmospheric conditions, that the users feel the only

answer is to obtain as much coverage as possible. Current coverage is such that users cannot always decide whether an anomaly on the surface of the earth is real or caused by atmospheric conditions.)

Repetitive Coverage

- Recommendations vary from daily to annual coverage. Cloud cover over many areas of interest requires that coverage be maintained on at least the current 9-day cycle to achieve useful coverage over many areas of interest.

Quick-Look Capability

- Develop procedure to provide users with a quick-look opportunity, even at reduced resolution.

Stereo Coverage

- Approximately a third of all users in the geoexploration field want LANDSAT data in "planned" not accidental, stereo coverage. Users say that the third dimension is necessary for recognizing detail and for adequately describing an area. Users do not want a computerized technique to produce a stereo effect, since this may result in interpretation of false image content.

Availability of Data

- Turn-around time of 2 to 3 days is desirable, and less than 10 days is a must for users, including the availability of tapes which currently take as long as 6 months to receive.

Browse Files

- Users want more browse files, and want them closer to centers of industry interest, i.e., in Houston, Denver, etc. They also want continuous updating of browse files.

Image Quality

- Users want improvement in radiometric (sensitometric) quality of imagery to avoid costly reprocessing. They also want improvement of geometric quality, especially greater precision in locating principal point of imagery.

Summary and Outlook

Private industry is currently the most prominent user of LANDSAT data, buying a fourth of all LANDSAT data sold by the data centers annually, at a cost of $483,000.

Private industry consists essentially of two types of LANDSAT data users: the industrial end user, who requires the data to locate new or monitor existing natural resources, and the industrial service-to-user who provides the end user (private, government, foreign) with hardware, software and/or services for the accomplishment of his mission. Among the private end users, the exploration industry for minerals and fossil fuels has used the data most successfully. All other end users have used the data less successfully. The success of the industrial service-to-users was noted primarily in supplying hardware, software and technical services. These activities eventually resulted in multidisciplinary applications among a broad spectrum of users. The use of LANDSAT data in the geoexploration industry is routine. The use of LANDSAT data in the service-to-user industry is also routine, however the resulting products are not always routinely used by the recipient.

An evaluation of LANDSAT data by the industrial sector revealed that most industrial users want additional spectral coverage in the thermal infrared bands (1-2 μm and 8-14 μm), better spectral and spectral resolution (at least 2X), more foreign and remote area coverage, quick-look capability, stereo coverage, better data processing, and (above all)much better delivery of data (days instead of weeks for tapes and imagery). Better located, and continuously updated browse files are also desired. The industrial user is the most appreciative user of LANDSAT data. The private end user is mostly using his own resources for obtaining and utilizing the data. Though not fully satisfied with LANDSAT data and

LANDSAT data delivery, the industrial user represents a high demand for LANDSAT data because the data provide him with the means to survey natural resources at scales not feasible before, over areas where sparse data previously existed, and because of the cost savings resulting from ERS data use.

Private industry will continue to use LANDSAT data indefinitely until better data become available. Exploration users will only purchase LANDSAT data to complete seasonal photocoverage of specific areas of interest. For many users, continued worldwide LANDSAT coverage is desirable since ERS data of foreign and remote areas are not available and since unfavorable cloud and atmospheric conditions often exist over many areas. The industrial user will continue to purchase LANDSAT data for the next 2 to 3 years. Unless improved ERS data become available by that time, industry users will primarily rely on the existing data base built up by them since 1972. This holds, of course, primarily for the exploration industries where changes in natural features occur relatively infrequently. In the agricultural industry, by contrast, demands for new data will continue, if the data provide answers to industry's problems. Since a large part of the industrial sector is made up of exploration end users or image-processing service to users, the demand by the industry user for LANDSAT data in its present format is expected to decline, unless improved or new data formats or new data become available within the next 2 years.

Private users will continue to use primarily LANDSAT imagery because it is cheap, much more readily available than the CCT's, and because it is in a format which has traditionally been used from aircraft sensors. Though service-to-user agencies and remote sensing groups within the private sector have demonstrated the utility and, at times, the superiority of using digital processing techniques, this technique is not being used routinely by most end users. Service-to-user industries are sometimes aiding end users to locate or monitor natural resources, but not routinely. Exploration industries are fairly sensitive about permitting service companies to process sensitive data which may decide the proprietary commitment of millions of dollars for exploration purposes. Although the use of LANDSAT MSS tapes will increase during the next 2 years, it will probably not reach the dollar volume or popularity of imagery formats, since the technology transfer required will not be achieved in such a relatively short period of time.

The addition of the thermal scanner on LANDSAT C and the 40-meter-resolution (RBV) sensor will satisfy some of the demands of the industrial user community. Customers are expected to buy MSS data, at least LANDSAT Bands 5 and 7, to provide correlation for the thermal data. In other words, the addition of the thermal sensor is expected to spur new interest in buying coverage in the other LANDSAT data areas as well. If the thermal sensor does not satisfy the user's needs, then overall interest in further conventional MSS data is expected to wane. The 40-meter-resolution RBV (Return Beam Vidicon) sensor data should affect usage by all users in all disciplines. Renewed interest can be expected, especially in its application to land use and agriculture. Industrial users will use the data to help solve more localized problems, but will continue to solve the bulk of their problems with aircraft and ground-based surveys until orbital data of 1 to 10 meters resolution are available.

SURVEY RESULTS

PART 2. STATE, REGIONAL (SUBSTATE), AND LOCAL GOVERNMENT

PART 2. STATE, REGIONAL (SUBSTATE), AND LOCAL GOVERNMENT USERS

General Description

Most efforts in this part of the survey were concentrated on state-level use of ERS data (rather than regional and local governments). States have more application requirements for ERS-type data products and state personnel are normally involved in or are aware of regional and local governmental programs using ERS data. To date, the use of ERS data by regional and local governments is minimal. Therefore, except where specifically noted, all assessments in this section of the report pertain to the use of ERS data by state agencies.

During the survey, politicians, decision-makers, planners, researchers, or remote sensing specialists in state agencies were interviewed in every state (130 contacts). In addition, 157 questionnaires were returned by state, regional, and local governmental personnel (105 were from users). Table 8 provides a list of principal ERS data user agencies in state governments that were identified during this survey. State universities, who often are associated with state use of ERS data have also been included in the table.(1-14)

In almost all states, more than one agency has participated in efforts to utilize ERS data in on-going programs. Normally, the state agencies most frequently found to use ERS data include the Departments of Geological Survey, Natural Resources, Development, Environmental Protection, and Transportation and Highways. In several of the states most actively involved in remote sensing, interdepartmental remote sensing committees have been established and/or remote sensing coordinators appointed, usually as part of the Governor's Office or Cabinet, to promote the utilization of ERS data, and to establish common data bases and data analysis facilities for use by all state agencies. Consequently, browse files and catalogues of ERS data and conventional aircraft data often exist within these states. In most states, however, because of differing data requirements, each state agency acts independently of other agencies in remote sensing activities.(2,4)

TABLE 8. USERS OF ERS DATA IN STATE GOVERNMENTS[1-4]

STATE	
Alabama	Geological Survey of Alabama
Alaska	Office of the Governor University of Alaska Federal/State Joint Land Use Planning Commission
Arizona	Department of Revenue Department of Transportation
Arkansas	University of Arkansas
California	University of California Department of Water Resources Department of Food and Agriculture
Colorado	Department of Natural Resources University of Colorado Colorado State University Colorado School of Mines
Connecticut	Connecticut Department of Environmental Protection
Delaware	Department of Natural Resources and Environmental Control University of Delaware
Florida	Department of Natural Resources Department of Administration Department of Transportation
Georgia	State Department of Natural Resources
Hawaii	Department of Planning and Economic Development University of Hawaii
Idaho	State Planning and Community Affairs Agency University of Idaho
Illinois	State Department of Conservation University of Illinois
Indiana	Indiana Department of Natural Resources Purdue University
Iowa	Iowa Geological Survey Iowa Office of Planning and Programming
Kansas	Kansas Geological Survey University of Kansas
Kentucky	Department of Natural Resources and Environmental Protection University of Kentucky
Louisiana	Office of the Governor Louisiana State University
Maine	Department of Transportation Department of Environmental Protection Maine State Planning Office
Maryland	Department of State Planning State Geological Survey Maryland Bureau of Mines Department of Natural Resources University of Maryland
Massachusetts	Department of Natural Resources Department of Public Works
Michigan	Department of Natural Resources Michigan State University University of Michigan

TABLE 8. (Continued)

STATE	
Minnesota	Minnesota State Planning Agency Department of Natural Resources University of Minnesota
Mississippi	Mississippi Office of Science and Technology
Missouri	Department of Natural Resources Office of Administration University of Missouri
Montana	Department of Conservation and Natural Resources Montana University
Nebraska	Nebraska Geological Survey University of Nebraska
Nevada	Department of Conservation and Natural Resources University of Nevada
New Hampshire	New Hampshire Geological Survey University of New Hampshire
New Jersey	Department of Environmental Protection
New Mexico	State Planning Office Bureau of Mines and Mineral Resources
New York	Department of Natural Resources, Cornell University Division of State Planning State Geological Survey State Department of Conservation
North Carolina	Department of Economic and Natural Resources State Planning Office North Carolina State University
North Dakota	North Dakota State University
Ohio	Department of Economic & Community Development Department of Natural Resources Environmental Protection Agency
Oklahoma	Oklahoma Geological Survey University of Oklahoma
Oregon	Department of Environmental Quality Oregon State University Department of Forestry
Pennsylvania	Department of Environmental Resources Pennsylvania State University
Rhode Island	Department of Natural Resources University of Rhode Island
South Carolina	State Development Board South Carolina Water Resources Commission University of South Carolina
South Dakota	South Dakota State Planning Bureau South Dakota State University University of South Dakota
Tennessee	Office of the Governor University of Tennessee
Texas	Office of the Governor - General Land Office Texas A&M University Texas Parks and Wildlife Department University of Texas Texas Water Development Board
Utah	Department of Natural Resources University of Utah
Vermont	Vermont Agency of Environmental Conservation University of Vermont

TABLE 8. (Continued)

STATE	
Virginia	Department of State Planning and Community Affairs
	Virginia State Water Control Board
	Virginia Institute of Marine Science
Washington	Department of Natural Resources
	University of Washington
West Virginia	Department of Natural Resources
	West Virginia University
Wisconsin	Department of Natural Resources
	Department of Administration
	University of Wisconsin
Wyoming	Wyoming Department of Land Use and Planning
	Wyoming Department of Economic Planning and Development
	University of Wyoming
	Wyoming Geological Survey

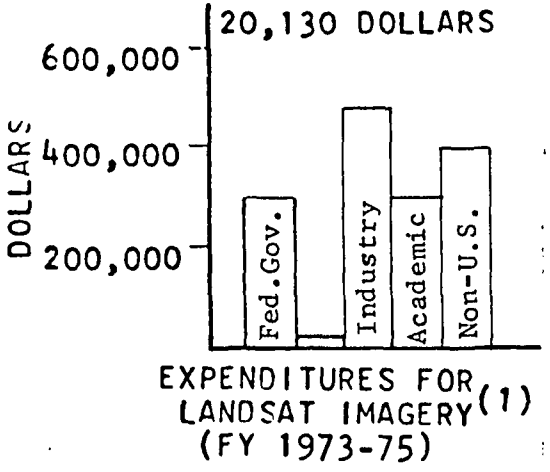
Within state governments, three distinct staff levels affect the use of remote sensing data: at the higher levels of government, political administrators, (Agency and Department Directors and other members of the Governor's staff and cabinet) decide the ultimate strength of a remote sensing program through executive decisions and financial controls. Middle-level managers, program coordinators and planners provide the key for linking state needs and program priorities with ERS and other remote sensing applications possibilities. At the working level are the image analysts and technologists, who ultimately influence the status and usefulness of remote sensing activity within a state. Within a state government generally no more than five to ten administrative and professional personnel are familiar with ERS data applications, and they are only involved in remote sensing applications on a part-time basis. In addition to their involvement with state ERS data programs, the same staff often assist local and regional government agencies in their programs involving ERS data applications.(2-4)

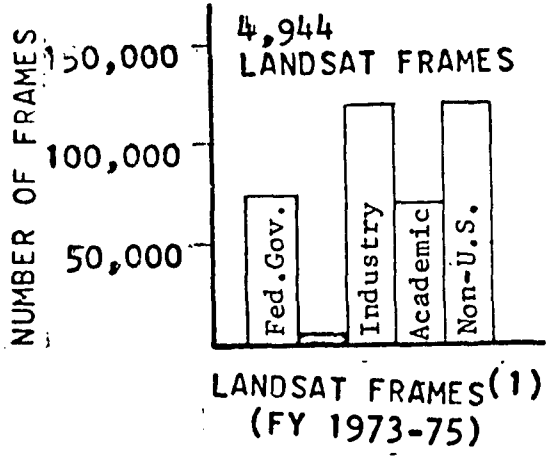
Users associated with state, regional and local governments are currently making more diversified use of ERS data than any other user group. In their ERS data programs, however, these governmental agencies extensively rely upon federal agencies, universities, and service-to-user industries for technical support and guidance. Without such outside leadership, state regional, and local agency use of ERS data would - except in rare cases - be minimal.(2-12)

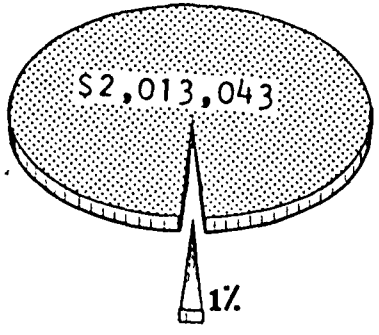
As shown in Figure 16, state, regional and local users of ERS data ordered only 1 percent of all LANDSAT data purchased from ERS data centers over a 3-year period. Specifically, this amounted to less than 5000 frames at a cost of $20,000. Also, as a user group, most users indicated that they are infrequent ERS data center customers. These statistics are somewhat misleading in that many of the data used at the state level are channeled to the states through universities, federal agencies, and private firms who are assisting state agencies in the development of practical applications of ERS data. For example, many university-based LANDSAT programs within the 50 states are directed toward state user application developments in their respective states. Also federal ERS data assistance facilities in Alabama, Ohio, Mississippi, South Dakota, Maryland, California, and Texas and NASA centers work hand in hand with states within their immediate geographic vicinity. The purchase of LANDSAT data by the academic community is 14 percent (by item); for

STATE, REGIONAL, & LOCAL GOVERNMENT USERS

- Records Show State and Local Governments to be Smallest and Most Infrequent Users of ERS Data Centers (Directly)
- However, Many State-Oriented Data Use Activities Are Being Done by State Universities, Private Contractors, and State Offices of Various Federal Agencies







PERCENTAGE OF TOTAL DOLLARS SPENT
(FY 1973-75)(1)

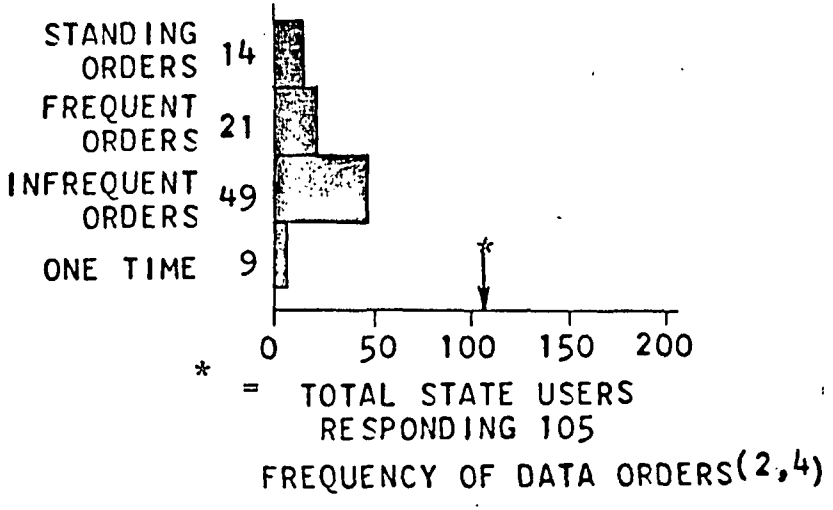


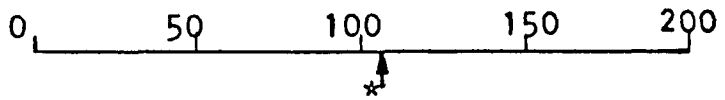
FIGURE 16. STATE, REGIONAL, AND LOCAL GOVERNMENTS - EARTH RESOURCES SURVEY DATA USER PROFILE(1,2,4)

federal agencies, it is 15 percent. It can therefore be safely concluded that state users indirectly benefit from these data as well. The rationale here is, that states during the LANDSAT I program received data directly from NASA or benefited from research performed by the academic or federal research community with the state through demonstration products, workshops, etc. The statistical information from the ERS data centers was supported by information obtained from survey questionnaires and interviews.[1-9] Figure 17 illustrates the relative discipline interest among state, regional, and local governmental ERS data users. While these agencies normally are involved in multidisciplinary ERS data application programs, the survey results emphasized their requirement for land use information and their involvement in land use applications. Approximately two-thirds of all state, regional, and local governmental ERS data users contacted indicated use of the data for land use inventorying, mapping, and change detection applications. Interest in all other disciplines was about equally divided, and typical (mostly experimental) applications of ERS data included:[2-4]

- Regional Planning Activities
- Statewide and Regional Earth Resources Data Information Systems
- Strip Mine Monitoring
- Statewide Survey of Irrigated Land
- Water Monitoring System
- Soil Association Maps
- Lake Inventories
- Water Quality Monitoring
- Coast and Near-Shore Process Studies
- Crop Inventories
- Ice Monitoring
- Flood Plain Mapping
- Wildlife Habitat
- Wetland Inventories
- Use of DCP for Water Quality Monitoring and Water Flow Monitoring
- Hydrological Studies
- Range Land Mapping
- Agricultural Resource Base
- Geothermal Source Locations
- Mineral Exploration
- Tectonic Studies.

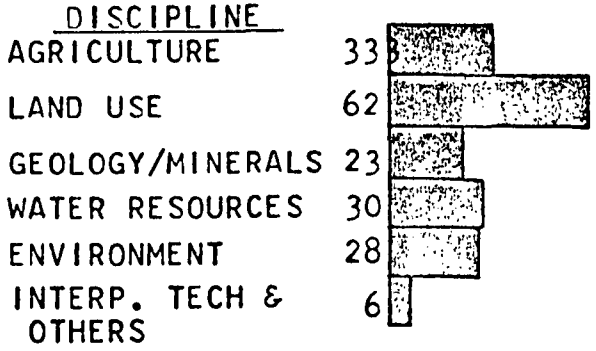
Survey results further indicated that about three-fourths of the current state, regional, and local governmental users employ both high-altitude aircraft and LANDSAT imagery as data bases in their remote sensing application activities. About a third of the users indicated use of LANDSAT CCT data. Most state ERS data users interviewed routinely use low-altitude photography. Aircraft photography (conventional and/or high altitude) and other reference data were required by state users for LANDSAT data applications.[2-4]

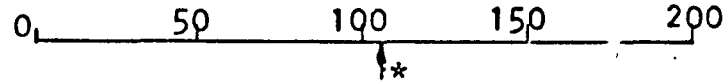
STATE



RELATIVE DISCIPLINE INTEREST

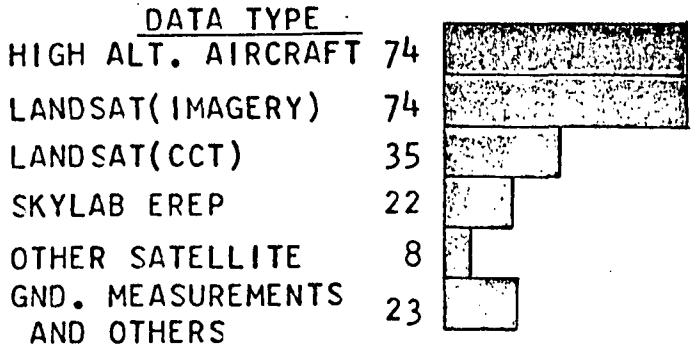
- Land Use Predominant Data Application of State/Local Users (Involves About Two-Thirds of the Current Users).
- Fairly Uniform Interest in Other Application Areas





RELATIVE TYPE OF DATA USE

- About Three-Fourths of Current State Users Use Both High-Altitude A/C And LANDSAT Imagery.
- About One-Third of State Users Involved With Digital LANDSAT Data.
- State Agencies Also Use Significant Amount of Medium- And Low-Altitude Photography.



*Total state users responding - 105; could be more than one respondent per agency.

FIGURE 17. STATE, REGIONAL, AND LOCAL GOVERNMENTS - GENERAL DATA USE STATUS(2-4)

State, regional, and local governmental agencies are not generally research oriented, and, consequently, most users indicated that their principal functional use of ERS data involved planning and decision-making activities (see Figure 18). Although many who responded indicated a research interest, this interest was, in most cases, research aimed at developing practical applications of ERS data. Few respondees indicated a current use of ERS data for monitoring activities.(2,4)

Figure 18 also shows the principal organizational use, as indicated by state users, to be about equally divided between routine operations and management and policy-making activities. Support for the current state ERS programs is about equally divided between federal and state sources. In general, state budget appropriations for general remote sensing development programs are meager, if any, and funds for specific remote sensing activities are usually incorporated into agency budgets on an "as-needed" basis.(2,4)

Evaluation of Specific Data Use

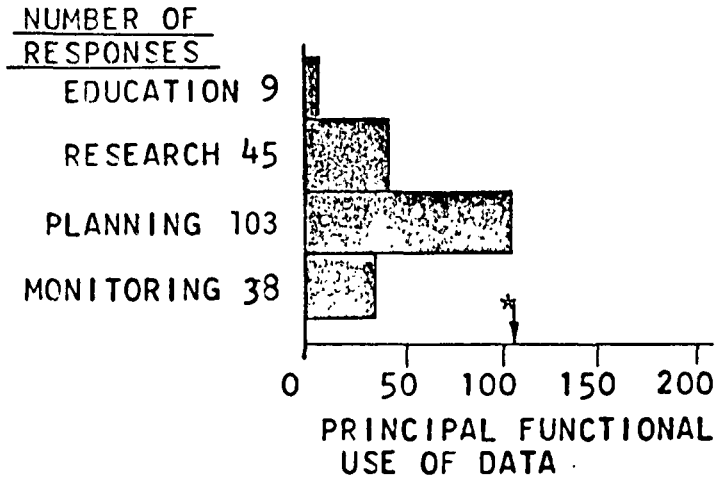
State Agencies

State agencies have been long-term users of remotely sensed data, primarily low-altitude aircraft photography, and are currently experimenting with high-altitude aircraft, LANDSAT, and Skylab EREP* data. However, information acquired during this survey clearly indicated that state agencies are mostly involved in evaluating and/or developing techniques for using ERS data to map, inventory and monitor temporal changes in land use/land cover. Use of ERS data for land use/land cover applications ranges from the collection of generalized state-wide land use information to large-scale, specialized assessments for near real-time localized problem-solving and decision-making requirements. Previously, state planners depended on a variety of heterogeneous, one-time inputs such as multi-date maps, randomly acquired aerial photography, and unreliable windshield survey data to fulfill state land use data needs. Such surveys were, and continue to be, undertaken by several governmental agencies, often at great expense, on an infrequent basis, and with questionable accuracies and inconsistent formats. States now face a growing need for reliable, comprehensive, and standardized data bases for planning and allocating resources,

* Earth Resources Experiment Package.

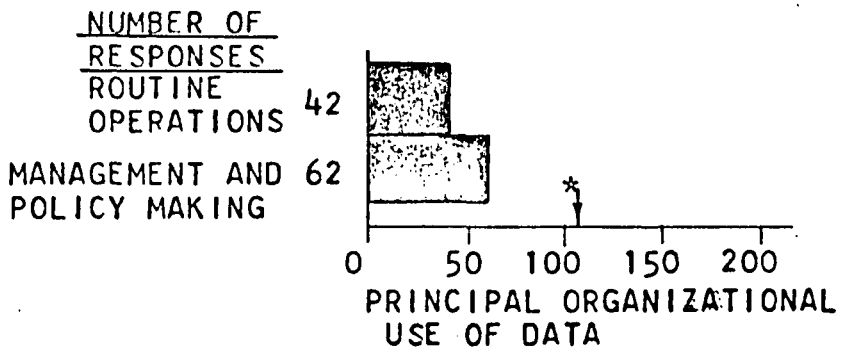
RELATIVE FUNCTIONAL USES OF ERS DATA[2,4]

- State Users Are Using Data Primarily For Routine Planning and Management Activities.
- Research Use is Definitely Applications Orientated.
- Monitoring is Currently a Secondary Use Area.
- Few State Users Appear to be Using ERS Data For Educational Purposes.



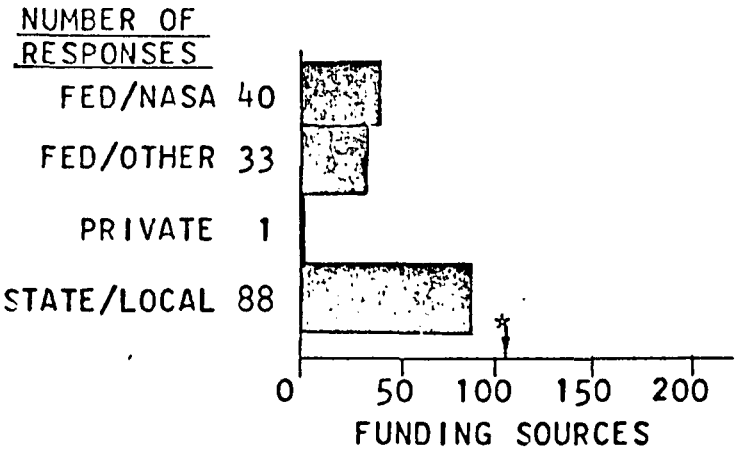
RELATIVE ORGANIZATIONAL USE OF ERS DATA[2,4]

- Level of Use Within States About Equally Divided Between Routine Operations and Management and Policy Making.



FUNDING SOURCES

- State Users About Equally Supported by Federal and State Sources.



* Total state users responding - 105.

FIGURE 18. STATE, REGIONAL, AND LOCAL GOVERNMENTS - TYPES OF USES AND FUNDING SOURCES[2,4]

meeting federal program requirements, and for routine day-to-day applications. However, the use of ERS data in this critical and extremely promising area appears to be occurring sporadically and very slowly.[1-12,16,18]

From the interview, questionnaire, and literature surveys, the level of ERS data use by state agencies within each state was assessed as follows:

(1) Planned/Potential - State agencies have no or few substantial programs which now use ERS data, but have data requirements which ERS data can supply.

(2) Experimental - State agencies themselves, or state universities, federal agencies, or private contractors have shown that ERS can be utilized in specific state programs or activities.

(3) Demonstrational/ Quasi-Operational - Extensive applications of ERS and LANDSAT data have been evaluated by state agency users of ERS and LANDSAT data products that were prepared under the states' directions.

(4) Operational/Routine - State agencies use LANDSAT data for planning and problem solving, as they already use aircraft data, and finance ERS programs to use the data.

As of this date, no state, however strong in its use of ERS data, was found to use LANDSAT data in an operationally/routine manner. However, the status is constantly changing with the current survey showing

- 17 States are Using ERS Data in Quasi-Operational/Demonstrational Modes,
- 23 States are Using ERS Data in Experimental Modes, and
- 10 States Plan to Use ERS Data and Are Potential Users.

Criteria used in the evaluation emphasized state acceptance of the responsibility for evaluating ERS and LANDSAT products generated by state agencies, federal centers, universities, and private companies. This assessment is not to be construed as an evaluation of the level of effort by all users within a specific state, but rather is an evaluation of the extent to which the data are being utilized in relevant applications by the state agencies. Had this assessment been based strictly on state use of LANDSAT data, the number of states in the quasi-operational/demonstrational category would be less. It was found that, even in some of the states most noted for their achievements in using LANDSAT data, representative state agency staff displayed little awareness of ERS data products or services.[2-4]

Extensive use is generally being made of conventional and high-altitude aerial photography by state users as primarily a data requirement in specific projects, such as highway route selection, flood plain mapping, and resource inventories for environmental assessments. However, state personnel have generally not worked enough with LANDSAT or Skylab ERS data products to have become "comfortable" with the utility of the products or to realize new or possible information needs which satellite ERS data may be able to satisfy. Consequently, state personnel mostly use ERS data products as a supplement to existing data bases such as topographic maps, field data, or aerial photography, and when asked what ERS data products they can use, often respond that they can use any products that can be provided. Nevertheless, some states are attempting to capitalize on the repetitive and synoptic nature of LANDSAT data for effectively updating and standardizing maps, for change detection, and for resource inventories of large areas.

Many state studies to determine the feasibility and utility of using ERS data have concluded that a specific application was successfully demonstrated and results "can be used" but operationally, few discuss facilities and/or equipment required, or plans to implement such applications.[5,9,12,16,18]

The successful use of LANDSAT data within state agencies has suffered more setbacks from constantly changing personnel within the states, than from technical and economic causes. During this survey, more fruitless state-user contacts, because of changes in management and staff personnel, were made, than in all other user groups combined. In most cases, staff changes occurred at both the decision-making and technical leadership levels. Only in states where federal centers operated in close support of state agencies was the impact of changing administrations minimal. The higher level decision-makers and middle-level managers and planners generally maintain their positions and financial program support for relatively short periods of time, in terms of the time required to establish an active remote sensing program. Their activities are highly dependent on the political aspects of the state. If ERS programs have not matured to provide products relevant to state programs and activities and/or have not become a line item in a state's budget, the ERS programs are highly vulnerable to administrative changes as are any research programs. The criterion is not always a lack of supporting funds. Newly elected or appointed state officials frequently drop R&D programs initiated by their predecessor, simply because they were started under a different administration.[3,7,8,13]

Case Study: State Government. A representative case study of a state undergoing such institutional changes and the subsequent adverse impacts on the technology transfer process is given below. The state in point has been active in aerial survey activities since the 1940's and state agency personnel have participated in the LANDSAT and Skylab programs as principal investigators since 1972. Current ERS data use within the state is defined as demonstrational/quasi-operational. Even though many state agencies participate in the LANDSAT and Skylab programs, no agency-wide remote sensing committee, common ERS data bank, or public user assistance facility have been established. Each agency traditionally supports its own programs with its own funds, and few state programs share the same data base. Although the state agencies routinely obtain conventional aerial photography with their own aircraft and have modern aircraft data interpretation, plotting and computer mapping facilities, they use private contractors to assist them in evaluating and using the LANDSAT and Skylab satellite data.(3)

Early in the state's LANDSAT I and Skylab programs, state agencies provided strong visibility to the program by conducting conferences and workshops for interested staff from governmental agencies, universities and the private sector. Through the expertise of private contractors, demonstrational products (such as land use, surface mining, and forestry maps) were produced from LANDSAT data and state agency staff were becoming trained and confident of data application potential as well as the limitations of data use. Other potential user groups within the state similarly became enthusiastic, and the state was developing a mechanism to provide seed money to encourage regional user participation. While not yet ready to commit substantial sums of money required to develop operational ERS data systems, state administrators did envision the relevance and importance of repetitive and synoptic ERS data to state programs, and sought a LANDSAT II program to continue the cooperative development (with NASA) of an operational resource management system.(3)

When the state was finally granted a LANDSAT II program, a change in administration had occurred. The advent of the new administration, of a different political party, resulted in a complete change of personnel at all levels from those who were involved in the initial LANDSAT and Skylab efforts. The objectives of the proposed LANDSAT II program were subsequently modified several times to be responsive to the new administration's priorities. New personnel were employed who eventually became familiar with the relevance and applications potential of the satellite data to the existing state information needs and data requirements. The new state administration also sought the services of private firms to assist state agencies in developing techniques for producing LANDSAT products of interest. The state once again is beginning to think in terms of long-range ERS data use programs, especially for land use/land capability applications.(3)

This representative case study shows that before ERS data are accepted in state agencies as one of the tools available to accomplish their goals and fulfill their data needs, administrators must be shown useful demonstrational products brought to completion in an efficient and cost-effective manner. Furthermore, until any remote sensing program becomes operational, it will remain highly subject to the whims of the political structure, as is any research endeavor. The length of time required for the establishment of a viable remote sensing program in a state can be envisioned in terms of 5 to 10-year periods or longer from conceptualization to a

self-sustaining operation. In essence, state government (as well as regional and local governments) is usually more concerned with applications that are (1) present rather than future, (2) direct rather than indirect, and (3) tangible rather than intangible. The state of the art of most ERS data applications does not meet these prerequisites. Also, the lack of a commitment to an operational satellite system tends to discourage the serious funding by state governments required to develop application systems.(2-10)

Regional (Substate) and Local Users

Some regional (substate) governmental agencies have sought assistance from service-to-user industries to prepare land use/land cover maps and inventories of natural and cultural features from ERS data. While they are users of ERS data products, regional and local governmental agencies do not possess the expertise, equipment or resources to develop the technology on their own. Monies available to them through revenue sharing and other federal programs, the cooperation from local governments within the region, and the requirement for comparable data bases for dealing with area-wide urban and rural problems are significant factors for their use of products derived from ERS data. While local users readily accept products derived from conventional aerial photography, they have been very reluctant to accept the sophisticated techniques required to prepare products from other ERS data sources, and question the credibility and advantages of such data products.(2-4)

As stated above, the major ERS product used by regional governmental agencies is land use/land cover maps. The maps and supplementary statistical information are used by these agencies in a number of their programs such as public transportation, major facility site selection, urban growth management, preservation of open spaces and prime agriculture lands, commercial development of natural resource extractive industries, etc. Such data bases generally require updating on a 3 to 5-year basis, and therefore, while regional governments may computerize the land use maps and statistical data bases, few will probably develop in-house capabilities to interpret raw ERS satellite data and will probably continue to rely on consulting (service-to-user) organizations for providing the products.(2-4)

The major problem encountered by regional and local governments and service-to-user industries in the production of regional land use maps and data bases is that regional programs require Level II and Level III detail expecially in urban areas, which cannot be obtained from current LANDSAT data. Aerial photography is often used in the production of the regional maps and data bases. In essence, regional agencies currently continue to rely on data derived from aerial photographs for their major programs and activities but they may become a major end user of satellite ERS data products with improved satellite resolutions.(2,3,7,8,16)

How State, Regional (Substate), And Local Government Users View ERS Data

Data Use Assessment

In general, state users were about equally divided as to the utility of ERS data. About half of the survey respondents considered the data to have high utility, the other half considered the data to have low utility. The results of the mail survey as related to the assessment of ERS data use by discipline indicated that most state users view ERS data as a new data source which currently complements existing data with major benefits to land use, geology (minerals) and water resources activities. Potentially, users believe that ERS data will be an important and better data source which will be of most benefit to state land use, geology and environmental interests.(4)

The following ERS data utility comments are representative of state, regional, and local user comments received during the survey:(2-4)

- "LANDSAT data will not be used or helpful until the resolution is substantially improved." (Coordinator, State Remote Sensing Programs)
- "Bureaucracy is slow to change—we have been using conventional aerial photography for the last 20 years and will probably do so for the next 20 years." (Remote Sensing Chief, Department of Natural Resources)
- "The synoptic view provided by LANDSAT has enabled us to take a better look at the problems confronting us on a regional basis." (Planner, State Dept. of Development)
- "We may reach an operational status for surface mining monitoring by 1977 at the end of our LANDSAT II program." (Principal Investigator, Dept. of Environmental Resources)
- "If states are to become users of ERS data, not only will NASA have to provide the data, but they must also develop the interpretation technology required and demonstrate reliable and cost-effective applications of the data. Very few people in state government are basic researchers, they are applied researchers. Once the technology is developed, then bring it to the state for applications." (Former Principal Investigator, Dept. of Environmental Protection)
- "We use orbital data and high-altitude photography for limited applications in planning stages." (Engineer, Department of Transportation)
- "As a photo mapping base, we find that LANDSAT data are more useful than USGS topographic maps since the user can add his annotations, and more original information is provided." (Research Leader/Engineer, Dept. of Transportation)
- "The use of satellite and aircraft photography is limited in this state because of the lack of education." (Research Leader/Engineer, Dept. of Transportation)
- "The greatest shortcomings of LANDSAT data are its resolution and timeliness of data receipt." (Manager, University-State Research Group)
- "We are very pleased with LANDSAT data. It has saved us thousands of man-hours for mapping rangelands."

  "We have not always achieved our expectations with LANDSAT data, but it is more than we could achieve any other way. We are not satisfied with the timeliness of LANDSAT data, but it is better than anything else we have." (Researcher, Soil Conservation Service)
- "LANDSAT data have shown us geological features that we have not seen before." (Research Leader/Engineer, Geological Survey)
- "LANDSAT data are important as a background data base for environmental impact and land use surveys." (Principal Investigator, State LANDSAT Program)
- "We prefer to spend our limited financial resources for use of the data rather than development of techniques." (Research Leader/Engineer, State Division of Water Resources)

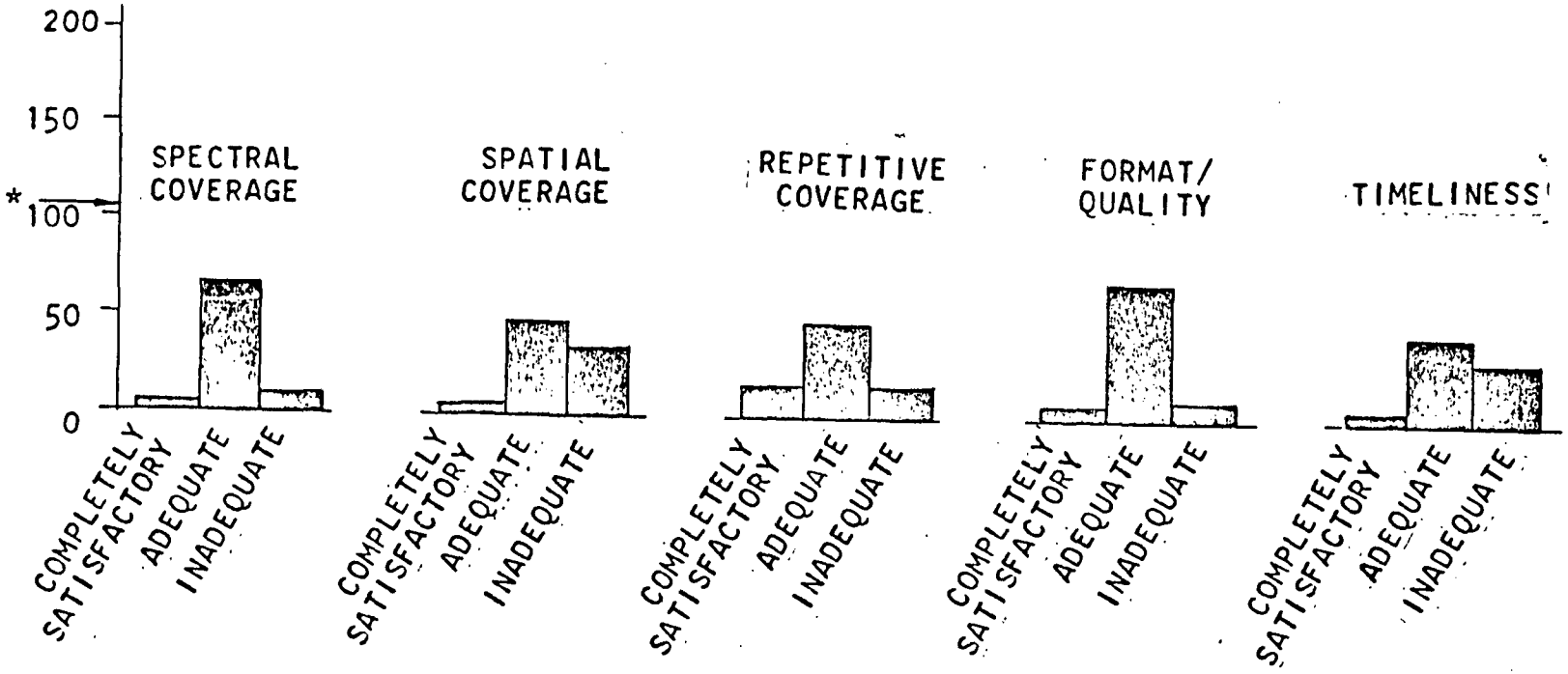
LANDSAT Data Assessment

Results of the questionnaire survey alone as to state, regional, and local governmental user views of LANDSAT data are summarized in Figure 19.[2,4] Through questionnaires and direct interviews, state users commented on the quality of current LANDSAT data. The most frequently mentioned items were:[2-4]

- LANDSAT MSS Data Spatial Resolution
- LANDSAT MSS Data Spectral Characteristics
- LANDSAT MSS Image Quality
- Frequency of Data Collection
- Timeliness of Data Delivery
- Stability of LANDSAT Program
- LANDSAT Data Format.

Spatial Resolution. More than any other aspect of LANDSAT data, state users complained most frequently about resolution limitations. State users have surprisingly taken to Anderson's classification scheme, which identifies three levels of land use/land cover classifications. Most users add their own sub-levels as needed. State and local users find themselves frustrated because they cannot effectively use LANDSAT data beyond the second level. For example, land use users desire not only the new boundaries of a city resulting from new construction, but also must be able to recognize the type of construction, such as commercial, family dwellings, and whether they are single family dwellings or apartments, etc.

State users are not interested in multicolored density-sliced maps, as such. They are only interested in what the individual densities in colors mean in terms of their need. Even the most enthusiastic users of LANDSAT data at this level rely extensively on high-flight and other conventional data to fill their more localized, urban-related information requirements. State users are not so much interested in terms of spatial resolution, as they are in terms of scale. The most frequently used scale within this user group is the 1:24,000 map scale. Simply stated, users in offices and in the field want 1:24,000-type products or better. Most agencies are reluctant to use LANDSAT data products at this scale. Users have stated that the present LANDSAT data resolution prevented them from using it for 90 percent of their information needs.[2-4]



- This use group is generally satisfied with the spectral coverage and format of LANDSAT data, and least satisfied with the spatial coverage and timeliness of data receipt.

* Total state users responding - 105.

FIGURE 19. STATE, REGIONAL, AND LOCAL GOVERNMENTAL USER ASSESSMENT OF LANDSAT DATA[2,4]

Spectral Characteristics. State users generally were found to make most use of LANDSAT data bands 5 and 7, and of color composites. The exception are computer-oriented users who use all four bands in digital processing.(2-4)

Image Quality. Users were generally satisfied with the quality of the imagery but were often surprised that digital data provided much more detail than was evident in image products.(2-4)

Frequency of Data Collection. Most users are generally satisfied with current data collection of 9 to 18 days since delivery of data takes longer than that anyhow. Current coverage is unsuitable for disaster and environmental monitoring applications.(2-4)

Delivery Times. Delivery times for imagery of 2 weeks or longer, and several weeks to months for CCT's are too long for routine use considerations, especially of an enforcement nature.(2-4)

Stability/Continuity of LANDSAT Program. State users feel uneasy about the lack of a federal commitment to provide operational satellites and the uncertainity of the continuity of resulting data and products. Such commitments must be made before states can be expected to allocate the substantial resources required to develop and operate LANDSAT data application systems.(2-4)

Data Format. In many instances, information obtained from ERS data and products, especially LANDSAT computer-compatible tapes, does not readily fit into the computerized information systems and decision models currently utilized by state agencies. Development of relatively inexpensive ($\cong$ 50K) digital data processing equipment adaptable to various computer systems and featuring color display, human-machine interaction, and software addition flexibility, would greatly increase state applications of ERS data.(2-4)

State, Regional (Substate), And Local User Recommendations

The most frequently mentioned recommendation from state personnel was to improve the spatial resolution of the data. Specific resolutions were usually not mentioned. When asked "what do you need", the answer usually was "what can you give me". But it is clear that state users want a resolution closely resembling

that of high-altitude aircraft data, specifically in the 1 to 10-meter range. State users also frequently mentioned the desire for more coverage by high-altitude data, which they find very useful.(2-4)

Additional spectral coverage in the thermal bands is requested by state users because they believe this may provide them with additional information in a given discipline especially for environmental studies. The type of thermal coverage needed is not offered readily; it appears as if state users are taking their cues from technical discussions when this subject was mentioned by other users more familiar with thermal imagery. Image quality is typically mentioned in conjunction with the resolution or scale of the data. ERS data for other applications such as land use mapping are adequate.(2-4)

Timeliness of ERS data receipt is not considered adequate for monitoring applications by this user group. ERS data are often needed on an hysterical, not historical, basis by this user group. State users require receipt of LANDSAT data in less than 2 weeks. Recommendations were made regarding a "quick look" capability of the data via telephone video link to determine image availability and image quality within 24 hours of data requisition. Receipt of ERS data for some current applications such as land use mapping, is adequate. However, the data must be collected under favorable atmospheric conditions so that the data are free from clouds and atmospheric haze.(2-4)

State governments by nature do not conduct research, but are research applications-oriented. States want more products to use rather than the development of complex, costly facilities which they view as a risk at this time. Consequently, this user group, more than any other user group, stressed the need for federal development of methodologies and end products which can readily be applied in state, regional, and local governmental programs.(2-4)

This user group also expressed a general lack of awareness of state-of-the-art applications of ERS data and were very interested in keeping up to date with technological application developments through newsletters, workshops, etc.(2-4)

The following quotations are representative of ERS data recommendations offered by state, regional, and local governmental personnel:(3)

- "If NASA really wants the states to use the ERS data, they must provide the data to the users on a timely basis." (Researcher, Environmental Protection Agency)

- "We need a quick look and a high quality look capability perhaps via specialized satellites." (Prominent Remote Sensing Expert involved in State Applications)
- "NASA is doing an injustice by refusing to provide high-altitude aircraft photography for all of the United States and by forcing us to use inadequate satellite data." (Director, State Development Department)
- "All photographic data should be formatted to common compatible scales based on planimetric bases rather than photographic bases." (Researcher, Dept. of Natural Resources)
- "NASA should establish a LANDSAT CCT loan program so that only the data required can be copied; and they should provide a quick-look computer hookup so that users can have access to LANDSAT data as soon as possible for routine day-to-day applications." (Program Manager, Dept. of Natural Resources)
- "Regional data assistance facilities similar to USGS's Earth Resource Laboratory at Bay St. Louis, Mississippi, should be established within a days drive from state capitals. Such facilities would provide an opportunity to learn of ERS data applications through a hands-on approach to problem solving." (Serveral State Gov't. Personnel)
- "A simplified cook book document which defines state-of-the-art ERS data applications should be prepared and circulated to potential users of the data". (Numerous State Gov't. Personnel)
- "Data interpretation services (imagery analysis and product preparation) should be provided for state users." (Researcher, Department of State Planning)
- "NASA should organize remote sensing workshops for state decision-makers (senior-level Management)."(Member, State Legislative Committee)

Summary and Outlook

Use of LANDSAT data on the state and local level was assessed to be in one of three stages of development: (1) planned/potential - 10 states; (2) experimental - 23 states; (3) demonstrational/qusai-operational - 17 states. No state was found to use LANDSAT data on a routine operational basis, but some states, such as Alaska, were found to place much importance on the value of ERS data. State and local users purchase only 1 percent of all LANDSAT data, but are frequently aided in research and funds by federal agencies, and in research by private and university remote sensing technologists.

State-level utilization of LANDSAT data are most impeded by: (1) insufficient time for technology transfer of a highly complex technology, (2) political processes wherein decision-makers and R&D priorities are

frequently changed, (3) the spatial resolution of LANDSAT data, and (4) lack of commitment to an operational satellite system. Of this, the spatial resolution of the data appears to be the most critical factor. Many state users were attracted from the beginning to the unique perspective provided by LANDSAT multispectral coverage, but were disappointed by the lack of detail when trying to determine detail at their conventional 1:24,000 scale. Detail in resolution is most required in the land use and environmental applications, and least required in geological mapping. State users are slow to accept computerized processing of data, especially if it may result in a reduction of their staff and/or large resource commitments.

State users are very product-oriented and are not as a group willing to invest heavily in costly equipment, especially digital processing equipment. State users are waiting to see what routine use of LANDSAT data can provide for them in a way that aircraft data already provide on a routine basis.

It has been clearly demonstrated that the opportunities exist for using ERS data in such state priority data need areas as surface mining and reclamation monitoring, land use/land cover studies, coastal zone management, waste water management and natural disaster damage assessment. However, progress toward developing operational systems has been slow.

Acceptance of LANDSAT data by state and local users will involve a long process in which federal support (in terms of funding and technological leadership) will continue to play a dominant role. Preference for NASA data will be for high-flight data currently flown at a scale of 1:120,000; LANDSAT data will be used for regional inventory and mapping. The planned introduction of 20 to 40-meter resolutions of future ERS satellite data systems will hasten the acceptance of ERS data, but until state users employ digital processing techniques, such data will remain underused.

State users will make routine use of the data when either large- and medium-scale products are made available for state and local use (1:24,000 to 1:100,000 scales) or computerized formats which readily adopt to state agency models. State users will make use of the data wherever they provide a clear advantage in terms of timeliness and cost over present data, as long as sufficient detail for planning and decision-making can be extracted from the data.

Until LANDSAT data and LANDSAT data products are a routine data base by state user agencies, and until the state users develop confidence in the validity of the data, federal and/or federal regional centers will have to carry the thrust of the research required to develop the application systems. Private and university groups should assist state, regional, and local agencies, but should be discouraged from developing a vast array of processing techniques which only serve to confuse the state user, unless a clearcut advantage of a new processing technique can be demonstrated.

SURVEY RESULTS

PART 3. FEDERAL GOVERNMENT USERS

PART 3. FEDERAL GOVERNMENT USERS

General Description

Federal users of ERS data were identified and user views were obtained from 205 returned federal questionnaires and 76 interviews. Survey efforts were coordinated to limit the number of responses received from any one office or program activity within a federal agency. The organizational distribution of the information base used in this survey and the types of individuals contacted in each federal agency are noted in Table 9.

TABLE 9. INFORMATION SOURCES USED IN ANALYSIS OF FEDERAL AGENCIES' ERS INVOLVEMENT(2-4)

	Houston Questionnaire	Interviews	Mail Survey	Total	Types of People Interviewed: Administrative	LANDSAT/SKYLAB PI	Remote Sensing Coordinators	R&D Personnel	Field Personnel
Department of Agriculture	17	14	14	45	x	x	x	x	x
Department of Commerce	6	12	6	24	x	x	x	x	
Department of Defense	7	7	51	65	x	x	x	x	
Department of Interior	20	20	43	83	x	x	x	x	x
Department of Transportation	1	4	2	7	x		x		
Department of State	2	2	1	5	x		x		
Other Federal Agencies & Commissions (Including EPA, HUD)	20	17	15	52	x	x	x	x	x
Total	73	76	132	281					

Federal agencies have, for a long time, routinely collected and analyzed remotely sensed data, especially aerial photography. Currently, federal agencies are a major experimental user of LANDSAT data. The federal user group includes those agencies within the Departments of Agriculture, Interior, Commerce, and Defense who have actively and directly participated with NASA in planning, developing, and evaluating the LANDSAT program; other federal departments and agencies who use aerial photography and who are conducting LANDSAT investigations relative to their areas of special interest; and, federally supported regional river basin and economic development commissions. In total, 26 major federal agencies have been identified as current users and are listed in Table 10.(1-12)

Federal users have devoted their efforts toward acquiring, analyzing, applying, and disseminating LANDSAT and other ERS data. Applications undertaken by federal agencies by discipline include:

- Agriculture - Forest, crop and soil classification, inventories and mapping; crop condition monitoring and yield prediction; disease detection; and, forest range and grassland management
- Geology - Mineral and fossil fuel exploration and geological mapping
- Hydrology - Water quality; reservior mapping and monitoring; snowfall and runoff estimates; flood damage assessments; and irrigation management
- Environmental/ Ecology - Wildlife habitat; surface mining monitoring; coastal zone, and critical areas
- Land Use and Mapping - Data base formulation; Levels I and II land use classification, environmental planning, and topographic and thematic mapping
- Oceanography - Ocean current monitoring; iceberg and sea ice monitoring; and ocean resources
- Other Disciplines - Interpretation techniques and equipment development; education; technology transfer; meteorology; data acquisition; and, data analysis systems.

TABLE 10. MAJOR FEDERAL AGENCIES USING ERS/LANDSAT DATA[1-4]

Department of Agriculture

- Agricultural Research Service
- Forest Service*
- Economic Research Service
- Soil Conservation Service*
- Statistical Reporting Service*
- Foreign Agriculture Service

Department of Commerce

- National Oceanic and Atmospheric Administration*
- Social and Economic Statistics Administration
- Economic Development Administration

Department of Defense

- U.S. Army Corps of Engineers*
- Defense Mapping Agency

Department of Interior

- Bureau of Outdoor Recreation
- Bureau of Land Management*
- Bureau of Mines
- Bureau of Reclamation
- Geological Survey*
- Fish and Wildlife Service
- National Park Service

Department of Transportation

- U.S. Coast Guard
- Federal Highway Administration

Department of State

- Agency for International Development
- American Embassy Offices

Federal Agencies and Commissions

- Energy Research and Development Administration
- Environmental Protection Agency
- National Aeronautics and Space Administration*
- Tennessee Valley Authority

* Most frequent Federal Government ERS data users - based primarily on frequency of ERS data orders from various data centers.[1-4]

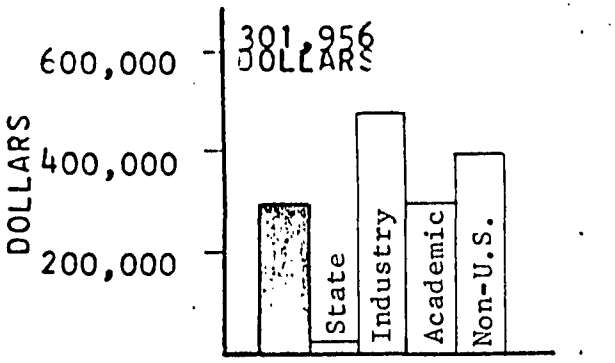
As shown in Figure 20, federal users are currently the third most active of the ERS data user groups in terms of items purchased from the three ERS data centers. They rank slightly above academic users and significantly below industrial and foreign user groups. Over a 3-year period (FY 1973-1975), federal users accounted for 15 percent of the data centers' business. In terms of frequency of data use, more than half of the federal users contacted during this survey (interviews and returned questionnaires) indicated they had standing or frequent orders at the various data centers.(1-4)

Many federal agencies are investing their resources to evaluate the utility of LANDSAT data in ongoing programs, and some agencies are developing quasi-operational programs related to their specific mission.

In addition to the Department of Interior's EROS Data Center at Sioux Falls, South Dakota, similar facilities for disseminating LANDSAT and ERS data are maintained by the Department of Agriculture in Salt Lake City, Utah, and NOAA in Suitland, Maryland. From 1973-1975 approximately 86 percent of LANDSAT data items were purchased from EROS Data Center, 8 percent from USDA, and 6 percent from NOAA. Federal agencies have established data user assistance facilities at Menlo Park, California; Phoenix, Arizona; Denver, Colorado; Reston, Virginia; Bay St. Louis, Mississippi; Fort Clayton, Canal Zone; Fairbanks, Alaska; Greenbelt, Maryland; and Sioux Falls, South Dakota. At these facilities trained staff and equipment are maintained to assist users in ERS data analyses and applications. In addition to these data user assistance facilities, several small LANDSAT Data Reference Files (Browse Files) have been established throughout the United States to maintain microfilm copies of data available from the data dissemination centers and to provide assistance to the public in reviewing and ordering data.(1)

High-altitude aerial photography frequently acquired by NASA, Department of Interior, and Department of Defense aircraft is used to support LANDSAT data programs and provide timely data for other federal programs. The Department of Agriculture and the Environmental Protection Agency also periodically acquire aerial photography for crop and forestry resource management and environmental protection activities, respectively.(1-8,11-13)

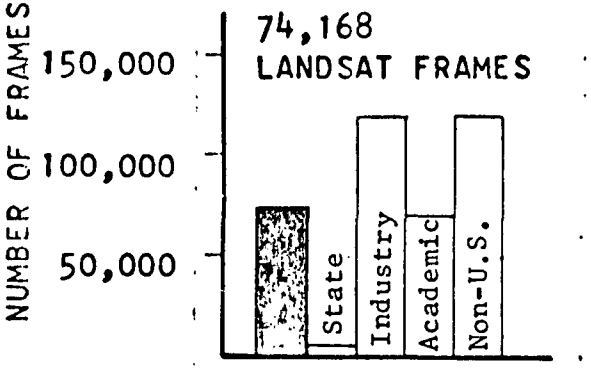
Figure 21 shows the relative discipline interests of current federal data users. Unlike other users, federal users span several disciplines. Questionnaire survey results indicate that current federal ERS data use is largest in the water/marine resources and land use areas. Agricultural, forestry and range management applications are third, with geology, environmental applications, and interpretation technique development being of lesser current interest. Also significant is that federal agencies are making the most extensive use of the LANDSAT Data Collection Platform (DCP) relay capabilities.(2,4)



EXPENDITURES FOR LANDSAT IMAGERY(1) (FY 1973-75)

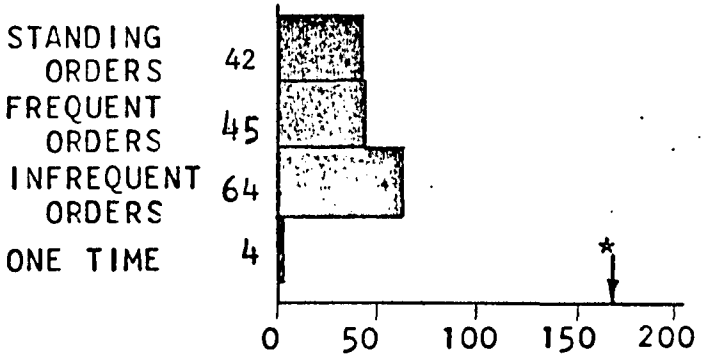
Federal Users

- Some 26 Major Federal User Agencies Have Been Identified
- Federal Users Purchased 15% of all LANDSAT Frames During FY1973-1975 and Account For 15% of Dollar Volume
- Federal Users Represent the Third Most Prominent ERS Data User Group
- Over Half of the Federal Users Surveyed Have Standing or Frequent Orders at Data Centers



LANDSAT FRAMES(1) (FY 1973-75)

PERCENTAGE OF TOTAL DOLLARS SPENT (FY 1973-75)(1)



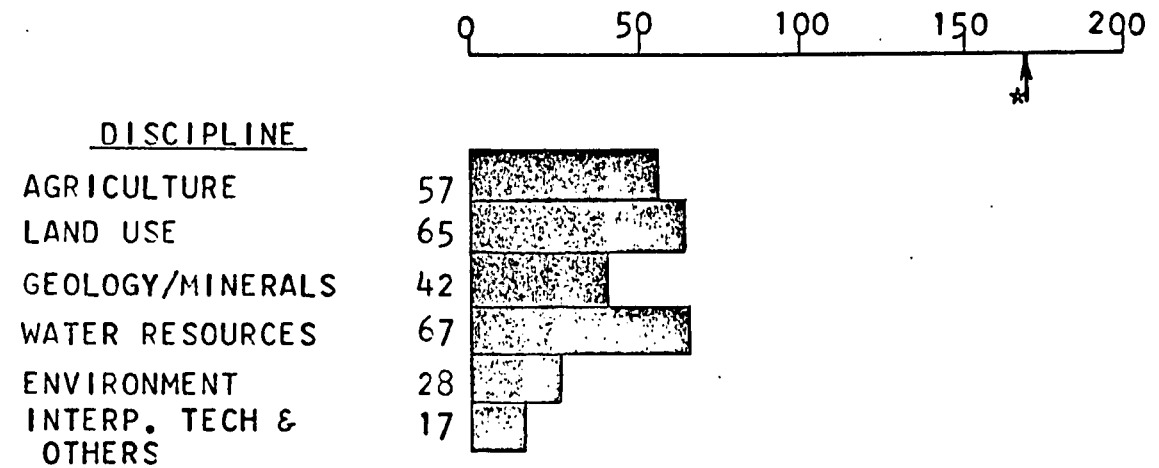
*Federal Users Responding - 169

FREQUENCY OF DATA ORDERS(2,4)

FIGURE 20. FEDERAL GOVERNMENT - EARTH RESOURCES SURVEY DATA USE PROFILE(1,2,4)

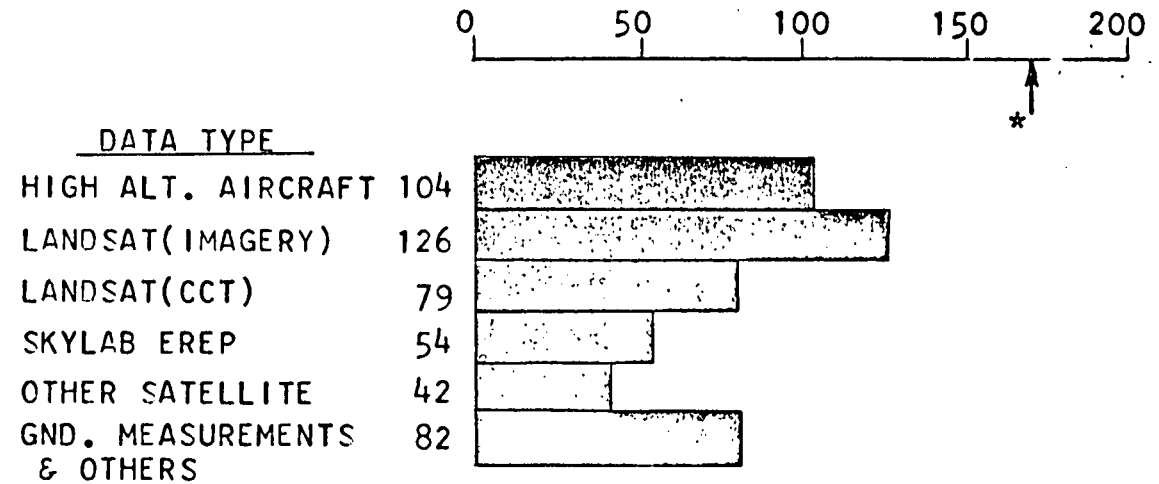
RELATIVE DISCIPLINE INTEREST

- Federal Agencies' Applications Span More Disciplines Than Any Other User Group
- Most Current Application Areas Involve Water/Marine Resources And Land Use Disciplines
- Fewer Application Interests Expressed in Agriculture, Forestry And Range Resources And Geology Disciplines
- Principal Users of Data Collection System (DCS)



RELATIVE TYPE OF ERS DATA IN USE

- Federal Agencies Most Commonly Use LANDSAT Imagery And High-Altitude A/C Photography
- Almost Half of the Users Contacted Use LANDSAT CCT Data
- On an Average Three Types of Data Are Used by Most Federal Users
- Federal Users Strongest on Ground-Based Measurements Required for Developing And Verifying Application Procedures



* 169 federal users responding.

FIGURE 21. FEDERAL GOVERNMENT - GENERAL DATA USE STATUS[2,4]

Questionnaire survey results indicated that, in terms of relative types of ERS data being used, LANDSAT imagery use leads all other ERS data types, followed very closely by high-altitude aircraft data. (See Figure 21.) About half of the federal users are involved in digital analysis of the CCT's and ground-based measurements. Most federal users indicate current use of at least three types of ERS data.[2,4]

Federal users contacted during the survey indicated that the ERS data were being used about equally for research and for planning purposes and, to a lesser degree, for monitoring and educational functions. Organizationally, the data are of about equal use in routine operations or management and policy-making activities. The relative comparison of functional and organizational use among federal users responding to this survey is shown in Figure 22. This figure also shows the relative distribution of the funding sources for federal ERS programs; NASA appears to be providing some level of financial support to less than one half of the federal user respondents.[2,4]

Evaluation of Specific Data Use[1-7,11-14,16,21]

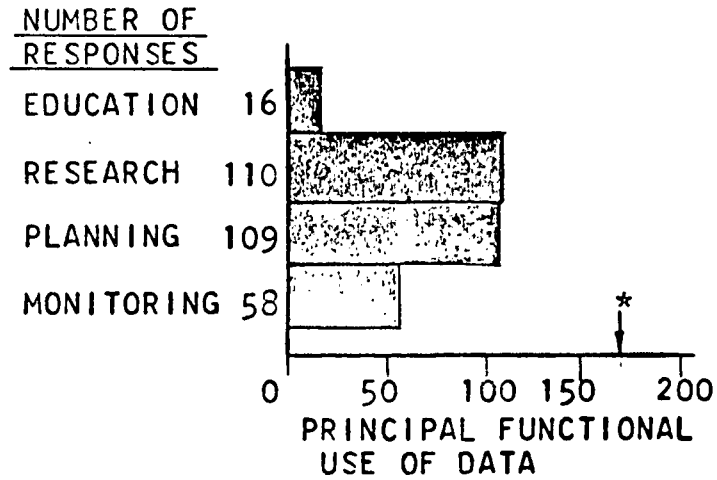
In analyzing the use of LANDSAT data by federal agencies four levels of use were defined in Table 11 as follows:

(1)	Planned/Potential	- Application Possibilities are Recognized and Desire Expressed to Evaluate and Use the Data.
(2)	Experimental Use	- Evaluation of Use/Application Possibilities (Involves Technical, Economic and Institutional Assessments).
(3)	Quasi-Operational/ Demonstrational Use	- Development and Demonstration of a Methodology and/ or System for Routinely Using Satellite ERS Data.
(4)	Routine/Operational Use	- User-Financed Employment of a Methodology and/or System for Routinely Using Satellite ERS Data.

This assessment of ERS data use for federal agencies is based upon questionnaires, interviews, and other information obtained during the study. The comprehensiveness of this assessment is limited to significant federal programs identified during the study and does not necessarily include all ERS data applications by all federal agencies or federal agencies which infrequently use ERS data. Also, use/users of medium to low-altitude photography have not been included. It is also important to note that some agencies, such as NASA and NSF, cannot become operational users of ERS data because of current charter limitations.

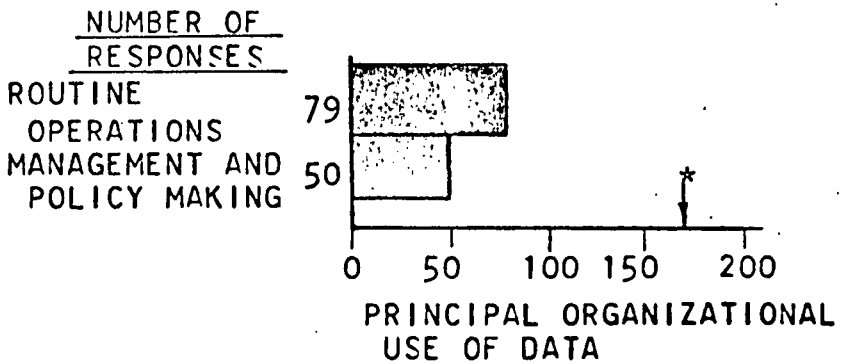
FUNCTIONAL USE

- Principal Functional Use by Federal Agencies is Evenly Divided Between Research And Planning And Decision-Making
- Application of ERS Data for Monitoring Was Indicated by One-Third of the Federal Users
- About 10% of Respondents Use Data for Educational Purposes



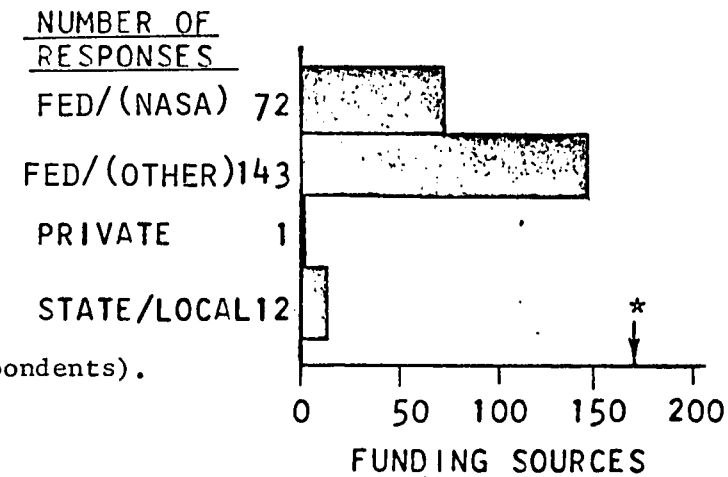
ORGANIZATIONAL USE

- Federal Agencies Are Using Data About Equally in Routine Operations And For Management And Policy Making



FUNDING SOURCES

- Federal Users Indicate Most Support For Data Use is Provided by Their Own Agencies



* Total federal users responding - 169 (includes 3 NASA respondents).

FIGURE 22. FEDERAL GOVERNMENT - TYPES OF USES AND FUNDING SOURCES[2,4]

TABLE 11. FEDERAL USER - SURVEY SYNOPSIS

Organization	Agencies	Level of Use*				Data Applications
		(1)	(2)	(3)	(4)	
Department of Agriculture	• Agriculture Research Service		X			Development of new agricultural practices
	• Agricultural Stabilization and Conservation Service	X				Technology transfer and data banks
	• Extension Service	X				Educational
	• Forest Service			X		Forest inventory and monitoring
	• Economic Research Service			X		LACIE ASVT/** Crop Forecasting
	• Soil Conservation Service		X			Soil and water conservation
	• Statistical Reporting Service			X		LACIE ASVT/** Crop Inventorying
Department of Commerce	• NOAA			X		Coastal zone applications, LACIE ASVT**, water management
	• Social and Economic Statistics Administration		X			Relationship of data to census data
	• Economic Development Administration		X			Resource inventory and management studies
Department of Defense	• U.S. Army Corps of Engineers			X		Environmental and water related resource studies
	• All Others: ARPA, DMA, etc.		X			Cartographic applications
Department of Interior	• Bureau of Indian Affairs		X			Management of Indian lands
	• Bureau of Outdoor Recreation		X			Land use and environmental studies
	• Bureau of Land Management			X		Rangeland monitoring
	• Bureau of Mines		X			Energy resources
	• Bureau of Reclamation		X			Land reclamation
	• Geological Survey				X	EROS program and other programs
	• Fish and Wildlife Service		X			Fish and wildlife habitat preservation
	• National Park Service		X			Park management and resource inventory monitoring
Department of State	• American Embassies		X			Technology transfer
	• Agency for International Development		X			Remote sensing technical assistance to developing countries
Department of Transportation	• Federal Highway Administration		X			Land use, route selection
	• Coast Guard		X			Pollution surveillance, ice detection, SAR
Federal Agencies and Commissions	• Energy Research and Development Administration		X			Geological and environmental applications
	• Environmental Protection Agency		X			Environmental monitoring
	• Federal Energy Administration		X			Resource inventory
	• National Science Foundation	X				Technology transfer
	• Tennessee Valley Authority			X		Resource inventory and management

* (1) Planned Potential.
(2) Experimental.
(3) Quasi Operational.
(4) Routine/Operational.

** LACIE ASVT - Large area crop inventory experiment application system verification test.

Department of Agriculture (USDA)

Within the Department of Agriculture, the U.S. Forest Service, Agricultural Research Service (ARS), Statistical Reporting Service (SRS) and the Foreign Agriculture Service (FAS) are the major agencies who use ERS data and other remotely sensed data.

The U.S. Forest Service, through its Washington, D. C., headquarters, is evaluating the utility of various ERS data bases and is developing procedures to use ERS data in Forest Service inventory and management programs which require forestry, rangeland, hydrology, soil, and land use planning evaluations. Forest Service offices throughout the United States use high-altitude photography and LANDSAT data for land cover/vegetation mapping and inventorying, insect and vegetative disease monitoring, and forestry resource planning.

The Large Area Crop Inventory Experiment (LACIE) project office is located within the Foreign Agriculture Service, but staff from the Statistical Reporting Service, Economic Research Service and Agricultural Research Service are actively participating in the project. LACIE is a major three-year cooperative USDA, NASA, and NOAA Application System Verification Test (ASVT) effort to determine the degree to which LANDSAT CCT data can contribute to crop identification and crop forecasting for large agricultural areas. In this project the growing cycles of wheat are being monitored over a nine-state U.S. area to establish valid techniques for predicting the yield of food crops globally.

The Statistical Reporting Service uses aerial photography for estimating crop yields and the Agricultural Research Service uses many sources of data, including ERS data, for spectral modeling of vegetation reflectance, land use change detection, carrying capacity and soil erosion estimates, crop vigor assessments and other similar applications. The Agricultural Research Service is also cooperating with NASA, NOAA and the Mexican Government by evaluating satellite and aircraft data for ground-cover analysis in the cooperative International Screwworm Eradication Program.

Other USDA agencies such as the Soil Conservation Service (SCS), Agricultural Stabilization and Conservation Service (ASCS) and the Extension Service also use aerial photography and some ERS data in their conservation, data bank, and educational programs. USDA maintains an ERS data distribution center at Salt Lake City, Utah.

Department of Commerce

The National Oceanic and Atmospheric Administration (NOAA) is the chief agency within the Department of Commerce that is concerned with ERS data acquisition, dissemination and utilization. Through its Environmental Data Centers NOAA distributes LANDSAT and other environmental satellite data through the National Environmental Satellite System (NESS) program. NOAA conducts an integrated national program of research and services related to oceans and inland water through its ocean survey (NOS) and marine fisheries centers (NMFS) and other environmental conditions through its Environmental Research Laboratory in Boulder, Colorado. NOAA researchers use many ERS data bases in their assessment and prediction programs involving snow monitoring, runoff estimation, marine fisheries, oceanography, sea ice, technology transfer, navigational chart preparation, coastal zone management and other water related programs.

Through cooperative efforts with other agencies (particularly USGS), the Bureau of Census is an occasional user of ERS data (primarily high-altitude photography) for urban growth studies. Also within the Department of Commerce, the seven Regional Action Planning Commissions (Coastal Plains, Four Corners, New England, Old West, Ozarks, Pacific Northwest, and Upper Great Lakes) have assisted state and local governments in land cover and resource inventory ERS data application programs which relate to economic development. While not a major source of funds or user of ERS data themselves, these regional commissions do coordinate ERS planning, demonstrational, and training programs and sources of federal funds for participating organizations. For example, the Pacific Northwest Regional Commission in conjunction with the Department of Interior, is performing an ASUT program to develop and demonstrate a natural resources inventory system based on LANDSAT data for resource planning and management agencies within the states of Washington, Oregon, and Idaho. The National Technical Information Source (NTIS) also aids ERS data users by serving as a public clearinghouse for scientific and technical reports.

Department of Defense (DOD)

Within the Department of Defense, the U.S. Army Corps of Engineers is the major agency using ERS data for civilian applications including resource inventories, environmental assessments, land use, water quality, and other resource programs. The Corps of Engineers is the chief user of Data Collection Platforms (DCP), which are used in conjunction with water runoff monitoring and other hydrological activities. Through its

research laboratories the Corps also assesses the relevance of and develops techniques for using ERS data. Other Department of Defense agencies, such as the Defense Mapping Agency and the Office of Naval Research, acquire and use significant amounts of ERS data for a variety of military-related applications such as topographic mapping, cartography and oceanographic analysis. To a lesser extent, other defense agencies such as the Army Material Command and the Advanced Research Projects Agency (ARPA) have conducted experiments involving ERS data.

Department of Interior (DOI)

Agencies within the Department of Interior, which utilizes more ERS data than any other federal department, use ERS data in programs that provide basic water, land and mineral resource data and data products for all of the United States. The Department maintains a capability to acquire high-altitude photography and, for over a decade, has closely assisted NASA in ERS satellite programs. The U.S. Geological Survey and the Bureau of Land Management are the major ERS data user agencies within DOI.

Within the U.S. Geological Survey (USGS) the Topographic, Geological, and Water Resources Divisions; the Office of International Geology; and the recently established Office of Land Information and Analysis (LIA) are involved in several ERS data programs. USGS ERS data applications have been investigated both at USGS Headquarters in Reston, Virginia, and at many other USGS offices throughout the United States and in other countries. The Topographic Division of USGS evaluates the utility of ERS data for making standard cartographic products that are publicly acceptable and develops procedures for the cartographic presentation of ERS data. The Geological Division has emphasized research and development efforts related to the recognition and evaluation of large-scale geologic features, delineation of areas of anomalous rock composition, and development of digital processing techniques. Mapping of floods, rangeland condition assessments, water quality, and snow and ice mapping are examples of the hydrological application of ERS data being investigated and used by the staff in Water Resources Division of USGS. The Office of International Geology coordinates efforts to use ERS data (particularly LANDSAT data) for mineral exploration efforts within other countries and promotes the transfer of remote sensing technology to other countries. The Office of Land Information and Analysis (LIA), which includes USGS's Earth Resources Observation Systems (EROS), Land Use Data and Analysis (LUDA) and Resource and Land Investigation (RALI) programs, focuses

on the land use/land cover and resource inventory applications of ERS data, development of ERS data products, user training and assistance, and dissemination of ERS data though its EROS Data Center at Sioux Falls, South Dakota.

Questionnaires returned by staff from the Bureau of Land Management (BLM) indicated that several ERS data sources are being used in the multiple use management of approximately 450 million acres of national resource lands located primarily in the Far West and Alaska. Specific ERS data applications of BLM include land use, vegetation, range, wildlife habitat, forestry, and soil inventories and assessments; watershed and ground-water management; cadastral surveys; and the monitoring of other environmental and resource conditions. Other DOI agencies with field offices which have evaluated the utility of various ERS data sources for environment impact assessments and resource management programs include:

• Bureau of Indian Affairs	Inventories of natural resources on Indian lands
• Bureau of Outdoor Recreation	Land cover determination within designated wilderness areas and wild and scenic rivers
• Bureau of Mines	Monitoring surface mining and reclamation efforts
• Bureau of Reclamation	Water and related land resource monitoring and weather modification programs
• Fish and Wildlife Service	Fish and migratory bird habitat evaluation, wetland inventories, and energy development impacts on land and water environments
• National Park Service	Land cover analysis, environmental protection and park management and planning
• Bonneville Power Administration	Cloud classification for areal precipitation and snow coverage estimates in watershed runoff forecasting and existing land use/land cover geographic applications.

Department of State

The Department of State provides ERS data and data products to foreign nations through American Embassies and provides remote sensing technical assistance and funds for studies in many disciplines through the Agency for International Development (AID).

Department of Transportation (DOT)

The Federal Highway Administration (FHWA) and the U.S. Coast Guard are the major agencies within DOT that utilize remotely sensed data. FHWA is primarily concerned with land use, geological, hydrological, environmental and route selection applications; the Coast Guard is involved with pollution surveillance, sea ice location, iceberg detection and classification in the Arctic Regions, development of a vessel traffic routing system, and search and rescue (SAR) missions. These agencies generally use aerial photography and remotely sensed data other than ERS data. However, FHWA sponsors and promotes research for developing new remote sensing technological applications of benefit to State Highway Administrations, and the Coast Guard is participating in the Great Lakes Ice ASVT effort to provide Great Lakes shipping companies with navigational information during the winter months of the year in an attempt to extend the shipping season.

Other Federal Agencies

Various ERS data are used in the programs of many independent federal agencies; these include: Energy Research and Development Administration (ERDA), Environmental Protection Agency (EPA), Federal Energy Administration (FEA), National Science Foundation (NSF), and the Tennessee Valley Authority (TVA). Regional offices of ERDA and FEA use numerous ERS and aerial photographic data bases for geological explorations and for environmental assessments of energy development sites. EPA acquires some high-altitude data over selected areas in times of environmental crises, but, in general, EPA use of ERS data is presently limited since most EPA programs require high-resolution data on a near-real-time basis. However, EPA maintains a Remote Sensing Laboratory in Las Vegas and an Environmental Photographic Interpretation Center (EPIC), through its four major research facilities and programs, conducts programs involving land use, water resource, and coastal zone applications of ERS data. NSF is monitoring the development of ERS data applications and assisting in the transfer of new ERS technologies. The TVA employs ERS data in several multiple-use resource programs within its jurisdiction.

Representative Federal Agency Use of ERS Data: A Case Study

In the past, the U.S. Army Corps of Engineers has been an extensive user of remotely sensed data, particularly of low to medium-altitude photography. Through the Army Civil Works Program, the Corps has the responsibility for the comprehensive management and development of the nation's water resources activities and assists other Federal agencies in programs related to flood protection, navigation, recreation, water supply and water quality, fish and wildlife habitat enhancement, and environmental improvement and preservation. In addition to its headquarters operations in Washington, D. C., and major research facilities such as the Waterways Experiment Station (WES), Engineering Topographic Laboratory (ETL), Construction Engineering Research Laboratory (CERL), Coastal Engineering Research Center (CERC) and Cold Region Research and Engineering Laboratory (CRREL), the Corps has established 10 division offices and 37 district offices geographically located throughout the United States.

Since the Corps of Engineers (1) has experience in remote sensing applications; (2) confronts contemporary multidisciplinary problems common to many other ERS data users; and (3) has an established nationwide organization, the Corps was selected as a likely representative user of ERS data in federal agencies. As part of the comprehensive survey, questionnaires were mailed to Corps designated "Remote Sensing Coordinators" at each laboratory, district, and division office. Completed questionnaires were received for 40 of 67 different offices and laboratories.

Analysis of the returned questionnaires, with supplemental telephone interviews, clearly indicated that the majority of ERS data applications by the Corps are experimental or demonstrational investigations being carried out at the laboratories and by LANDSAT investigators. Division and district offices are, for the most part, not extensively using LANDSAT or ERS data. Eleven offices reported that they are not presently using any ERS data and sixteen other offices indicated that ERS data are used only on an infrequent basis. Districts, in general, acquire ERS data on an "as needed" basis for specific activities and do not currently have a continuing program of involvement in the use of ERS data. Those who responded indicated that, while ERS data do provide a synoptic view of river basins (the normal jurisdictional area), LANDSAT data are not applicable in many specific day-to-day Corps activities such as engineering, construction, site planning, and park and dam management, because of resolution, timeliness, and data analysis limitations. However, high altitude aerial photography has been used to map natural and cultural resources of selected basins, and Data Collection Platform (DCP) data are being used as information sources for water quality and flood control programs.

While aware of ERS data applications, Remote Sensing Coordinators at the division and district offices are not fully aware of the state of the art of data analysis procedures and applications. Some Corps studies involving ERS data are conducted in-house, but most studies are completed by contracts to research and A&E firms who have specialized facilities and capabilities.

In essence, the research laboratories of the Corps of Engineers are presently experimenting with developing application techniques that will enable the district and division offices to uniformly and routinely use ERS data. Division and district use of ERS data has been generally limited to one-time or specialized applications such as river basin mapping and sedimentation transport modeling studies of nearshore processes.

How Federal User Agencies View ERS Data

Data Use Assessment

Federal user views as to the utility of LANDSAT data and LANDSAT data products vary significantly according to agency missions and programs. Representatives of the Departments of Interior, Agriculture, and Commerce; the Corps of Engineers; and other federal agencies which are more concerned with large area programs see LANDSAT data as a unique and exciting new data base with significant potential utility. Some significant one-time applications, such as in the Mississippi flooding program, have occurred because of the unique synoptic advantage LANDSAT provides; however, most LANDSAT data products are viewed as supplemental or complementary to conventional high-altitude aerial products currently being used in many operational programs. Although these agencies recognize present LANDSAT technological limitations, they are accepting the challenge to effectively use current LANDSAT data and are working to explore future opportunities for operationally utilizing ERS data. On the other hand, representatives from other federal agencies who depend largely on low- or medium-altitude aerial photography, generally view the LANDSAT program as an unnecessary federal effort. Representatives of these agencies feel that NASA is not being responsive to their present needs, which require high-resolution aircraft data on a regular basis. If resolutions and products comparable to those of low- and medium-altitude photography can be achieved, then this segment of the federal user community will also become users of ERS data.(2-6)

Such federal agency user views are reflected in the following selected comments:(3)

- "We know that the current resolution of the LANDSAT system prohibits us from currently using the data, but we are developing the interpretation methodology so that we will be ready to operationally utilize data from future satellite systems. Nevertheless, we are trying to use LANDSAT data whenever possible." (Ass. Administrator, USDA)
- "We don't have a new technology looking for problems; we have problems developing our technology to compete with conventional remote sensing data sources to solve today's problems." (Program Manager, USDA)
- "Applications research and technological improvements are needed. Stop promising applications before they are developed. For us, the real heart of the problem in remote sensing is to develop a product (data) meaningful to state and local agencies." (Program Manager, USDA)
- "Is anybody really seriously using LANDSAT data ?" (Senior Research Scientist, USDI)

- "There seem to be a few special-purpose places where ERS data are useful (oil surveys, geological research) but no really widespread uses for a diverse spectrum of users (farmers, city planners, etc.)." (Researcher, USDA)
- "I am quite gratified to see widespread concern about technology transfer. It has long been a problem for us because of lack of time, money, and manpower." (Senior Management, USDA)
- "Computer analyzed LANDSAT data resulted in the production of large area maps which were not subjected to operational bias." (Hydrologist, USDI)
- "Individual water bodies 5 hectares and larger can be readily identified with relatively small error." (Regional Coordinator, Corps of Engineers)
- "Further refinement in sensors and data processing techniques should make multispectral imagery collected from space platforms a valuable tool in water body surveys and monitoring activities." (Hydrologist, U.S. Coast Guard)
- "LANDSAT images uniquely highlight both localized and regional linear features of geological significance." (Geologist, USGS)
- "LANDSAT data offer exploration geologists a reconnaissance tool at a new scale and at a very reasonable cost." (Researcher/Manager, USGS)
- "The costs of Sierra Nevada snow maps produced from imagery of LANDSAT I and NOAA-2 are estimated to be 1/200 the costs of maps made from aerial surveys." (Scientist, NOAA)
- "A trained photogeologist can compile the information in one LANDSAT image in approximately two weeks that would take one field season to accomplish on the ground." (Research Geologist, USGS)
- "MSS imagery as corrected and printed in bulk form is, in effect, a defined map projection. This projection, if optimized for cartographic presentation, will have distortions in the order of only one part in 10,000." (Cartographer, USGS)
- "The data are of great value since the surveys directly support improvement of the economics in major areas of concern." (Project Manager, Department of Commerce)

Most federal users contacted during the comprehensive survey indicated that water resources and land use applications were disciplines currently benefiting from ERS data products, and, similarly, had the best potential for future utility. Most assessed the current data as complementary to other data sources, but potentially very important. The major value of the current data was considered to be its uniqueness. Most respondents noted that, in the future, such data could become a cheaper data source.(4)

LANDSAT Data Assessment

Figure 23 depicts graphically the results of the questionnaire survey related to how federal users assess the characteristics of the current LANDSAT data. As was the case with all user groups surveyed, federal users generally responded favorably to the adequacy of the spectral coverage, repetitive coverage and format and data quality features. The spatial coverage and the data delivery (timeliness) aspects were considered less adequate.[2,4]

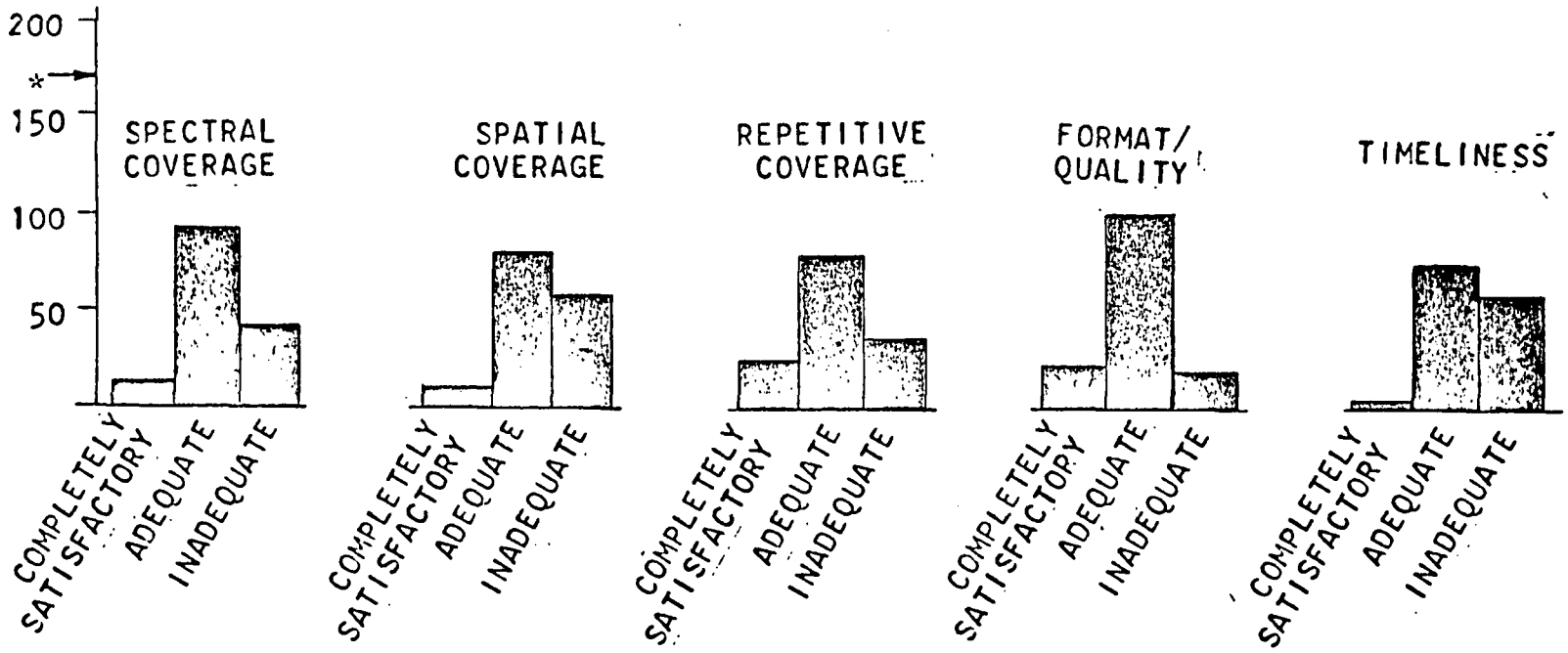
Survey questionnaire and interview responses from federal agencies revealed that no agency was completely satisfied with any LANDSAT data characteristics, and evaluations of LANDSAT data varied considerably among federal agencies and according to specific application programs. In general, personnel from the Departments of Interior, Defense, and Commerce considered LANDSAT spectral and spatial resolutions as adequate for current applications but many expressed the requirement for increased spectral and spatial capabilities. Personnel from USDA, DOT, EPA, and other less involved federal agencies (HUD, FEA, ERDA, etc.) strongly indicated that the spectral coverage and/or spatial resolution of LANDSAT data are inadequate for most of their agency data needs. Responses from most federal agencies rated LANDSAT data format and data quality as adequate. Department of Agriculture and Commerce personnel clearly indicated that the timeliness of LANDSAT data delivery was not adequate, while staffs from the Department of Interior, Corps of Engineers, and most other federal agencies generally viewed the timeliness of LANDSAT data delivery as adequate.[2-4]

Federal User Recommendations

The recommendations of ERS data users in federal agencies to improve the utility of the data were extremely different, depending upon application discipline, level of application and specific use of the data. Most user recommendations related to either improvements in spectral coverage and spatial capabilities or coverage and timeliness of data receipt.

Spectral and Spatial Capabilities

Current LANDSAT resolutions are adequate for large-area applications such as geological mapping and LACIE ASVT programs. However, current LANDSAT resolutions are considered inadequate for other applications such



- Although less than completely satisfied, Federal agencies are generally satisfied with LANDSAT data characteristics
- Most concern of federal users is with respect to slow data delivery times and spatial resolution limitations.

* Total federal users responding - 169.

FIGURE 23. FEDERAL USERS - LANDSAT DATA ASSESSMENT[2,4]

as environmental monitoring and transportation planning. Many federal agencies, especially those who work closely with state, regional, and local governments, strongly recommended that future ERS satellites provide large-scale spatial resolutions comparable to high-altitude photography. This segment of the federal user community also strongly recommended that more user services and specialized data products should be made available to assist all users. In general, for day-to-day applications, field personnel recommended higher spatial resolutions than administrative Headquarters personnel. Federal users also strongly recommended that spectral coverage be extended to include the thermal IR and microwave regions, and that spectral bandwidths be made narrower to accelerate use of ERS data and to improve the accuracy of resulting products.(2-4)

Repetitive Coverage and Data Delivery

User recommendations related to coverage and timeliness of user receipt of ERS data depended upon the current use of the data. For some LANDSAT data applications, especially those related to mapping and inventorying the Earth's resources, the current 9-day repetitive coverage provided by LANDSAT I and LANDSAT II is adequate. Cloud conditions are a problem for repetitive data acquisition over selected areas of the country and world. However, for other applications such as environmental monitoring and natural disaster assessments, more frequent repetitive ERS data coverage was recommended. In mapping applications, rapid user receipt of data is not as critical as the quality and resolution of ERS data, but in most monitoring and damage assessments operations, the timeliness of data receipt becomes extremely significant.(2-4)

Other Federal Recommendations

Other federal user recommendations frequently mentioned for improving the utility of ERS data include: low sun angle coverage, stereo viewing, special request data format options, development of specialized satellites, addition of a quick-look capability, increased funds for R&D and technology transfer efforts, more user inputs into planning future systems, specialized user-oriented training workshops and conferences, and routine information publications.(2-4)

Some of these user recommendations are reflected in the following specific user comments:(3)

- "I hear many comments on how fine U-2 imagery is. It seems that an effort should be made as soon as possible to have satellite imagery equal to U-2 imagery in quality and resolution." (Scientist, DOD)
- "We could probably use the data but improved data processing and distribution systems are needed first." (Research Manager, Army Corps of Engineers)
- "Better communications on research needs between ERS technologists and users, and education of users are needed." (Scientist, Environmental Protection Agency)
- "Products from military hardware systems are in many cases superior to what NASA has available." (Scientist, DOD)
- "NASA should publish a book outlining advantages and disadvantages of remote sensing sensors." (Geologist, USGS)
- "The ability of the LANDSAT DCS system to furnish meaningful hydrological data has been successfully demonstrated. However, the frequency of data collection is too low for many hydrological applications. Data collection every 3 or even 6 hours would be of great value." (Hydrologist, USGS)
- "NASA should involve more users in their programs and missions planning." (Technical Program Manager, FHWA)
- "LANDSAT data should be required once every 3 to 5 days and the data should be made available to operational users on a near-real-time basis, within 72 hours after the imagery is taken." (Researcher, USGS)
- "Standard cartographic mapping requires higher resolution imagery (1 to 2 meters) than is currently available from LANDSAT. Such data can probably be efficiently collected from dedicated unmanned spacecraft--probably launched and serviced by the Space Shuttle." (Scientist, USGS)
- "End-use equipment is too expensive for infrequent users; regional support facilities and terminals with access to EROS should be made available." (Researcher, Army Corps of Engineers)
- "Means to show cost savings...." (Administrator, Bureau of Reclamation)
- "Funded application training sessions for present and potential users...." (Scientist, Forest Service)
- "Access to more highly trained and experienced discipline specialists...." (Administrator, DOT)
- "NASA should adopt economic and social use descriptors in classifying remote sensing applications instead of existing technical or disciplinary descriptions, e.g.,

Instead of:	Adopt:
agriculture	food production
forestry	timber development
wildlife	natural resource preservation
land use	civil engineering, urban development
land cover	natural resource preservation
mineral, fuels, geology (commercial)	extractive industry
geology (scientific)	natural resources preservation
water, marine resources	natural resources preservation
environment, ecology	natural resources preservation
education, technology transfer	social development
R&D	industrial development, social development, scientific development.

The adoption of such terms will enable NASA to plan more effectively with end use in mind, and, importantly, justify such plans as being user-designed." (Technical Administrator, AID)

Summary and Outlook

In general, most federal ERS data efforts, to date, have been piecemeal, experimental, investigative, or continuing demonstrational efforts, and some federal agencies have taken a "wait and see" attitude and have made no real commitment to develop the technology.

ERS data operational and quasi-operational/demonstrational agencies are located within the Departments of Agriculture, Defense, Interior, and Commerce. These agencies routinely utilize high-altitude aerial photography and attempt to use LANDSAT in their day-to-day operations. These agencies will probably continue to commit significant staff and funds to cooperate and closely work with NASA in developing methodologies and procedures to formulate an integrated information system for rapidly processing and interpreting data from future improved ERS satellites. This user group collectively has the largest budgets and has more staff with remote sensing expertise than any other user group.

The Departments of State and Transportation, and agencies such as EPA, ERDA, and FEA utilize high-altitude photography only in specific program areas. These agencies are exploring potential applications of satellite ERS data and are likely to become operational users for selected agency programs with improved

sensor resolutions. Other federal agencies such as Economic Development Commissions are, in general, bureaucratic and administrative in nature with none or few major program activities. Such agencies may provide a nucleus for cooperative ERS programs among member organizations.

Federal agencies represent the key to ERS data technological transfer and development, and progress in the use of this technology, not only within federal agencies but also as it relates to the transfer and acceptance by other user groups. Congressional expectations and increasing demands by other user groups have placed federal agencies in a delicate situation in the development of ERS data technologies. Substantial funds are necessary to meet these expectations and demands; however, measures required to obtain funding (such as integrated, comprehensive long-range plans for establishing operational data requirements and systems) seemingly do not exist.

Increased resolutions and improved data handling capabilities in the LANDSAT C and planned satellite programs will be quite significant to expanding the role of federal agencies in developing the technology and will increase ERS data applications within federal agencies. However, except for specific applications which can take advantage of the unique advantages of LANDSAT-type ERS data, ERS data will continue to be used by federal agencies chiefly as a supplementary or complementary data base as compared to other data bases. In the meanwhile, user groups will be increasingly requesting better resolution data from federal agencies on a more timely basis as they use ERS data.

SURVEY RESULTS

PART 4. ACADEMIC/EDUCATIONAL USERS

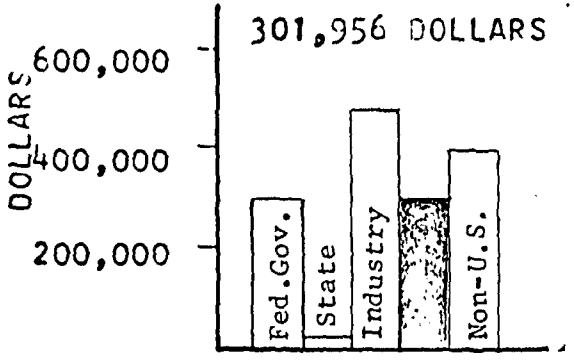
PART 4. ACADEMIC/EDUCATIONAL USERS

General Description

This group of ERS data users includes faculty members, researchers and students at academic centers (universities, colleges and research centers attached to such institutions) who are using ERS data for educational and research purposes. Academic users of ERS data are quite diversified, touching all disciplines, and by their sheer number, may very well constitute the largest domestic user community. In many instances, academic users provide the leadership in developing techniques for utilizing LANDSAT data. Often the academic community is the means whereby state, regional, local, and private end users are made aware of the application potential of LANDSAT data. This is especially true in geographic areas where no private service-to-user organizations or regional federal facilities exist. In fact, progress made by state, regional, and local governmental users would not nearly be as successful were it not for specialized expertise and equipment support provided by academic institutions. During interviews conducted in this survey, it was typically the academic user at state universities who provided the insight and overview of the ERS efforts conducted by state agencies throughout the state. However, it was also noted frequently that academic user views as to the usefulness of ERS data were too optimistic and often not shared by the actual state end user(s). State universities associated with major state agency programs noted in Table 8 under the State Regional and Local Governmental section of this report.(1-4)

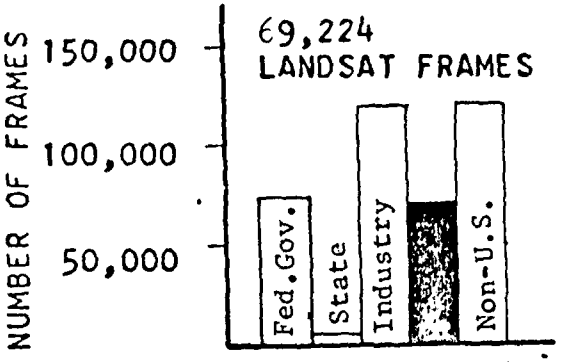
Figure 24 contains a profile of academic/educational user involvement in ERS data use based on a combination of data center records and questionnaire responses. During a 3-year period, (FY 1973-1975), universities spent more than $300,000 for LANDSAT data, or about 15 percent of the total sales volume. Academic users were tied for third place with federal users in terms of dollars spent for LANDSAT data purchases. Academic users purchased close to 70,000 LANDSAT frames during this 3-year interval. During this survey nearly two-thirds of the academic users participating indicated that they frequently purchased data from the ERS data centers. Major colleges and universities that were identified as users of ERS data during this survey are contained in Table 12.(1-4)

Academic Users

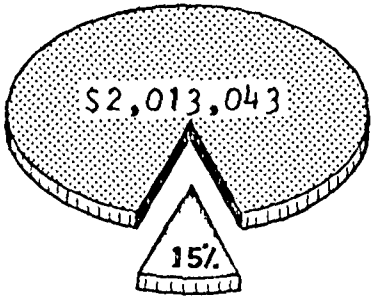


EXPENDITURES FOR LANDSAT IMAGERY (1)
(FY 1973-75)

- Fourth Largest User of ERS Data
- Close to Federal Government in Total Dollars Spent on LANDSAT Data

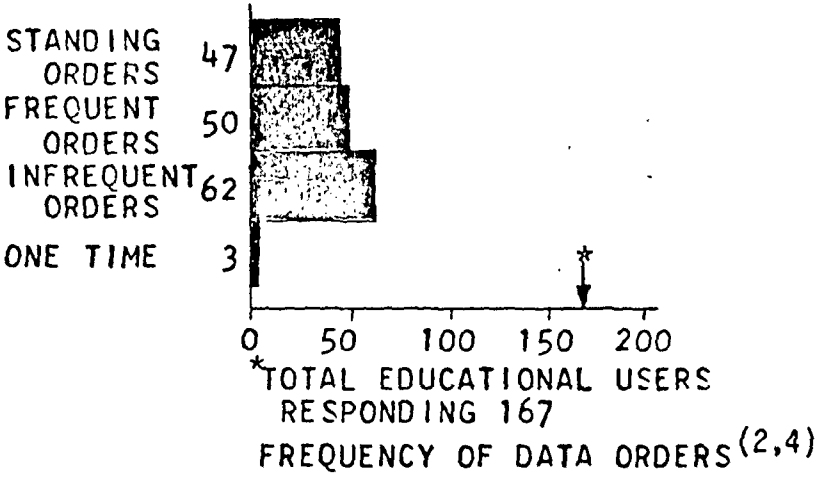


LANDSAT FRAMES (1)
(FY 1973-75)



PERCENTAGE OF TOTAL DOLLARS SPENT
(FY 1975-73) (1)

- Nearly Two-Thirds of University Users have Standing and/or Frequent Orders



FREQUENCY OF DATA ORDERS (2,4)

FIGURE 24. ACADEMIC/EDUCATIONAL EARTH RESOURCES SURVEY DATA USER PROFILE (1,2,4)

TABLE 12. MAJOR COLLEGES AND UNIVERSITIES WHO ARE USERS OF ERS DATA[1-4]

Alabama, University of (a)
American University (a)
Arizona State University (a)
* Arizona, University of (a)
Arkansas, University of
* Alaska, University of
Bringham Young University (a)
* California State College
* California State University (a)
(Various Branches)
* California, University of (a)
(Various Branches)
Clemson University (a)
* Colorado State University (a)
Colorado, University of
Columbia, University of
Cornell University (a)
Dartmouth College
* Delaware, University of (a)
Florida, University of (a)
Florida Atlantic University (a)
Georgia Institute of Technology (a)
Georgia, University of (a)
Harvard University
Hawaii, University of (a)
Houston, University of
Idaho, University of (a)
Illinois, University of (a)
Indiana University (a)
Iowa State University
Iowa, University of (a)
Kansas, University of (a)
Kentucky, University of (a)
Louisiana State University (a)
Maryland, University of (a)
Massachusetts Institute of Technology (a)
* Michigan, University of (a)
* Michigan State University (a)
Michigan Tech University (a)
Minnesota, University of (a)
* Mississippi State University (a)
Mississippi, University of
Missouri, University of (a)
Montana, University of
* Nebraska, University of (a)
Nevada, University of (a)
New Mexico, University of (a)
New York, State University of (a)
North Carolina State University (a)
North Dakota, University of (a)
Ohio State University (a)
Ohio University
Oklahoma State University (a)
Oklahoma, University of (a)
* Oregon State University (a)
* Pennsylvania State University (a)
* Pennsylvania, University of
Pittsburgh, University of (a)
* Purdue University (a)
Rice University
Rutgers State University (a)
South Carolina, University of (a)
* South Dakota State University (a)
South Florida, University of
Southern California, Univ. of (a)
Southern Illinois, Univ. of
* Stanford University (a)
Tennessee, University of (a)
* Texas A&M University (a)
Texas Tech University (a)
* Texas University of (a)
Utah, University of (a)
Utah State University (a)
Virginia Polytechnic Institute
Washington State University
* Washington, University of (a)
West Virginia University (a)
* Wisconsin, University of (a)
Wyoming, University of (a)
Yale University

* *Most frequent data users.*

(a) Institutions having remote sensing programs.[22]

As illustrated in Figure 25, academic users are fairly uniformly involved in all ERS discipline areas. Land use investigations appear to be somewhat in the majority, whereas environmental uses and interpretation technique development are considerably less in relative interest. The academic community is making extensive use of both high-altitude aircraft and LANDSAT photography. Also, it is significant that over half of the questionnaire survey respondents in this user group indicated use of digital LANDSAT data. Frequent use of Skylab EREP data was also noted by this user group, as was their emphasis on ground-based measurements. Survey results (Figure 26) also indicated that over 90 percent of the academic users were using the data for research purposes. Even though many university ERS programs depend on NASA and other federal agency for funding support, a large percentage of the academic programs involved commitment of state resources.(2-4)

Evaluation of Specific Data Use

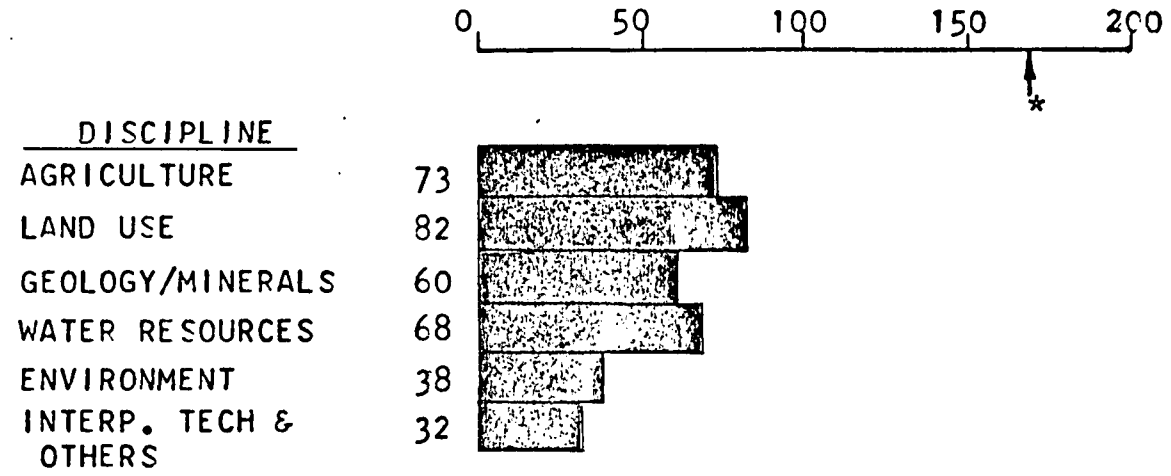
The primary effort within the academic user community for using LANDSAT data is strongly research-oriented. The magnitude of individual effort varies widely, falling roughly into two categories:

(1) University groups with strong remote sensing backgrounds and discipline expertise (agriculture, environment, land use, etc.), most of which have been supported by NASA for a number of years. The intent of these efforts was to develop new techniques and software for using orbital data. Also, these university groups have played an active role in training other LANDSAT data users.

(2) Discipline-oriented individuals who, utilizing university facilities and graduate students, have researched LANDSAT data for its potential usefulness in their discipline areas of interest. While some of these efforts have produced valuable results which are applicable to user needs, most efforts are not closely linked to end users, and therefore contributed mostly to the academic aspects of the technology development.

RELATIVE DISCIPLINE INTEREST

- Academic Users Equally Involved in all Discipline Areas (except environment and interpretation technique development, which are considerably less).



TYPES OF ERS DATA USE

- Majority of Academic Investigations Involve Both A/C and LANDSAT Data Use.
- Little Over One-Half of Academic Users Involved With LANDSAT CCTs.
- Heavy Academic Involvement in Both Skylab EREP and Ground-Based Measurements.

* 167 Educational users responding.

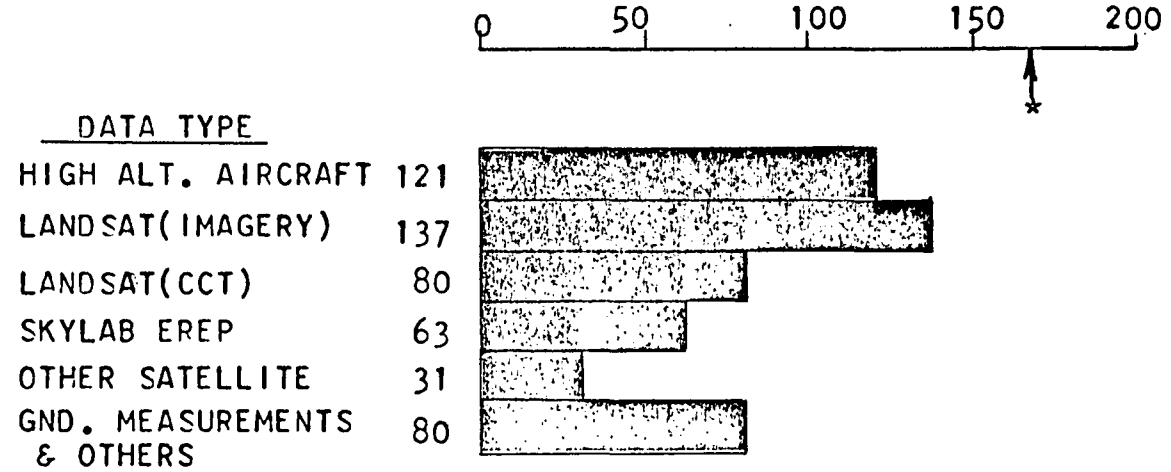
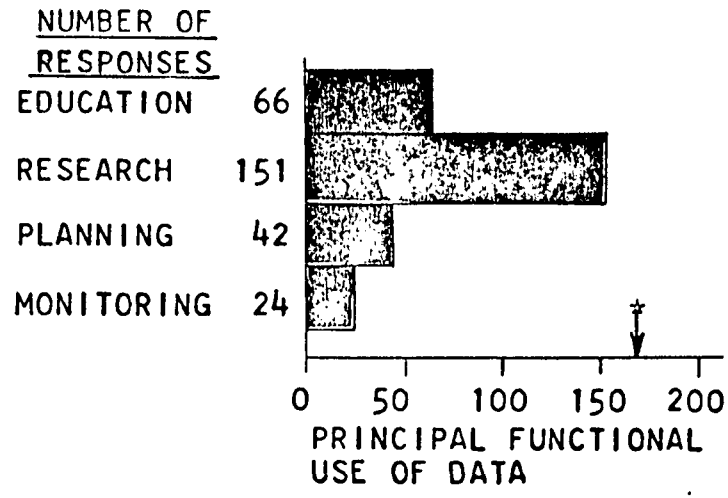


FIGURE 25. ACADEMIC USERS - GENERAL DATA USE STATUS[2-4]

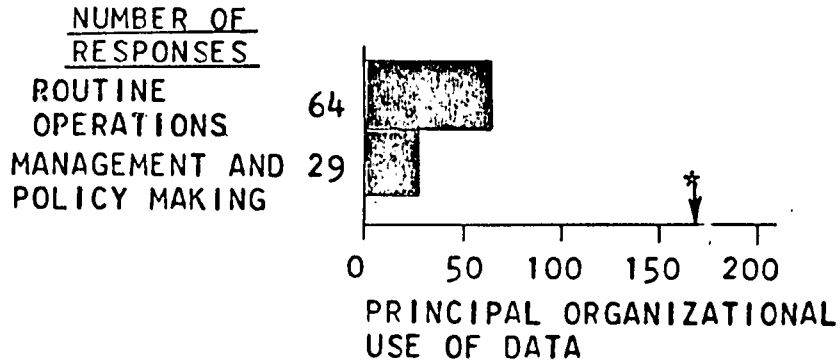
RELATIVE FUNCTIONAL USES

- As Expected, Majority of Academic Use is For Research Purposes (>90% of Total Academic Users Responding).
- About One-Third of Use is For Educational Purposes.



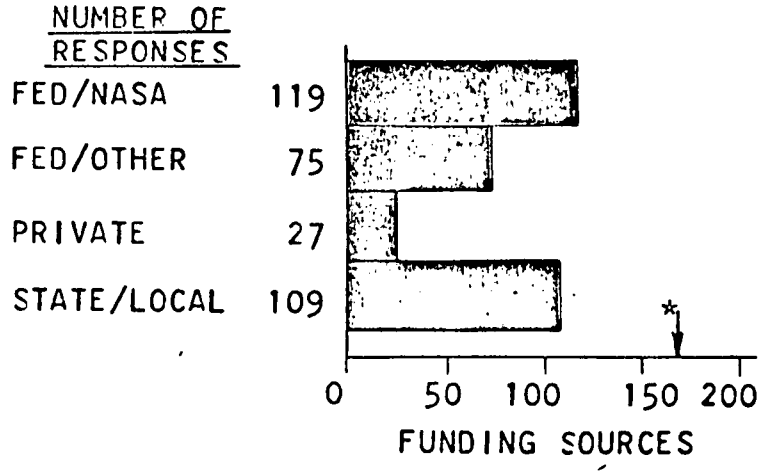
RELATIVE ORGANIZATIONAL USES

- Small User Response, as Question Not Really Applicable to Academic/Educational Users.



FUNDING SOURCES

- Most Academic ERS Involvement Stems From NASA and Other Federal Agencies' Support.
- Significant State Support (Over Half of Academic Users Responding to Survey Indicated Use of State Resources).



* 167 Educational Users Responding

FIGURE 26. ACADEMIC USERS - TYPES OF USES AND FUNDING SOURCES(2,4)

The sophistication with which users analyze ERS data is typically a function of their budget, technical background and imagination, and facilities/equipment available. At recent remote sensing symposia, academic users have presented research results employing various methods for using the LANDSAT data ranging from sophisticated digital techniques, precision optical processing, additive color viewing, and density slicing analysis to simple photointerpretation techniques utilizing handheld magnifiers. Academic users in the United States have utilized aircraft data for forest inventories, civil engineering applications, photogrammetry, architecture, etc., for at least the last 30 years. However, with the launching of LANDSAT I, the use of orbital and aircraft data reached a new interest level which varied widely in scope. Those who had a strong background in remote sensing applications were quick to evaluate the potential of data collected from space. Others who had little background in remote sensing technology often rushed to use the data but abandoned their efforts quickly, primarily because: (1) the spatial resolution and scale of the imagery proved disappointing, (2) insufficient or no knowledge existed about machine processing of the data, and (3) available aircraft imagery proved more useful than orbital data. Often researchers spent more time analyzing aircraft underflight photography while using LANDSAT imagery only as a fill-in. Those who never used remote sensing data before, and who were simply not aware of its precise scientific nature, felt that the data could apply to virtually any discipline, and consequently set out to use it in this manner.[1-8,11,16]

Although some of the latter activities led to disappointing results, overall progress of this user group has been significant. To date, academic users of LANDSAT data have investigated the use of the data in the following applications:[1-8, 11-13]

- Water resources
- Ice jam flooding
- Flood hazards
- Coastal studies
- Rangeland inventories
- Agricultural inventories
- Wildlife studies
- Lake water quality monitoring
- Water use by agricultural crops
- Strip mine mapping
- Hydrological studies
- Water circulation studies
- Mapping of snow avalanches
- Physical oceanography
- Geologic studies
- Urban and regional planning
- Major landslide mapping
- Structural geology
- Engineering/geoscience
- Air pollution studies
- Snow cover mapping
- Sea ice monitoring
- Coral reef monitoring
- Wetland ecology
- Land use mapping
- Forest inventories
- Meteorology
- Geomorphology
- Crop yield
- Insect damage to crops

- Strip mine reclamation
- Environmental analysis
- Shoreline form analysis
- Groundwater mapping
- Vulcanological studies
- User education
- Modeling techniques
- Interpretation techniques development
- Teaching
- Mineral resource location
- Flooding assessment
- Erosion studies
- Estuarine management
- Geothermal studies
- Landcover mapping
- Land use
- Delineation of swamps and marshes
- Geological mapping
- Soil surveys
- Wetland mapping
- Geography
- Irrigated land studies
- Soil moisture studies
- Wildlife habitat
- Landform analysis for archeological interpretation
- Recreational area mapping

How Academic Users View ERS Data

Data Use Assessment

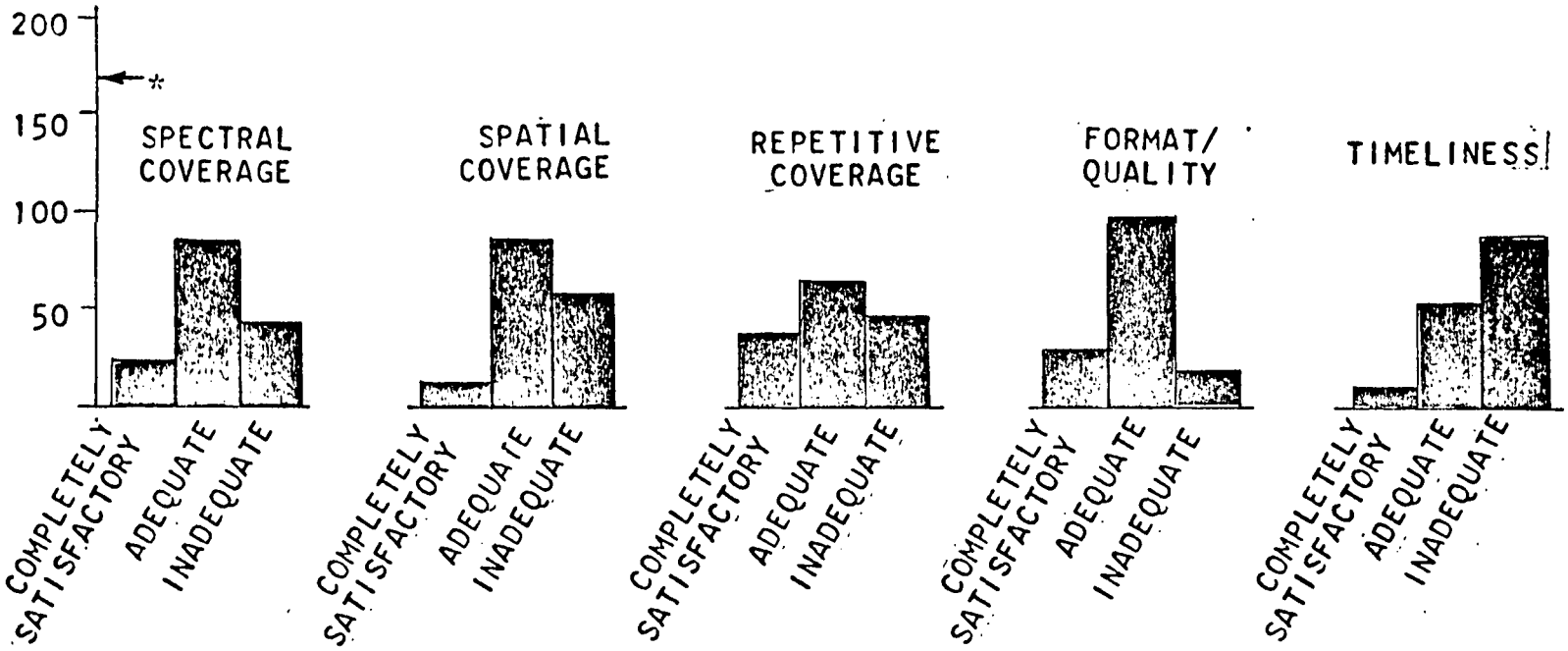
This survey indicated that most academic users view ERS data products as having high general utility. In assessing their usefulness relative to the various disciplines with which they are familiar, this user group felt that current data products are of most significance to land use and agriculture, forestry and range resources disciplines. Impact on all other disciplines was rated about equal, except a much lower rating was given to marine resources and ocean surveys. Potentially, most academic users thought the data products will remain a unique data source which will be very important, especially in the water resources and environment areas[4].

LANDSAT Data Evaluation

Academic users commented most frequently on the following aspects of LANDSAT data:

- Spatial resolution
- Spectral Coverage
- Narrowing of spectral bands
- Better timeliness
- Information regarding the use of LANDSAT CCT's and digital processing on university-type computers
- More high-altitude aircraft photo coverage.

Spatial Resolution. Questionnaire responses (see Figure 27) indicated that more than half of the academic users described LANDSAT spatial resolution as adequate. These same users, however, also strongly and repeatedly asked for improved resolution, often on the same questionnaire which indicated that the data are adequate. There is really no conflict in such a view. The user simply wants to express



- Over half of academic users responding in survey consider spectral and spatial capabilities of LANDSAT as adequate
- Although satisfied with present LANDSAT data, many users in this group felt strongly that improved spectral, and, more importantly, spectral capabilities would significantly improve data usefulness
- Very strong on inadequacy of present data delivery times
- Data formats acceptable but need more digital processing assistance
- Need for high-altitude A/C data to use in concert with LANDSAT data

* 167 Educational Users Responding

FIGURE 27. ACADEMIC USERS - LANDSAT DATA ASSESSMENT(2-4)

his satisfaction with LANDSAT data, and that it provides an information base which was not previously available. However, current LANDSAT data do not solve all the users' problems, and improved resolutions will help satisfy these needs.(2-4)

Spectral Coverage. More than half of the academic users thought the spectral coverage adequate, and yet made strong recommendations for addtional coverage in thermal bands. The same reasoning applies here as under Spatial Resolution.(2-4)

Timeliness. Delivery of LANDSAT data to the academic user proved to be a sensitive point with this user community also. Frequent complaints were made regarding delivery times of 30 to 60 days, especially in the delivery of CCT's.(2-4)

Standardized Information Regarding the Use of LANDSAT CCT's. The typical university ERS data user feels somewhat left out of efforts to develop techniques for machine processing of LANDSAT data. Many academic users know the importance of machine processing, and want to do machine processing, but are not knowledgeable in developing software packages. Users want more education on digital processing, standardized digital procedures, standardized software packages and information on how university computers may be utilized for image processing of LANDSAT data.(2-4)

Other High-Altitude Coverage. Academic users are impressed with high-altitude aerial data and feel more should be made available. Upon examination of many tasks performed by academic users involving both LANDSAT and underflight aircraft photography, it appeared that considerable effort was often expended on the analysis of the aircraft photography, with LANDSAT data providing only the framework for the analysis. The use of aircraft data in this manner only further substantiates the desire for higher resolution data by the academic community.(2-4)

Academic User Recommendations

The academic user community provided strong and specific recommendations for improving the utility of current and future earth resources satellite data. Recommendations most frequently suggested for improving the usefulness of current LANDSAT data included:[2-4]

- Better radiometric and geometric quality of the data
- More flexibility in data products (i.e., greater enlargements and choice of selected areas of interest within a LANDSAT scene)
- Increased assistance in digital processing procedures, including the standardization of software, and/or procedures for using LANDSAT CCT's on different computers
- Additional training and career opportunities in remote sensing
- Cheaper CCT's
- More high-altitude photography coverage of the United States
- Additional funds for research
- Faster data delivery.

In future operational ERS satellite systems, the university community frequently suggested:

- Better turnaround time for data delivery - five to ten days from day of data collection
- Improved spatial resolution from 40 meters to 5 meters
- Additional spectral coverage including 1.55-1.75, 2.2, 3-5, 10.2-12.5, and 8-14 micrometers
- Additional microwave/all-weather sensors
- Develop special application satellites
- Establish a repetitive data collection cycle of approximately 6 to 9 days
- Develop regional centers to receive, process and disseminate LANDSAT data directly.

Summary and Outlook

The academic user community has been primarily instrumental in developing techniques and providing assistance to other user groups for using ERS data. Educational institutions purchase 15 percent of all LANDSAT data at an approximate cost of 100K annually. While academic users are primarily research-oriented, they also use ERS data for educational purposes. Probably no other user community has utilized LANDSAT data for so many applications. The most frequent investigations are for land use and agriculture applications. Academic users are heavy users of digital data but have also used a variety of other techniques such as optical processing, additive color viewing, density slicing and simple photointerpretation techniques.

Academic users in general consider most LANDSAT data parameters as "adequate", except for data delivery time. Most users specify improvements to help them do a better job or to help them convert from standard photo interpretation techniques to automated image processing. Among these are:

- Spatial resolution improvement from 40 to 5 meters
- Thermal band coverage from 1.55 to 14 micrometers and peaking of all bands
- All-weather sensors (microwave, radar, etc.)
- Delivery times of 5 to 10 days
- Standardized information regarding the use of LANDSAT CCT's and digital processing on university computers
- More high-altitude aircraft photography.

Academic researchers will continue to utilize current ERS data in research and educational programs, but probably not to the extent or with the enthusiasm displayed in the past because:

- Most LANDSAT users are aware of the limitation and potential of the data and thus have decided whether the data are useful to them.
- Research funds are not as plentiful.
- Digital data processing is just coming into its own but many academic users are not yet sufficiently informed as to the techniques and costs.

- Most university users are too much on their own in researching the data. Regional centers help some, but an insufficient number exists. Private companies can help, but by university standards are often too expensive.
- Most university applications are in a land use, agricultural, and environmental areas, which require considerably higher spatial resolution, thermal channels, and timeliness; this is why so many users prefer high-altitude photography.
- The addition of higher resolution sensors and thermal channels will renew activity in this user community. Data processing techniques will become considerably more standardized. Thus, new satellites will not cause such a severe technological shock as was caused by LANDSAT I. The academic user community will continue to provide leadership in researching orbital data. With few exceptions, however, it cannot be expected to become a self-supporting user of the data, but will continue to depend on federal and local funding.

SURVEY RESULTS

PART 5, NON-U.S./FOREIGN USERS

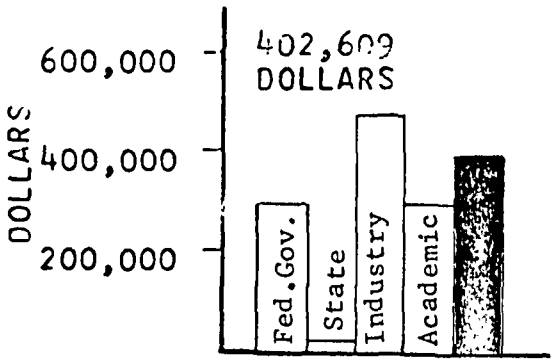
PART 5. NON-U.S./FOREIGN USERS

General Description

Foreign users are currently the second largest user of ERS data based on records of the various Earth resources data centers.(1) As shown in Figure 28, about 20 percent of the total dollars spent for LANDSAT imagery during a 3-year period (FY 1973 - FY 1975) came from non-U.S. customers. In addition to the nearly half million dollars spent during this period for data products, most countries currently have standing data center orders. Also, several countries have made major capital investments in facilities and equipment to directly acquire and process LANDSAT data. Currently, these countries include Canada, Brazil, and Italy, and signed agreements have been made with Chile, Iran and Zaire. Japan, Egypt, and South Africa are considering direct participation, and several other countries are known to be interested (Australia, India, Upper Volta and Scandinavian countries). More recently Canada has completed construction of its second ground station (this one on the East Coast), and Brazil and Italy have agreed to act as regional stations for providing LANDSAT imagery to neighboring countries (1-6,13,15-17).

Major reasons for this impressive and increasing international involvement include: (1) the over 100 foreign scientists who have been trained to date in the use of LANDSAT data at the EROS Data Center, (2) the extreme need of most countries for such comprehensive data, (3) the assistance being provided by U.S. industry in developing programs for using satellite data, and (4) the strong international support being provided by international developmental agencies such as the World Bank and the United Nations Development Program. Figure 29 shows the results of the non-U.S. user questionnaire responses as to the relative discipline applications and types of ERS data in use. (The reader is cautioned that this represents a very small sample, and it may not be representative of the total non-U.S. user community.) Survey results indicate that geologically-related data use slightly leads other application areas. Data use in all other disciplines is fairly uniform, except the environmental area, which appears to be somewhat smaller. Most foreign users

NON-U.S. USERS



EXPENDITURES FOR LANDSAT IMAGERY(1) (FY 1973-75)

- >120 Nations Involved
- Second Largest User of ERS Data Centers

Expanding LANDSAT Ground Station Involvements

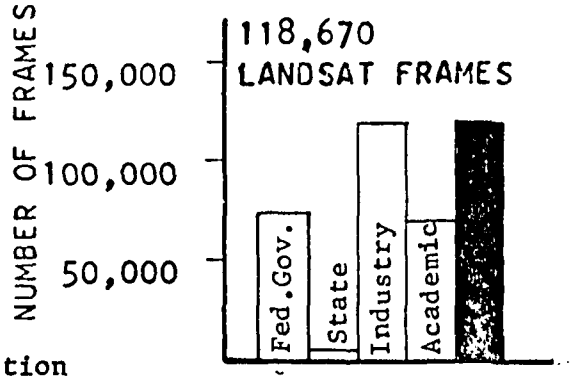
Current - Canada
Brazil
Italy

Under Construction - 2nd Canadian Station (East Coast)

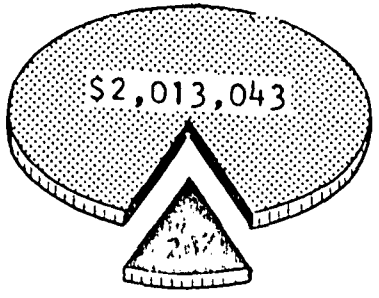
Signed Agreements/Planned Construction - Chile
Iran
Zaire

Under Consideration - Japan
Egypt
South Africa

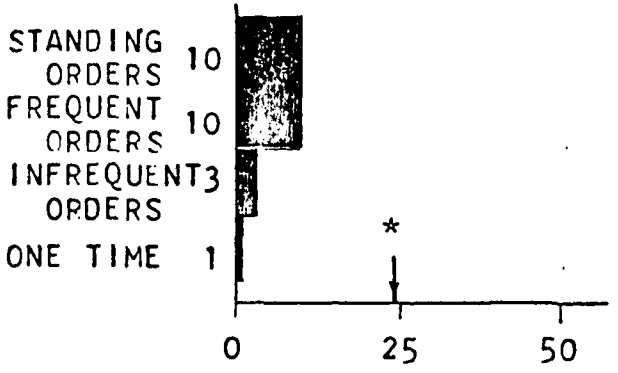
Interested - Australia
India
Upper Volta
Scandinavian Countries



LANDSAT FRAMES(1) (FY 1973-75)



PERCENTAGE OF TOTAL DOLLARS SPENT (FY 1973-75)(1)



*TOTAL FOREIGN USERS RESPONDING 24

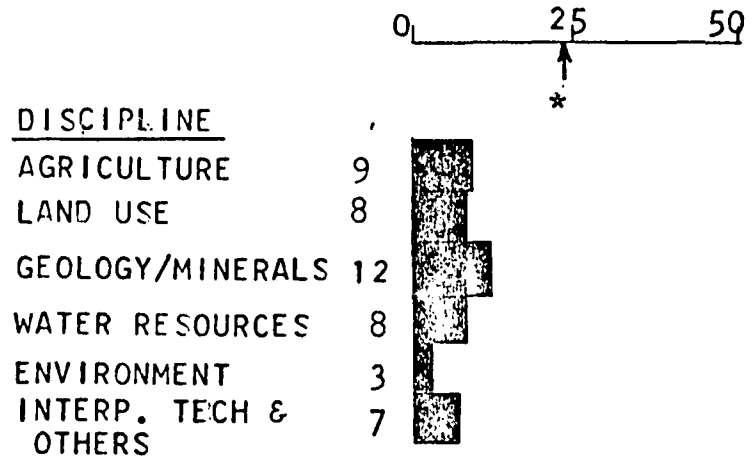
FREQUENCY OF DATA ORDERS(2)

- Most Foreign Users of ERS Data Centers Have Standing Orders or Are Frequent Users
- 90% of Foreign Data Requests For LANDSAT Data

FIGURE 28. NON-U.S./FOREIGN - EARTH RESOURCES SURVEY DATA USER PROFILE(1,2)

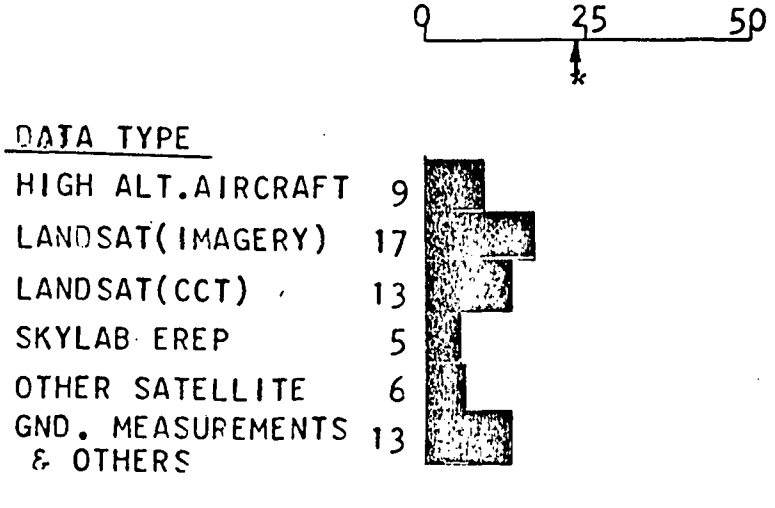
RELATIVE DISCIPLINE INTEREST:[2]

- Geology (Including Extractive Resources) Strongest Discipline Area of Foreign ERS Data Use
- Other Discipline Use Fairly Uniform Except Small Environmental Data Use



TYPES OF ERS DATA IN USE:[2]

- Most Foreign Users Using LANDSAT Imagery
- Large Percentage of Those Surveyed Indicate Use of Digital Tapes



* 24 Foreign users responding.

FIGURE 29. NON-U.S./FOREIGN - GENERAL DATA USE STATUS[2]

surveyed at the Houston ERS symposium indicated that they were involved in LANDSAT imagery use. A surprising high percentage of the few surveyed indicated a current involvement in LANDSAT digital data.[2]

Evaluation of Specific Data Use

Specific Users of Data

Foreign ERS data use varies from routine multidisciplinary uses in Canada to specialized, priority problem-solving applications in Lesotho, South Africa. Specific examples of major progress include:[1-3,5,11,12,16,20]

- Significant geological/lineament discoveries in South Africa, Switzerland, Germany, Australia, Sweden, Malaysia, Ethiopia, Bolivia, Italy, and France
- Land use and land cover mapping in South Africa, Ethiopia, and Greece; land accretion studies in Bangladesh
- Thematic mapping (timber) in Spain, snow type and melting maps in Switzerland and Norway, and resources inventory in Venezuela
- Locating targets for mineral exploration in North and South Africa, Venezuela, and Bolivia
- Measurement of dwarf shrub invasion on grassland in South Africa, and location of locust breeding sites in Saudia Arabia
- Locating unmapped islands in the Amazon, and improving Brazilian maps on which roads and rivers were in error by as much as 20 km.
- Measurement of sea pollution along Belgian coast
- FAO/UNDP/World Bank programs for selecting and monitoring developmental sites and for specialized applications such as flood damage assessment in Pakistan.

Of all foreign countries, Canada apparently utilizes LANDSAT data the most. For this reason, the representative case study of Canada was chosen to illustrate foreign use of ERS data.

Canadian ERS Date Use--A Case Study.[3,16,20] Canadian progress in the use of ERS data is noteworthy. In addition to being among the first countries to establish a ground station for direct receipt of LANDSAT data, the Canadians have pioneered in the development of practical data application concepts. One of the most significant developments has been the highly successful "quick-look" (LANDSAT fische) program. Currently, the Canadians are constructing their second ground station for East Coast coverage, which they claim represents a breakthrough in that the total station cost less than 1.5 million dollars. Canadian researchers have also prepared some of the most documented ERS data use cost benefit studies, especially in the sea ice navigation application area. As successful as this program has been to date, some concern exists as to the impact that the non-U.S. user fee ($200 K/year) will have on ERS data use in Canada. Of most concern is that data center costs may have to double or triple, which could reduce overall data use.

The best way to describe the overall Canadian program is as semioperational, in that it involves ERS data use at all levels of development - planned, experimental, and operational. Currently, Canada has operational programs for sea ice monitoring and navigation, and oil and mineral exploration. Demonstrational programs are underway to develop operational techniques for using LANDSAT data for forest fire management and for planning alternative pipeline routes. Experimental programs showing the best potential include land cover inventories and land use mapping, map revisions at 1:250,000 scale, and bud worm detection and control applications. Current data are assessed as inappropriate for agricultural uses, forestry inventories and urban land use studies. A recent Canadian survey of ERS data use produced the following major findings:[3,20]

- Over 1,000 customers have been associated with ERS data use at the Canadian Centre for Remote Sensing.
- As of September, 1975, total LANDSAT data sales for the prior 3-year period totaled $88,764.
- As in the United States, geologists are the largest single class of users of Canadian LANDSAT products (over 40 percent of purchases are in the geological discipline area). Uses are related to reconnaisance for geological structures and disposition of surficial materials by oil and mineral companies. Operationally, the data are used for regional surveys, analysis of linears,and the selection of targets for more detailed investigation. Secondary uses include spectral discrimination of rock types and use of images as base maps for planning and managing exploration projects.
- Major Canadian benefits noted in their survey included (in order of importance):

  (1) Acquisition of new information previously unavailable
  (2) Acquisition of supporting information when integrated with other data

(3) Savings in time.

- The principal method of analysis is visual interpretation of black and white prints, with little automatic processing involved.
- Half of the industrial users claim a modest to large benefit from LANDSAT data use; however, specific dollar benefits cannot be estimated as yet
- Canadian colleges and universities are currently playing a very small role in the use of remote sensing technology.

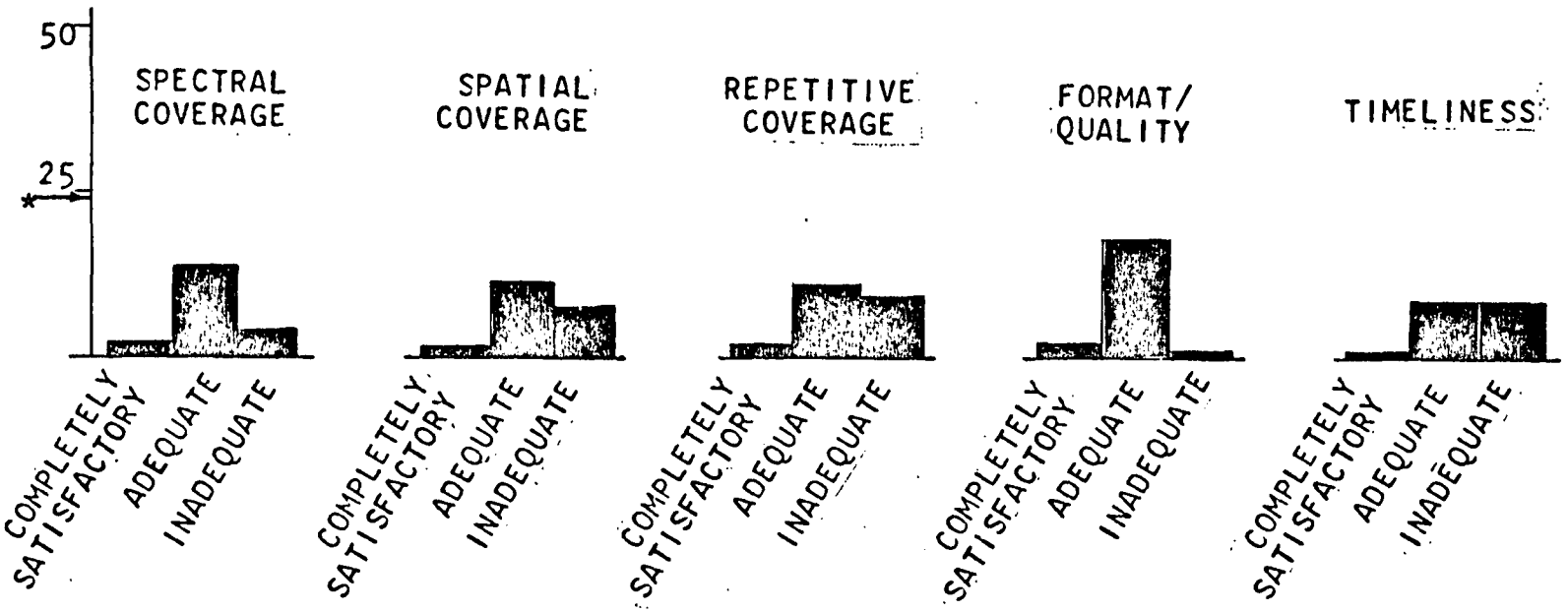
In the future, Canadian investigators would like satellite systems with better spatial resolution, extended spectral coverage (especially thermal and microwave) and faster delivery time (2 to 7 days). Because of the extent of interest, consideration is being given to developing a specialized satellite for sea ice navigation application.

How Foreign Users View LANDSAT Data

In terms of data use, most foreign users are very enthusiastic about the long-term operational promise of LANDSAT, and their own current experimental and semi-operational accomplishments. In terms of ERS data products Figure 30 contains a summary of the few foreign responses acquired during this survey. In general, most foreign users consider LANDSAT capabilities adequate for many of the applications they are currently investigating. Of major concern is the lack of good quality coverage over all areas, especially poorly mapped regions. Also, some concern exists as to what impact the NASA foreign user fee will have on current and future LANDSAT data use.

Foreign User Recommendations[2,3,16]

In order to strengthen LANDSAT data use, most foreign users contacted in this survey recommended the following:



- Few Foreign Users Completely Satisfied With Current LANDSAT Capabilities
- Majority View Spectral and Spatial Capabilities as Adequate
- About Equally Divided on Adequacy of Repetitive Coverage
- Strongly Approve of Format and Data Product Quality
- Equally Divided on Data Delivery Responsiveness

* 24 Foreign users responding.

FIGURE 30. NON-U.S./FOREIGN USERS - LANDSAT DATA ASSESSMENT(2)

(1) More frequent and more complete coverage, which, because of cloud conditions over some areas, may require developing an all-weather data collection capability

(2) Better data delivery time required for operational use

(3) Improve spatial and spectral capabilities of future satellites (especially thermal and microwave capabilities)

(4) Provide more information on future NASA programs and current U.S. techniques that may be applicable to foreign country users

(5) Provide more in-country training (tailored to countries' environmental and capability limitations.)

(6) Provide multi-language presentations at future ERS symposia

(7) Provide more frequent product options (e.g, larger scale first-generation photo products)

(8) Use social/economic descriptors in classifying remote sensing applications instead of technical/disciplinary descriptions, as activity will receive higher priority and more support; such terms will enable NASA to plan more effectively with end-use in mind, and more importantly, justify such plans as being user designed.

Summary and Outlook

Non-U.S. users of ERS data currently represent a large user community which has the potential to become the predominant single user group in the near future. Foreign use of ERS data centers and the establishment of independent ground stations are steadily expanding. As many as ten ground stations may be operative by the end of 1976. Major impact is in areas where maps are inadequate and/or unavailable as required for resource development and economic programs. Current data capabilities are finding extensive use, but improved capabilities involving more and better foreign area coverage and data delivery will produce more extensive uses and benefits. Advanced foreign ERS data users, e.g., Canada, may develop their own specialized ERS satellites, such as for sea ice navigation and forestry management uses.

Prospects are favorable for gradual purchase by recipient countries of technology, equipment and services associated with LANDSAT programs. There are a number of cases in which countries have purchased processing and analytical equipment as a first step from such companies as Earthsat, Bendix and General Electric. NASA's recently announced plan to charge a fee for the use of ground stations seems to be a natural deterent to purchases by such countries. Zaire is a good example of a country which is still seriously planning for the construction of a ground station, mostly with American equipment, and without U.S. funding aid, and apparently without financing by international banks. Egypt is a case where AID funds are used for purchasing remote sensing equipment - it could be presumed that other countries will begin to purchase equipment with their own funds.

SURVEY RESULTS

PART 6. NON-ERS DATA USERS

PART 6. NON-ERS DATA USERS

Approximately one in five individuals returning questionnaires or interviewed during the survey were not users of ERS data. Most expressed some interest in attempting to use ERS data in the future. However, several stated that significant advances in the state-of-the-art of data acquisition, processing, and product formulation must occur before they could possibly use the data in routine applications. In addition, time and costs pose serious limitations to their utilization of ERS data products. Potential applications of ERS data suggested by non-users (i.e., federal government, universities, industries) span all disciplines. Representative user interests included the following:[2-4]

- Flood plain (contour) mapping and delineation
- Park administration and visitor surveillance
- Reservoir monitoring
- Snow depth estimation
- Air quality damage assessment
- Environmental and socio-economic baseline planning studies
- Control and monitoring of forest insect and disease infestations
- Level III land use/land cover mapping at large scales
- Beach and harbor operations
- Information source for public interest groups (e.g., Sierra Club, Nat. Wildlife Federation Resources for the Future, etc.).

Although some individuals indicated that they had previously experimented with LANDSAT, high-altitude aircraft, and data collection system data, they still rely on field investigations and low-altitude aerial photography as data sources. Most non-users were not well versed in the state-of-the-art of remote sensing applications and characteristically have small data acquisition budgets, if any. In some instances, a technical person within the organization was found to be knowledgeable of ERS data application opportunities, but administrative and managerial staff responsible for manpower and funding allocations were not convinced that the return on the investment would justify the development of the application system.[2-4]

Non-users generally view ERS data and data products as a new data source having potential utility only. They also view ERS data as a potentially cheaper data base, but not necessarily a better data source. The processing required to extract usable information is judged to be too complex, which is a serious

roadblock to current data use. Simplification of data processing techniques and standardization of ERS product formats will be required before individuals/organizations other than users with specialized research staffs will become ERS data users. Some non-users, such as agencies that are not data analysis oriented, require ERS data and data products on a very limited basis.(4)

(1) Earth Resources Data Center Information; Staff Interviews and Reports, EROS Data Center, (Sioux Falls, S.D.), USDA, Aerial Photography Field Office (Salt Lake City, Utah), and NOAA Satellite Data Services Branch (World Weather Building, Washington, D.C.), 1975.

(2) Houston ERS Symposium Survey (Questionnaire), June, 1975.

(3) Telephone and Interview Surveys (June-December, 1975).

(4) Mail (Questionnaire) Survey (February, 1976).

(5) Houston ERS Symposium and Symposium Proceedings, 1975.

(6) Other Recent R.S. Symposia (Pecora Conference, Michigan Conference, etc.), 1975

(7) Other Surveys (e.g., GAO Survey, Ambionics), 1974-1975.

(8) Ambionics User Reference Manual, 1974.

(9) Study of Needs and Problems of State Agencies, NASA Technology Applications Center (1974).

(10) Practical Applications of Space Systems (and 14 supporting panel papers), Space Applications Board, 1974.

(11) ERTS/LANDSAT Significant Results Summary, NASA/GSFC, 1975.

(12) Skylab EREP (Follow-on Investigations) Significant Results Summary Discussions, NASA/Johnson Space Center Program Managers, January, 1976.

(13) Discussions With NASA/Goddard Space Flight Center and NASA Headquarters Personnel (ASVT Status, etc), 1975.

(14) Definition of Total Earth Resources System for the Shuttle ERA (TERSSE), General Electric, 8 Volumes, 1974.

(15) The space Applications Program, NASA Headquarters/Office of Applications, 1974.

(16) Remote Sensing Literature in General, 1974-1975.

(17) LANDSAT News Letters 1-7, 1974-1976.

(18) An Evaluation of Natural Resource Data Products by State Data Users, Council of State Governments, Lexington, Kentucky, August, 1975.

(19) Science, Technology, and Innovation, prepared for NSF by BCL, February, 1973, 33 pages.

(20) Canadian Progress in the Use of LANDSAT Data in Geology, A. F. Gregory and L. W. Morley, 1st W. T. Pecora Memorial Symposium, October 28-31, 1975, 32 pages.

(21) Land Satellite Project, U.S. General Accounting Office, PSAD-76-76, January 1976, 42 pages.

(22) L. David Nealey, Remote Sensing and Photogrammetry in the United States, Proceedings of the American Society of Photogrammetry, February 1976, pp. 395-428.

ADDENDUM TO
SURVEY OF USERS OF EARTH RESOURCES REMOTE SENSING DATA

PART 1. SAMPLE SURVEY QUESTIONNAIRES

PART 2. HOUSTON ERS SYMPOSIUM QUESTIONNAIRE RESULTS

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WASHINGTON, D.C. 20546

REPLY TO
ATTN OF:

June 6, 1975

A SURVEY OF USERS OF EARTH RESOURCES SURVEY DATA

The National Aeronautics and Space Administration is conducting a comprehensive survey of users of earth resources data acquired by high-altitude aircraft and satellites.

The information obtained from this survey will be invaluable in establishing a clearer understanding of the user communities involved, of the specific end purpose and applications for which these data are being used, and of the levels within your organizations at which the results are useful.

Since information of this kind can only be provided by the users themselves, we are taking advantage of this opportunity with its unique collection of conference participants to solicit your cooperation in accomplishing our purpose. Please help us by completing the enclosed questionnaire and returning it to the registration desk. Strictest confidentiality will be maintained. No individual responses will ever be identified--only general conclusions and results. Should you know of others who should participate in this survey, please have them complete and return a copy of the questionnaire as soon as possible.

We trust that this survey can contribute to the development of an earth resources survey program which will better satisfy your needs and those of other current and future users.

Thank you for helping NASA better serve the user community.

Sincerely,

Charles W. Mathews
Associate Administrator
for Applications

Enclosure

OMB Approval No. 104-S73
Expiration Date: 9-30-73

EARTH RESOURCES SURVEY (ERS) DATA USER QUESTIONNAIRE

[Note: For each of the items below check more than one if appropriate]

1.0 USER DESCRIPTION

Name_____ Title_____

Organization _____ Div. _____ Telephone_____

1.1 User Category

- ☐ NASA
- ☐ Other Federal Gov't
- ☐ State Gov't
- ☐ Local Gov't
- ☐ Regional Agency
- ☐ Industry
- ☐ Research
- ☐ Education
- ☐ Non U.S. Gov't
- ☐ Non U.S. Industry
- ☐ Other (Identify):

_____

1.2 Your Status as a User of ERS Data

- ☐ Past
- ☐ Current
- ☐ Planned
- ☐ Potential
- ☐ Not Potential
- ☐ Other (Identify):

_____

1.3 User Type

- ☐ Educ. User
- ☐ Research
- ☐ Development
- ☐ Service to Users
- ☐ End User
- ☐ Other (Identify):

_____

1.4 Involvement in NASA Experimental Programs

- ☐ Previous Principal Investigator
- ☐ Current Principal Investigator
- ☐ Other:_____

_____

2.0 ERS DATA DESCRIPTION

2.1 ERS Data You have Evaluated

- ☐ High Alt. Aircraft
- ☐ Landsat (ERTS) Imagery
- ☐ Landsat (ERTS) Digital Tapes
- ☐ Skylab Data
- ☐ Other Satellite
- ☐ Ground-Based Measurements
- ☐ Other (Identify):

_____

2.2 ERS Date You Are Currently Using

- ☐ High Alt. Aircraft
- ☐ Landsat (ERTS) Imagery
- ☐ Landsat (ERTS) Digital Tapes
- ☐ Skylab Data
- ☐ Other Satellite
- ☐ Ground-Based Measurements
- ☐ Other (Identify):

_____

2.3 ERS Data You Plan to Use

- ☐ High Alt. Aircraft
- ☐ Landsat (ERTS) Imagery
- ☐ Landsat (ERTS) Digital Tapes
- ☐ Skylab Data
- ☐ Other Satellite
- ☐ Ground-Based Measurements
- ☐ Other (Identify):

_____

2.4 Source of ERS Data

- ☐ EROS Data Center
- ☐ USDA
- ☐ NOAA
- ☐ NASA
- ☐ Other (Identify): _____

2.5 Frequency of Your ERS Data Orders

- ☐ Standing Order
- ☐ Frequent
- ☐ Infrequent
- ☐ One Time
- ☐ N/A

3.0 ERS DATA USE DESCRIPTION

3.1 Discipline Applications/Uses (Identify):_____

_____

_____

3.2 Your Principal Use of ERS Data

- ☐ Educational
- ☐ Research
- ☐ Planning
- ☐ Decision Making
- ☐ Monitoring
- ☐ Other (Identify):

_____

3.3 Principal Use Within Organization

- ☐ Routine Operations
- ☐ Management
- ☐ Policy
- ☐ Other (Identify):

_____

3.4 Source of Funds For Your ERS Work

- ☐ Federal-NASA
- ☐ Federal-Other
- ☐ Private
- ☐ State
- ☐ Local
- ☐ Other (Identify):

_____

3.5 Estimation of Your Organization's ERS Budget

- ☐ Less than $10,000
- ☐ $10,000 - $50,000
- ☐ $50,000 - $100,000
- ☐ More than $100,000
- ☐ Don't know

3.6 Type of Organization Covered in Question 3.5

_____

(e.g., Individual, Office, Division, etc.)

(Continued on reverse side)

EARTH RESOURCES SURVEY (ERS) DATA USER QUESTIONNAIRE
(Continued)

4.0 DATA EVALUATION - CURRENT LANDSAT (ERTS) DATA ONLY

4.1 Spectral Coverage

- ☐ Completely Satisfactory
- ☐ Adequate
- ☐ Inadequate
- ☐ No Opinion

4.2 Spatial Resolution

- ☐ Completely Satisfactory
- ☐ Adequate
- ☐ Inadequate
- ☐ No Opinion

4.3 Repetitive Coverage

- ☐ Completely Satisfactory
- ☐ Adequate
- ☐ Inadequate
- ☐ No Opinion

4.4 Format Options & Product Quality

- ☐ Completely Satisfactory
- ☐ Adequate
- ☐ Inadequate
- ☐ No Opinion

4.5 Timeliness of Response

- ☐ Completely Satisfactory
- ☐ Adequate
- ☐ Inadequate
- ☐ No Opinion

Please comment if appropriate.

_____

_____

_____

5.0 USER RECOMMENDATIONS

Remote sensing data utility in my user category can best be improved by: _____

_____

_____

6.0 SYMPOSIUM EFFECTIVENESS

Based on your previous knowledge of Earth Resources Survey information, this Symposium was:

- ☐ Of Limited or No Value. Nothing New or Interesting
- ☐ Highly Informative
- ☐ Moderately Interesting

Please comment: _____

_____

_____

_____

_____

_____

_____

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WASHINGTON, D.C. 20546

DEC 22 1975

REPLY TO
ATTN OF: EK

A SURVEY OF USERS OF EARTH RESOURCES SURVEY DATA

The National Aeronautics and Space Administration is conducting a comprehensive survey of users of Earth resources data acquired by high altitude aircraft and satellites. The purpose of the survey is to determine the current usefulness of such data and ways to improve practical usage throughout the world. Specifically, the objectives of this study are:

(1) to identify who is using the data;

(2) to determine how the data are being used;

(3) to assess the effectiveness/value of use; and

(4) to obtain user views as to ways to strengthen use.

You have been identified as a current and/or potential user who can provide a significant input to the NASA survey. Accordingly, I request your cooperation in this important study by asking you to complete and return the enclosed questionnaire to my office within one week of receipt using the preaddressed, postage-paid envelope provided.

A glossary of selected terms is also attached for respondents unfamiliar with some of the technical terms used in the questionnaire.

All responses will be used in the final study results; however, in no case will individual responses be identified.

We trust that this survey can contribute to the development of an Earth resources survey program which will satisfy your needs and those of other current and future users throughout the world.

Charles W. Mathews
Associate Administrator
for Applications

Enclosure

GLOSSARY OF TERMS

Principal Investigator	-	Designation for individual having principal technical and administrative responsibilities of NASA funded investigations.
High Altitude Aircraft Data	-	Remotely sensed data from altitudes above 60,000 ft. RB-57 and U-2 aircraft.
Landsat Data	-	Photographic and digital data acquired by first Earth Resoures Technology Satellite (Landsat 1) and Landsat 2.
Skylab Data	-	Data acquired by the Earth Resources Experiments Package (EREP) during the three manned Skylab missions.
Ground-Based Measurements	-	Photographic and radiometric measurements made on the ground to assist in interpreting aircraft and satellite data. Also includes measurements made in combination with a Data Collection Platform (DCP).
Spectral Coverage	-	The spectral regions (or wavelengths) of the electromagnetic spectrum in which the satellite sensors acquire data. (E.g., visual, infrared, thermal infrared and microwave regions)
Spatial Coverage	-	Used here as the ability of a remote sensing system to distinguish ground objects located close to each other spatially, i.e., spatial resolution.
Repetitive Coverage	-	The frequency or cycle wherein satellite sensors repeat their earth observation coverage. E.g., every 18 days for each of the Landsat payloads.

OMB Approval No. 104-S75003
Expiration Date: 2-28-76

EARTH RESOURCES SURVEY (ERS) DATA USER QUESTIONNAIRE

[Note: For each of the items below check more than one if appropriate]

1.0 USER DESCRIPTION

Name_____ Title_____

Organization _____ Div. _____ Telephone_____

Address_____

1.1 User Category

- ☐ NASA
- ☐ Other Federal Gov't
- ☐ State Gov't
- ☐ Local Gov't
- ☐ Regional Agency
- ☐ Industry
- ☐ Research
- ☐ Education
- ☐ Non U.S. Gov't
- ☐ Non U.S. Industry
- ☐ Other (Identify):

_____

1.2 Your Status as a User of ERS Data

- ☐ Past
- ☐ Current
- ☐ Planned
- ☐ Potential
- ☐ Not Potential
- ☐ Other (Identify):

_____

1.3 User Type

- ☐ Educ. User
- ☐ Research
- ☐ Development
- ☐ Service to Users
- ☐ End User
- ☐ Other (Identify):

_____

1.4 Involvement in NASA Experimental Programs

- ☐ Previous Principal Investigator
- ☐ Current Principal Investigator
- ☐ Other:_____

_____

2.0 ERS DATA DESCRIPTION

2.1 ERS Data You have Evaluated

- ☐ High Alt. Aircraft
- ☐ Landsat (ERTS) Imagery
- ☐ Landsat (ERTS) Digital Tapes
- ☐ Skylab Data
- ☐ Other Satellite
- ☐ Ground-Based Measurements
- ☐ Other (Identify):

_____

2.2 ERS Data You Are Currently Using

- ☐ High Alt. Aircraft
- ☐ Landsat (ERTS) Imagery
- ☐ Landsat (ERTS) Digital Tapes
- ☐ Skylab Data
- ☐ Other Satellite
- ☐ Ground-Based Measurements
- ☐ Other (Identify):

_____

2.3 ERS Data You Plan to Use

- ☐ High Alt. Aircraft
- ☐ Landsat (ERTS) Imagery
- ☐ Landsat (ERTS) Digital Tapes
- ☐ Skylab Data
- ☐ Other Satellite
- ☐ Ground-Based Measurements
- ☐ Other (Identify):

_____

2.4 Source of ERS Data

- ☐ EROS Data Center
- ☐ USDA
- ☐ NOAA
- ☐ NASA
- ☐ Other (Identify): _____

2.5 Frequency of Your ERS Data Orders

- ☐ Standing Order
- ☐ Frequent
- ☐ Infrequent
- ☐ One Time
- ☐ N/A

3.0 ERS DATA USE DESCRIPTION

3.1 Discipline Applications/Uses (Identify):_____

_____

_____

3.2 Your Principal Use of ERS Data

- ☐ Educational
- ☐ Research
- ☐ Planning
- ☐ Decision Making
- ☐ Monitoring
- ☐ Other (Identify):

_____

3.3 Principal Use Within Organization

- ☐ Routine Operations
- ☐ Management
- ☐ Policy
- ☐ Other (Identify):

_____

3.4 Source of Funds For Your ERS Work

- ☐ Federal-NASA
- ☐ Federal-Other
- ☐ Private
- ☐ State
- ☐ Local
- ☐ Other (Identify): _____

3.5 Estimation of Your Organization's ERS Budget

- ☐ Less than $10,000
- ☐ $10,000 - $50,000
- ☐ $50,000 - $100,000
- ☐ More than $100,000
- ☐ Don't know

3.6 Type of Organization Covered in Question 3.5

_____

(e.g., Individual, Office, Division, etc.)

3.7 ERS Data Utility

- ☐ High Utility
- ☐ Low to Moderate Utility
- ☐ No Utility
- ☐ Potential Utility Only

(Continued on reverse side)

EARTH RESOURCES SURVEY (ERS) DATA USER QUESTIONNAIRE
(Continued)

4.0 DATA EVALUATION - CURRENT LANDSAT (ERTS) DATA ONLY

4.1 Spectral Coverage

- ☐ Completely Satisfactory
- ☐ Adequate
- ☐ Inadequate
- ☐ No Opinion

4.2 Spatial Resolution

- ☐ Completely Satisfactory
- ☐ Adequate
- ☐ Inadequate
- ☐ No Opinion

4.3 Repetitive Coverage

- ☐ Completely Satisfactory
- ☐ Adequate
- ☐ Inadequate
- ☐ No Opinion

4.4 Format Options & Product Quality

- ☐ Completely Satisfactory
- ☐ Adequate
- ☐ Inadequate
- ☐ No Opinion

4.5 Timeliness of Response

- ☐ Completely Satisfactory
- ☐ Adequate
- ☐ Inadequate
- ☐ No Opinion

Please comment if appropriate.

_____

_____

_____

5.0 DATA USE ASSESSMENT

For the benefit assessment please indicate the current(C) and potential(P) value of satellite ERS data use to each application area of interest to your organization. For the relevance assessment please indicate the current(C) and potential(P) relevance of satellite ERS data to the achievement of organizational objectives, in application areas of interest to your organization.

Application Area	Benefit Assessment: ERS Data Products are or will be				Relevance Assessment: ERS Data Products are or will be			
	Of No Value	A Cheaper Data Source	A Better Data Source	A Unique/ New Data Source	Very Important	Important	Complementary	Incidential
1. Agriculture/Forestry/and Range Resources								
2. Land Use Survey and Mapping								
3. Mineral Resources, Geological, Structural and Landform Surveys								
4. Water Resources								
5. Marine Resources and Ocean Surveys								
6. Environment								
7. Interpretation Technique Development								
8. Other (Identify):								

6.0 USER RECOMMENDATIONS

Remote sensing data utility in my user category can best be improved by: _____

_____

_____

_____

_____

_____

_____

_____

_____

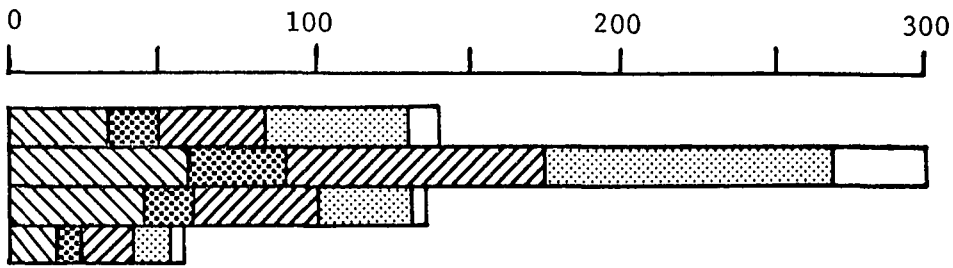
7.0 USER CONTACT(S)

Please identify who in your organization should be contacted for additional information regarding remote sensing data use and needs:

Representative	Title	Address	Phone

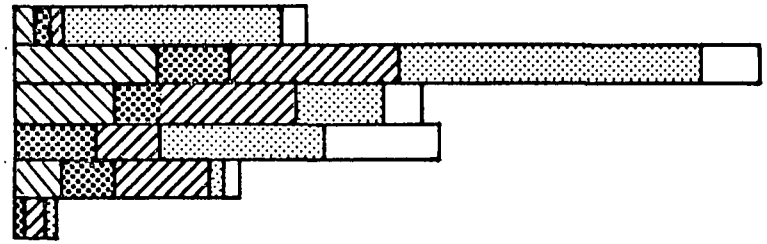
1.0 USER DESCRIPTION

1.2 Your Status as a User of ERS Data



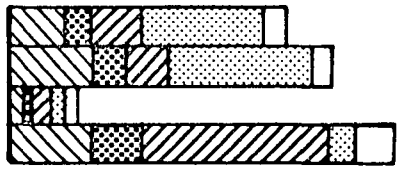
Past *(43)*/(141)**
Current *(107)*/ (294)
Planned *(45)* / (124)
Potential *(16)* / (55)

1.3 User Type



Educ. User *(32)*/(79)
Research *(79)*/(245)
Development *(46)*/(134)
Service to Users *(52)*/(136)
End User *(25)*/(71)
Other *(2)*/(13)

1.4 Involvement in NASA Experimental Programs



Previous PI/*Co PI (27)* /(91)
Present PI/*Co PI (43)*/(105)
Others (22) / (23)
No Involvement (21) /(130)

Code/Legend:
- Federal Gov't.
- State, Regional & Local Gov't
- Industry
- Education/Research
- Foreign

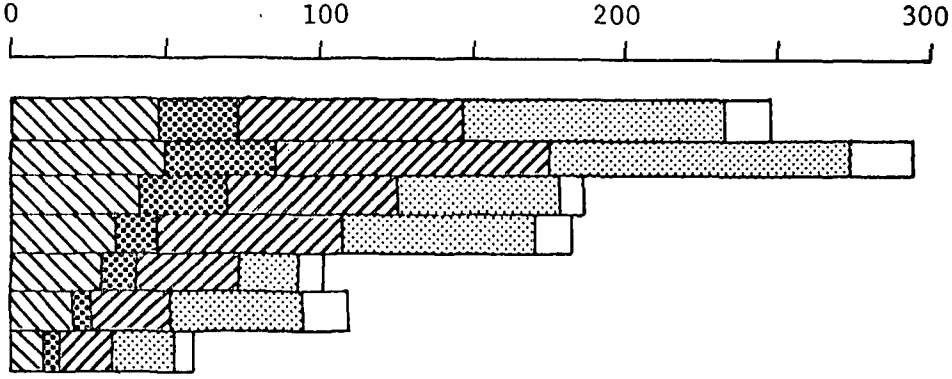
* Number of questionnaires returned at Houston ERS Symposium

** Number of questionnaires returned by mail at later date

2.0 ERS DATA DESCRIPTION

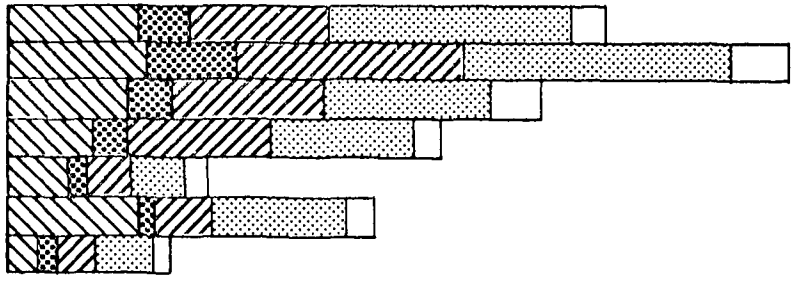
2.1 ERS Data You Have Evaluated

High Alt. Aircraft *(89)* /(249)
Landsat (ERTS) Imagery *(101)* /(296)
Landsat (ERTS) Digital Tapes *(64)* /(193)
Skylab Data *(62)* /(183)
Other Satellite *(29)* /(101)
Ground-Based Measurements *(48)* /(109)
Other *(18)* /(55)



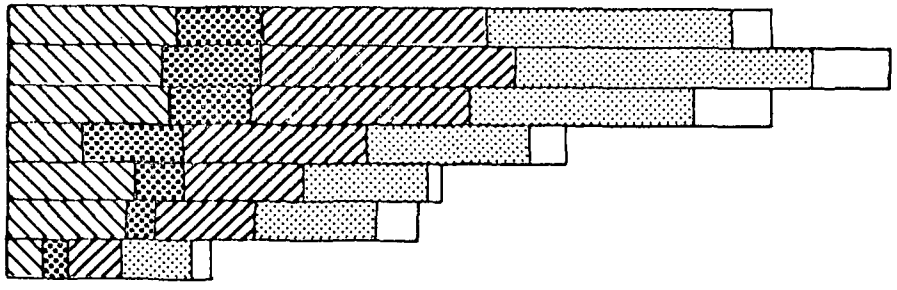
2.2 ERS Data You Are Currently Using

High Alt. Aircraft *(71)* /(194)
Landsat (ERTS) Imagery *(87)* /(255)
Landsat (ERTS) Digital Tapes *(63)* /(174)
Skylab Data *(49)* /(141)
Other Satellite *(24)* /(64)
Ground-Based Measurements *(43)* /(19)
Other *(16)* /(52)



2.3 ERS Data You Plan to Use

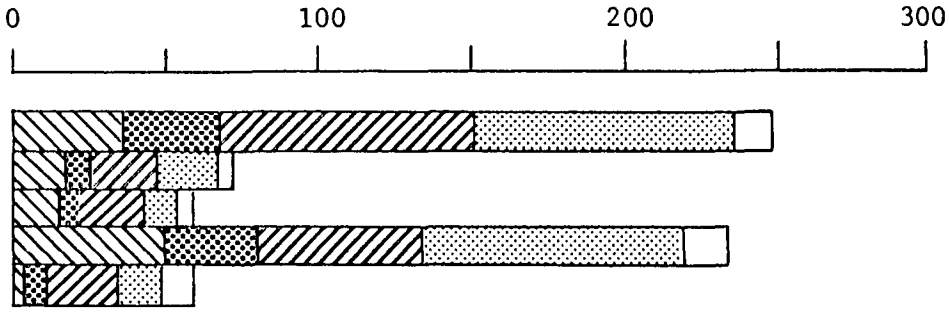
High Alt. Aircraft *(85)* /(247)
Landsat (ERTS) Imagery *(99)* /(286)
Landsat (ERTS) Digital Tapes *(85)* /(247)
Skylab Data *(57)* /(170)
Other Satellite *(44)* /(139)
Ground-Based Measurements *(52)* /(132)
Other *(24)* /(68)



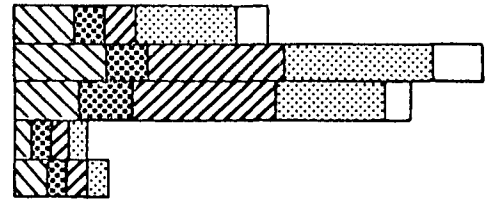
Code/Legend:
Federal Gov't.
State, Regional & Local Gov't
Industry
Education/Research
Foreign

2.0 ERS DATA DESCRIPTION
(Continued)

2.4 Source of ERS Data



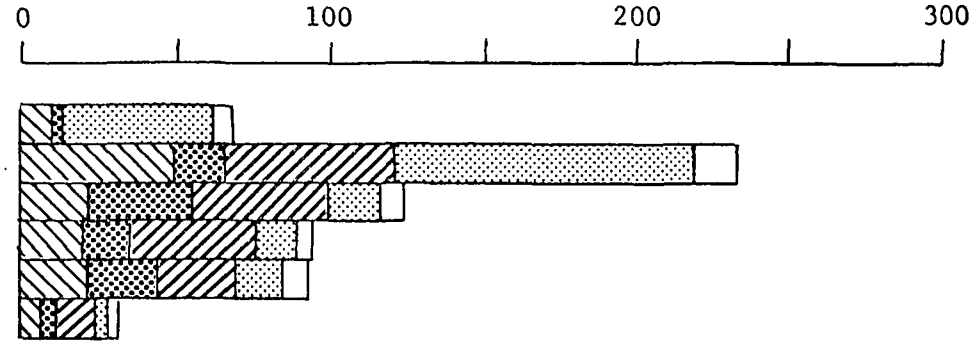
2.5 Frequency of Your ERS Data Orders



Code/Legend:
- Federal Gov't.
- State, Regional & Local Gov't
- Industry
- Education/Research
- Foreign

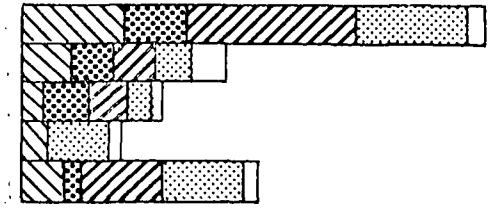
3.0 ERS DATA USE DESCRIPTION

3.2 Your Principal Use of ERS Data



Educational *(25)* / (69)
Research *(80)* / (235)
Planning *(41)* / (125)
Decision Making *(36)* / (93)
Monitoring *(29)* / (93)
Others *(8)* / (29)

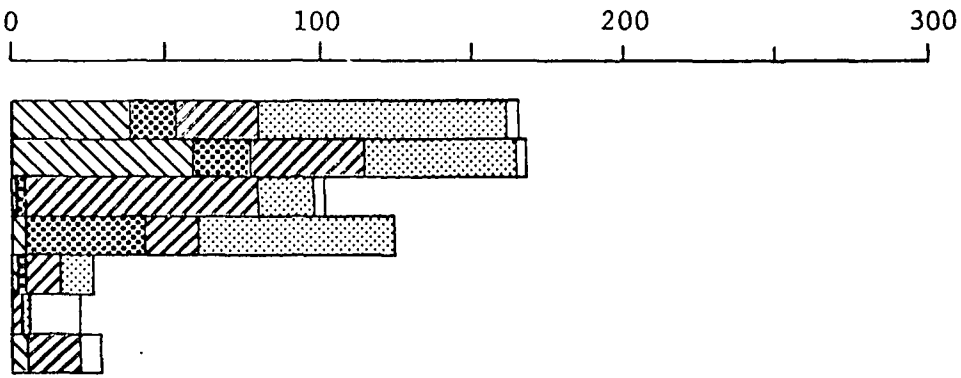
3.3 Principal Use Within Organization



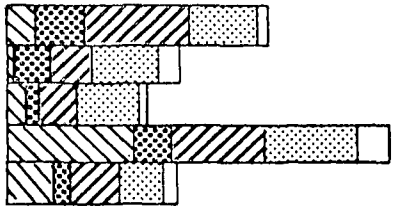
Routine Operations *(54)* / (153)
Management *(26)* / (68)
Policy *(16)* / (41)
R&D (25) / (34)
Other *(11)* / (77)

Code/Legend:
- Federal Gov't.
- State, Regional & Local Gov't
- Industry
- Education/Research
- Foreign

3.4 Source of Funds for Your ERS Work

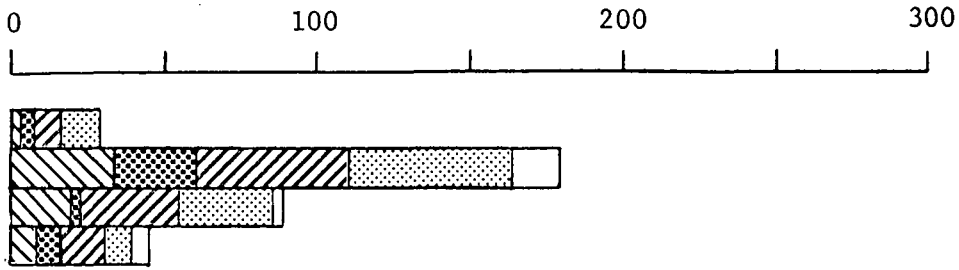


3.5 Estimation of Year Organization's ERS Budget

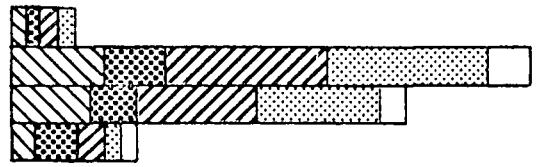


Code/Legend:
- Federal Gov't.
- State, Regional & Local Gov't
- Industry
- Education/Research
- Foreign

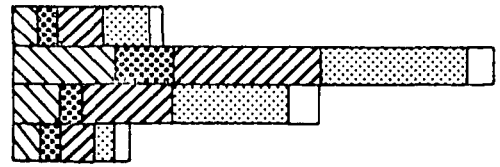
4.1 Spectral Coverage



4.2 Spatial Resolution



4.3 Repetitive Coverage

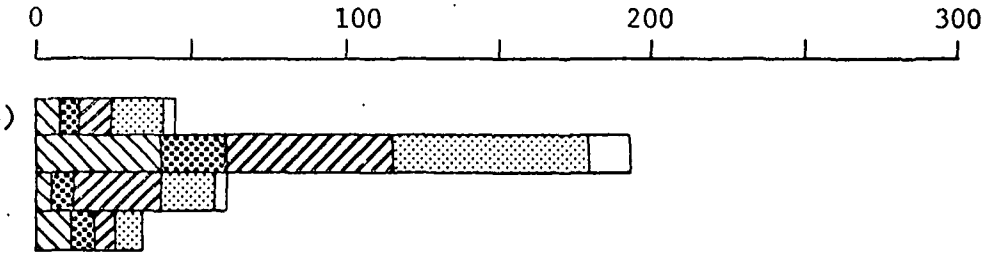


Code/Legend:

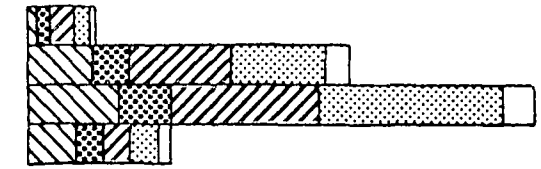
- Federal Gov't.
- State, Regional & Local Gov't
- Industry
- Education/Research
- Foreign

4.0 DATA EVALUATION - CURRENT LANDSAT (ERTS) DATA ONLY
(Continued)

4.4 Format Options & Product Quality



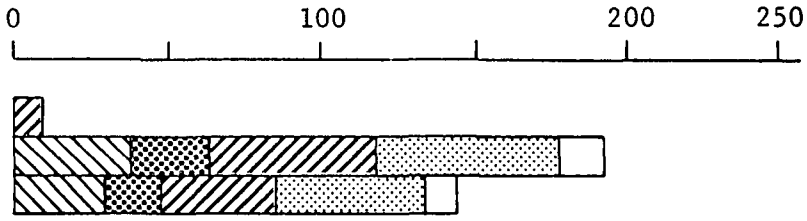
4.5 Timeliness of Response



Code/Legend:

6.0 SYMPOSIUM EFFECTIVENESS

6.0 Symposium Effectiveness



Of Limited or No Value. Nothing New or Interesting *(1)*/(12)
Highly Informative *(81)*/(193)
Moderately Interesting *(39)* (144)

Code/Legend:
- Federal Gov't.
- State, Regional & Local Gov't
- Industry
- Education/Research
- Foreign