Chapter 5

U.S. Government Needs for Remote-Sensing Data

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U.S. Government Needs for Remote= Sensing Data

This chapter summarizes Federal requirements for Landsat and metsat data as they apply to individual agencies. A number of Government-sponsored studies based on the use of Landsat data have engendered optimism about the utility of space remote sensing for a wide range of resource survey, mapping, and environmental monitoring tasks. However, the results of such studies remain tentative because the Landsat system has not been optimally configured for operational use nor managed according to business-like principles. Questions persist in Government agencies about system continuity, data cost, and timely delivery.

FEDERAL METSAT DATA USERS AND THEIR MISSIONS

The largest Federal user of metsat data is, not surprisingly, the National Weather Service (NWS) in the National Oceanic and Atmospheric Administration (NOAA). Indeed, the agency responsible for operating the first weather satellites in the early *1960's* was the National Earth Satellite Center, a part of the old Weather Bureau. It was not until a decade later that a separate satellite service (National Environmental Satellite Service—NESS, now National Environmental Satellite Data and Information Service—NESDIS) was established.

NOAA'S mission is to explore, map, and chart the global ocean and its living resources; to manage, use, and conserve these resources; to describe, monitor, and predict conditions in the atmosphere, ocean, air, and space environment; to issue warnings against impending destructive natural events; to develop methods of environmental modification; and to assess the consequences of inadvertent environmental modification over several scales of time. The global scope of NOAA's mission makes metsat data valuable to the various agencies within NOAA. NWS makes widespread use of satellite data to improve its forecasts to aviators, farmers, fishermen, fruit growers, commercial shippers, sport boaters, recreationers, and just plain citizens.

For example, the geostationary satellites can identify and track the characteristic cloud shapes of tornadoes, allowing warnings to affected areas. Hurricane tracking by satellite is a second vital lifesaver. The NWS Severe Storm Warning Center in Kansas City and the Hurricane Alert Center in Miami would both be severely handicapped without frequent satellite imagery to aid in issuing warnings.

The NWS Office of Hydrology produces river-basin snow maps and precipitation estimates for NESDIS to add to computerized hydrologic models for runoff and flood forecasting. Sounding data, sea-surface temperature data, cloud cover, and snow cover are but a few of the satellite-derived data that are processed by the NWS computers to improve global analysis and forecasting.

The powerful mixture of computers and satellites has produced new data sets that could well improve the ability of meteorologists to prepare longer range, even seasonal forecasts. NWS is now investigating sea-surface temperature changes or anomalies in the North Pacific and the percentage of snow cover in the Northern Hemisphere as important new variables in the study of climatic variations. Prior to metsats, these variables were unmeasurable (figs. 5 and 6).

The National Ocean Survey (NOS) explores, maps, and charts the oceans. The 1.1-km resolution of the polar-orbiting metsats is more than adequate to provide NOS with sea-surface temperature charts and ice charts of polar areas and the Great Lakes. NOS and NESDIS oceanograph-

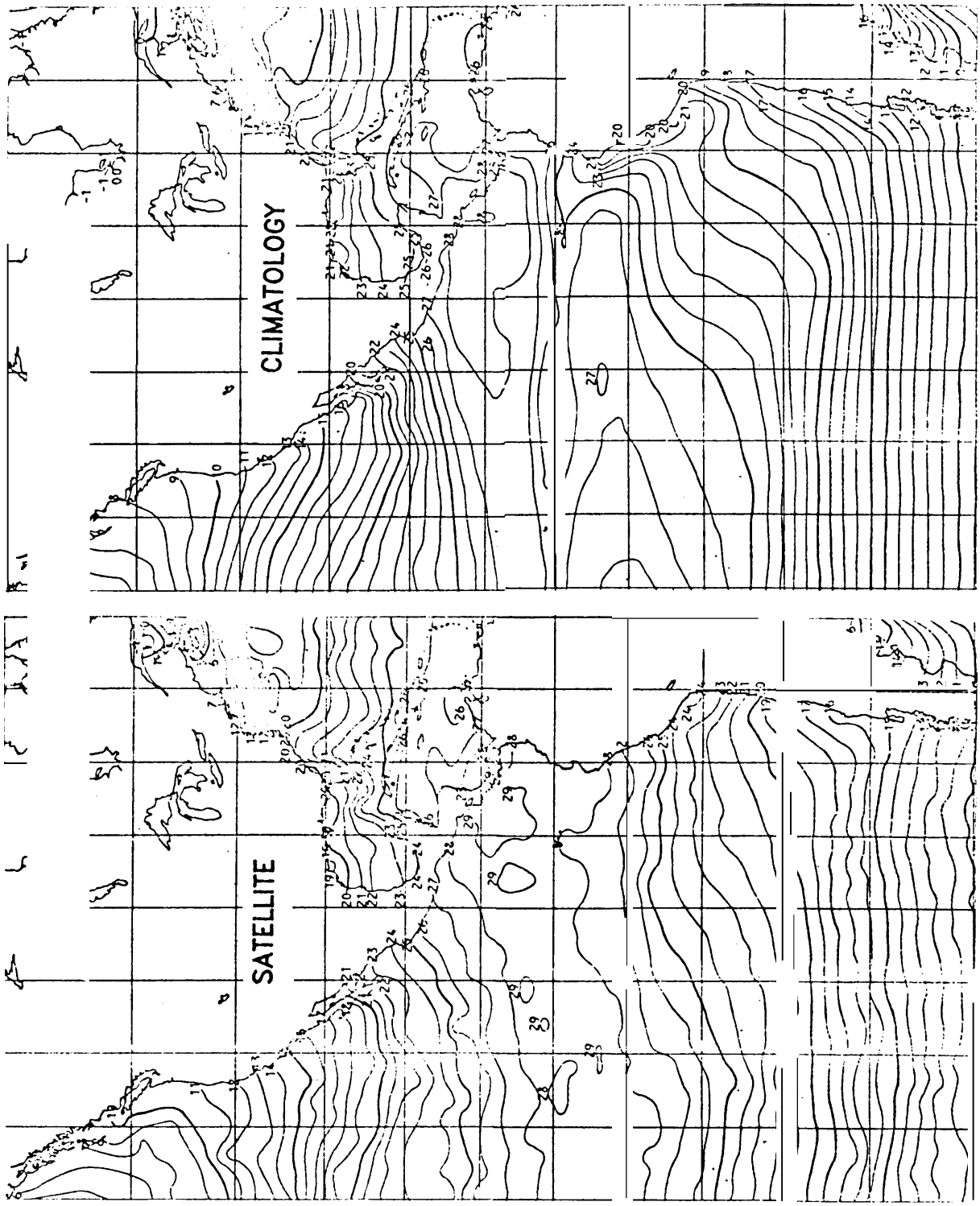
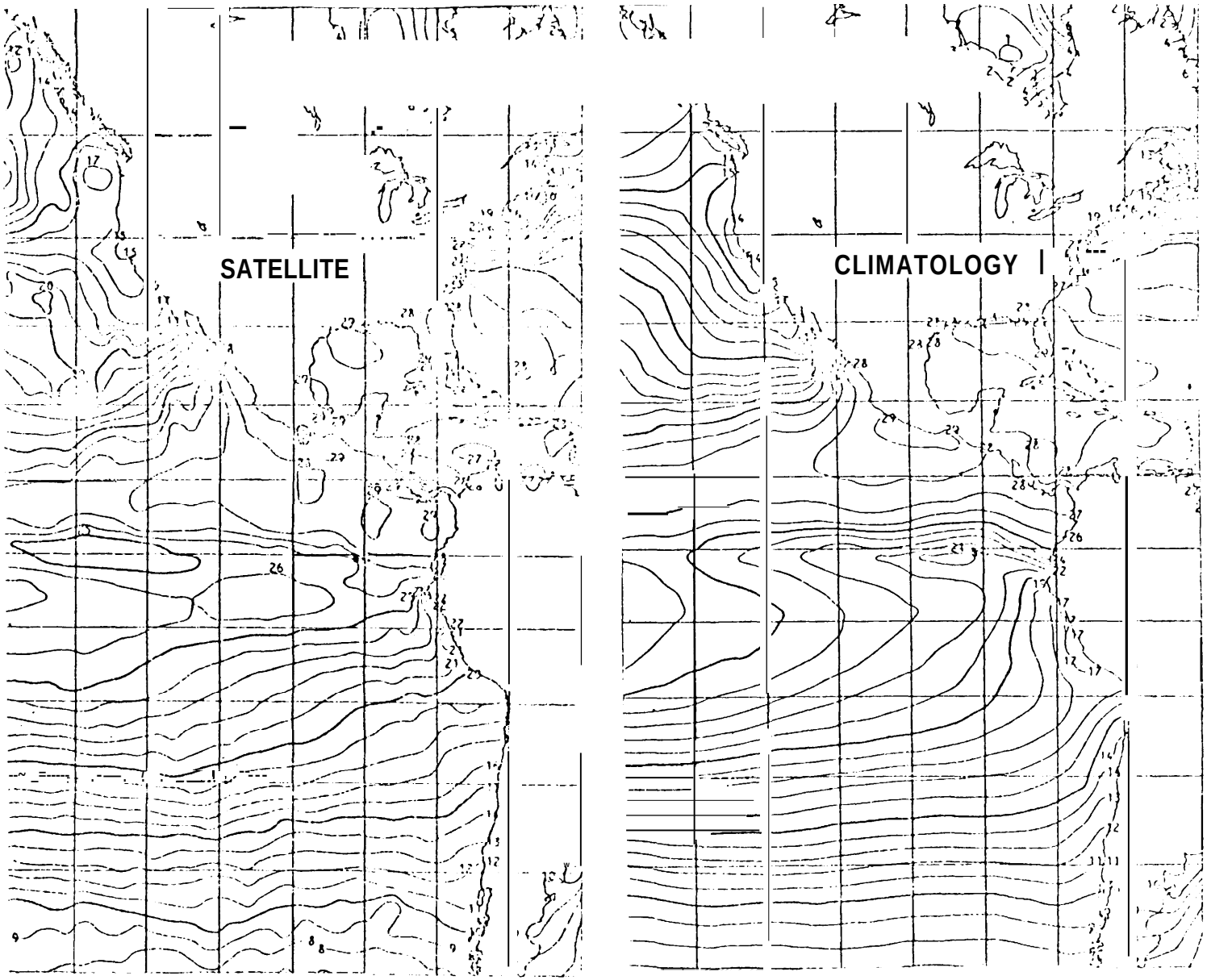


Figure 5.—April 1983 Sea-Surface Temperature, Eastern Pacific Ocean

SOURCE: National Oceanic and Atmospheric Administration.

Figure 6.—July 1983 Sea-Surface Temperature, Eastern Pacific Ocean



SOURCE: National Oceanic and Atmospheric Administration

ers also chart currents using thermal infrared measurements. NOAA produces a monthly analysis of the Gulf Stream movements that aids in ship routing as well as in oceanographic research studies (fig. 7), It also uses satellite data to study the highly variable tidal and estuarine currents close to shore. It warns of tsunami from measurements collected by ocean buoys and relayed by satellite telecommunications.

The National Marine Fisheries Service has for many years used satellite thermal maps to indicate areas of nutrient-rich upwellings for commercial fisherman; such areas constitute the most probable good fishing areas.

Part of the National Climate Plan is to identify broad areas of environmental modification, whether manmade or natural. The results of prolonged drought, such as areas of desertification in the Sahel in Africa, are easily monitored by metsats. Metsat data can also be used to monitor the recent deforestation and development in Brazil's upper Amazon basin. The Department of Agriculture's (USDA) Foreign Agricultural Service (FAS) continuously monitors foreign crops using some NOAA polar-orbiter imagery in its efforts to project overseas markets for U.S. agricultural products. The Forest Service has found thermal infrared data from metsats useful for early detection of forest fires.

The need for up-to-date meteorological information is acutely felt by the Department of Defense (DOD) (see also ch. 6). Though many of its needs are met by the Defense Meteorological Satellite Program (DMSP), a system which includes two polar orbiters, DOD also relies heavily on NOAA satellites. The U.S. Air Force derives information from both the DMSP and NOAA's metsats to make flight weather summaries and forecasts; the U.S. Navy uses metsat data to monitor sea-surface temperature, currents, and water mass or ocean color, important variables for both surface and subsurface operations.

The mission of the U.S. Army Corps of Engineers includes programs to protect the environment, improve waterway navigation, control floods and beach erosion, engage in water-resources development, and provide natural disaster relief assistance. The Corps was an early user of metsat and Landsat data. Data Collection Platforms (DPCs), which relay data to the metsats, are widely used to provide operational hydrologic data to Corps offices. The New England Division of the Corps working with the Corps Cold Regions Research and Engineering Laboratory in Hanover, N. H., and the University of Connecticut, are determining the effectiveness of satellite imagery for real-time water-control management. The Corps Great Lakes Division has studied how to use data from space to improve their management of the Great Lakes water resources and navigation control.

The Office of Naval Research, the Naval Oceanographic Research and Development Activity, and the Naval Oceanographic Command, as well as DOD's Advanced Research Projects Agency, conduct, manage, and coordinate research in oceanography that requires metsat data.

The Department of the Interior is responsible for managing public lands and natural resources. A pilot program of monitoring vegetation in remote areas of Nevada and Arizona with data from the polar orbiters has been successful in the Bureau of Land Management's fight against range fires. This work was actually performed by the U.S. Geological Survey (USGS), which has a mandate to chart the Nation's water and mineral resources. Although the Landsat system is the preferred data source for some of the applications, especially hydrologic and tectonic studies, the USGS has increasingly turned to NOAA metsat data. The USGS's North American Tectonic Plate mosaic project is currently considering the use of enhanced images from the polar orbiters. It is also planning to make a mosaic tectonic map of Antarctica from enhanced metsat images.

In the Department of Energy, metsats furnish certain hydrologic information useful for the Power Administrations—e. g., Bonneville Power and Alaska Power. The Department of Transportation's U.S Coast Guard (USCG) has a direct obligation to provide search and rescue for ships in distress and to monitor the Contiguous Fisheries Zone, USCG icebreakers benefit from metsat observations of ice. The Coast Guard also uses metsat data to monitor oil spills, such as the Xtoc well in the Gulf of Mexico in 1979. Though it relies

Figure 7.—NOAA-7 Thermal IR Image of the Gulf Stream Meandering Eastward Toward Europe

SOURCE: National Oceanic and Atmospheric Administration.

The dark (warm) band is the Gulf Stream. Warm and cold eddies can also be seen

on Government and private forecasters to advise pilots, the Federal Aviation Administration's (FAA) mission to regulate air commerce and to foster air safety requires that it consider all types of meteorological hazards and volcanic hazards as well; thus, metsat data are of direct interest to FAA.

The Environmental Protection Agency (EPA) has been charged with the responsibility to protect and enhance our environment. The EPA mission is to control and abate pollution from solid waste, noise, radiation, and toxic substances. Metsat data provide timely and frequent observations of air pollution such as windblown dust, oil spills, and nearby ocean currents, and trajectories for toxic or nuclear airborne pollutants based on satellite-derived wind vectors.

Many of these agencies have a continuing interest in following potential national disasters such as volcanic eruptions, floods, hurricanes, tornadoes, or earthquakes. The Federal Emergency Management Agency (FEMA) has the specific mission of enhancing emergency preparedness at Federal, State, and local levels to coordinate and oversee hazard mitigation, preparedness planning, relief operations, and recovery assistance. A recent study[1] found that although metsats, by virtue of their coarse resolutions, are not highly suitable for disaster management, they can be used by FEMA to detect the overall effects of drought and floods. Metsat data area useful adjunct to Landsat data, which are more directly useful in disaster management.

NASA uses data from the metsats in its Earth Science and Applications Program. It also conducts research on improved sensors in partial support of the NOAA/NESDIS metsat program.

The U.S. Agency for International Development (AID) has provided assistance to developing countries in building their capacity to receive and use metsat data through programs like the Sahel Development Program, International Disaster Assistance, Food for Peace, and Science and Technology. Vegetation and hydrologic studies are also prepared by AID scientists using NOAA metsat data and imagery.

[1] **P, B.** Richards, C. J. Robinov, D. R. Wiesnet, and M. S. Maxwell, "Recommended Satellite Imagery Capabilities for Disaster Management," proceedings of the 33d Congress International Astronomical Federation, Paris, September-October 1982.

FEDERAL LANDSAT DATA USERS AND THEIR MISSIONS

Landsat Data Purchases and Use by Federal Government Agencies

During the 1970's the National Aeronautics and Space Administration (NASA) was especially attentive and responsive to satisfying data needs of Federal agencies as part of its program to demonstrate the new technology, and transferred funds to potential user agencies for them to experiment with applying Landsat data to their missions. Because of the success of this close collaboration, some Federal agencies became major users of Landsat imagery and digital tapes. NASA followed the earlier precedent of the meteorological program in encouraging and stipulating open access to the satellite data. Yet, while the Earth imagery has proved effective for broad-area monitoring of events which affect private sector interests, such as oil spills, floods, the spread of insect infestation, and regional geology, many private companies continue to rely on the use of higher resolution aerial photography for commercial applications.

Over more than a decade of Landsat operation, the market for the data has grown slowly and Government agencies have not requested data at rates forecast by early studies. Nevertheless, a score or so of agencies have experimented with the data and several now have operational programs dependent on the application of space imagery. Direct Government data purchases from the EROS Data Center (EDC) account for between 20 to 30 percent of sales through 1982 (table 7). Sales information, however, is a poor indicator of actual data use, especially in the earlier, highly subsidized years. Some agencies used the data most extensively when they obtained them for free. Users have employed a variety of means to

Table 7.— Federal Government and Total Sales of Landsat Data by EROS Data Center and NOAA: 1973-83 (in thousands of dollars)

Fiscal year	Government sales	Total-sales
1973	$ 63	$ 228
1974	87	528
1975	183	909
1976	594	1,641
1977	366	1,454
1978	610	1,976
1979	501	2,131
1980	393	2,389
1981	481	2,495
1982	572	2,941
1983	5,270	7,026[a]
	(1,188)	(2,934)

[a]Includes special acquisltions and service charges The numbers in brackets indicate the sales excluding these special charges

SOURCE EROS Data Center National Oceanic and Atmosperic Administration

conceal or reduce the costs of acquisitions. Some were able to arrange for direct transmission of data to ground receivers, bypassing EDC completely.* In addition, agencies of both the Federal Government and various industry organizations have reproduced computer-compatible tapes (CCTs) (the most expensive items) and imagery and traded them among themselves. In the past year, as stricter accounting measures and control of data flow have been applied, overall dollar volume of sales to Federal agencies has increased dramatically. This change in procedures has resulted from an Office of Management and Budget (OMB) directive that system operating costs will be recovered by sales, and is a direct consequence of the shift from R&D to an operational system.

Current Level of Landsat Data Sales

Information on the sale of Landsat imagery and tapes is available from the authorized Government distributor, EDC at Sioux Falls, S. Dak., and from cooperating foreign ground stations. The January 1983 study of Landsat prepared by NOAA/ ESDIS provides information through fiscal year 1982.[2] OTA has supplemented these figures by data extending through fiscal year 1983, obtained directly from EDC and NESDIS. Tables 7 through *12* and figures 8 through 10 express the sales information in a variety of ways and formats to make it as meaningful as possible. Federal purchases are shown, variously, in absolute dollar figures, as percentage of total sales, in number of items distributed, and as broken down among separate Government agencies.

Sales of Landsat data to Federal agencies have been negatively affected by two primary circumstances: 1) the present state of extreme uncertainty over the future of the Landsat program has effectively deterred Federal agencies from placing orders for future delivery of data to be used for satisfying mission data needs in cases where failure to receive the material on time would limit their ability to carry out their assignments, and 2) OMB has closely supervised purchases of Landsat data and required that money spent for this purpose by Government agencies be accompanied by a corresponding reduction in funds allocated for alternative methods of data collection. Agencies are often unwilling to give up older methods when they are unsure about their ability to receive Landsat data as needed. In addition, agencies that have need for only one frame of multispectral scanner (MSS) data for a given area have already satisfied most of their data needs; other agencies are simply waiting for thematic mapper (TM) data to be more widely available.

Overview of Landsat Data Sales

In contrast with the rapidly expanding market for the services of communications satellites, the market among Federal agencies for Landsat data has grown slowly. Thus, by fiscal year 1982, Federal purchases of Landsat data amounted to about $500,000 out of **a** total sales for all imagery of $3 million (table 7). * This difference in growth is explained by the fact that the communications industry was already well established and organized to use the new technology. For satellite communications, space technology replaced older terrestrial methods because it was cheaper or more efficient.

By contrast, data from the Landsat system presented unique and novel problems of handling,

● For example, for a period, the FAS received transmissions directly at its Houston receiving station.

"'Transfer of the Civil Operational Earth Observation Satellite to the Private Sector, " U.S. Department of Commerce, February 1983,

*The more-than-doubled Federal sales in 1983 (bracketed figures) reflects the dramatic Increase in 1983 prices over 1982 and the requirement that all Federal agencies must now pay for data.

processing, and interpretation. In most cases they supplement other means of gathering data; in others, they present an entirely new data resource. The record of Landsat sales from 1973 through 1983 (table 8) reflects continuing, but decreasing, interest in the data on the part of Government agencies. During this period, Federal agencies tested these data for a wide range of possible applications to determine the potential advantages of switching away from conventional monitoring programs. NASA assisted the testing process by supplying data free to selected investigators (NASA investigators in table *8),* and in 1976 some 21 percent of all reimbursed data distribution was in this category. NASA broadened the base of trained people and stimulated the purchases of computers and other specialized equipment necessary to use the new material.

Recent Trends **in Landsat Product Sales**

Expressed in terms of unit deliveries, sales of Landsat MSS data to all Federal users reveal a downward trend after 1978 and by key user agencies after 1980 (fig. 8). These trends can be attributed primarily to the decrease in funding for research in applying Landsat data, and price increases. In addition, the pace at which user agencies can marshal internal resources effectively to exploit the data is governed by OMB oversight and internal agency budgetary considerations. Some of the potentially large users of Landsat data are the resource survey and environmental agencies whose budgets have been most constrained during the recent period of fiscal austerity. In such times, managers find it more prudent to continue with well-known conventional monitoring systems (which, however, require more manpower) than to risk adopting new procedures based on a novel type of data requiring large capital costs for trained personnel and new processing equipment, especially when there is no guarantee of data continuity.

Experience with the Landsat data has demonstrated the superiority of computer-compatible digital products over Landsat photographic products for Government users as well as industrial purchasers. The inherent advantages of information acquired from space (e.g., its repetitive standardized format) are best exploited through selective manipulation of digital tapes.

Total income from Federal Government purchases for calendar year 1983 increased substantially over calendar year 1982 (tables 7, 8, and 9). * This jump can be attributed to two major factors: a nearly threefold price increase and the imposition of charges for special acquisition orders. * * About 20 separate agencies of the Government are recorded as purchasers of the data, but most purchases are made by about a half dozen large data users.

Although income from data sales increased, the number of scenes delivered actually declined (table 10). The extent of decrease is not known since the deliveries to the FAS are not available. Special acquisition charges paid by both FAS and the Central Intelligence Agency (CIA) in order to assure scenes of specified areas at desired times and with minimal cloud cover, account for most of the increase in income, In the absence of purchases by these two agencies, Landsat data sales to Government agencies would have fallen dramatically .

The scale of Landsat data usage by FAS and CIA (table 11), appears to indicate that their applications have moved well beyond the experimental or demonstration phase into practical operations. For example, years of research with Landsat data have established its effectiveness in some types of crop forecasting. The importance to the national economy of accurate global crop data increases as the world's population increases with the world population growth and with a proportionate rise in U.S. exports of agricultural products, As an arm of USDA, FAS is charged with this function.

Sales data show a dropoff in use by agencies primarily concerned with domestic assessment and management. Direct interviews with Federal agency technical staff, however, temper any conclusions one may draw from inspecting only the

*Figures in tables 9 and 10 cannot be compared directly to tables 7 and 8. The former are expressed in terms of calendar year, the latter in terms of fiscal year.

*‘ Purchasers may stipulate cloud-free coverage of specified areas at specified dates by paying a surcharge.

Table 8.–Customer Profile of Landsat Total Data

Customer category	FY 1973[a] Items	Item (%)	Dollars	Dollar (%)	FY 1974" items	Item (%)	Dollars	Dollar (%)	FY 1975 Items	Item (%)	Dollars	Dollar (%)
Federal Government (less N.I.'s)	21,780	27%	62,756	270.	*28,493*	18° %	*87.156*	16%	34,346	17 %	169,283	19" c
NASA investigators	—	—	—	—	—	—	—	—	*5.456*	*3%*	*15,992*	*2 %*
State/local government	2,995	4 "/0	10,639	5 %	2,534	2 %	10,920	2%	*1,969*	1 %	***16,988***	***2 %***
Academic	13,071	16 %	*28,679*	13 %	18,611	12 %,	63.964	12°'0	*27,727*	14 %	142,054	16'o
Industrial	24,430	30 %	67,360	300 %	35,890	23 %	114,140	220 'o	*45,671*	23 %	219,704	24 %
Individuals .	5,109	6 %	17,143	7 %	17,266	11 %	67,127	13 %	18,643	9%	100,953	11 %
Non-U.S.	8,497	11 %	28,154	12 %	37,038	23 %	120,499	230"0	47,174	24 %	174,659	1900
Non-identified	5,189	6 %	13,311	6"C	17,346	11%	64,708	12"o	17,397	9%	69,376	7 %
Total data	81,071	100 %	*228,042*	1000,	157,178	100 %	528,514	10000	198,383	100%	909,009	100"0

Customer category	FY 1976 Items	Item (%)	Dollars	Dollars (%)	TQ 1976 items	Item (%)	Dollars	Dollar (%)	FY 1977 Items	Item (%)	Dollars	Dollar (%)
Federal Government (less N.I 's) ., .,	31.645	1300	253,166	*1500*	7,77?	1 5"o	*73,436*	16%	21,074	16"O	*269,825*	19%
NASA investigators	63,329	25%	341,056	2100	5,730	11 %	48.111	11 %	9,827	*7 %*	*96,032*	7 %
State/local government	1.214	1%	8,191	0 %	149	0 %	1.168	0 %	1.360	1 %	*20,168*	1%
Academic	26.077	11%	178,160	11	8.489	160.	*40,129*	9° o	14,063	11%	141 ,077	10 %
Industrial	42.833	17 %	322,699	2	12,122	24%	121,025	27 Co	36,979	28%	412,183	28%
Individuals .,	18,052	7%,	141,556		3,755	7%	28,683	*6%*	8,003	*6%*	*72,129*	5%
Non-U.S.	65,100	26 %	391<673	24	13,702	27 %	138. 632	*31 %*	40, 632	*31*	*442,079*	30%
Non-Identified . .	488	0 %	4,892	0 0/0	96	0%	1,087	0 %	49	0	344	0%
Total data	248,738	1000,	1,641,393	100 %	51.814	100 %	452.271	10000	131,271	100%	1,453,837	100%

Table 8.—Customer Profile of Landsat Total Data—Continued

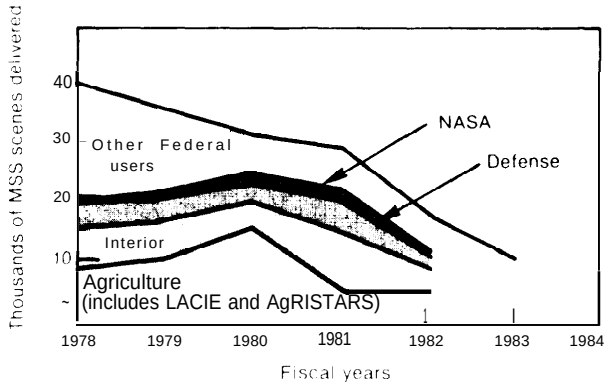
Customer category	FY 1978 Items	Item (%)	Dollars	Dollar (%)	FY 1979 Items	Item (%)	Dollars	Dollar (%)	FY 1980 Items	Item (%)	Dollars	Dollar (%)
Federal Government (less N.I.'s)	28,020	25%	597,269	30%	31,692	24%	501,214	23%	25,919	19%	392,591	16%
NASA investigators	522	0%	13,431	1%	0	0%	0	0%	0	0%	0	0%
State/local government	1,515	1%	31,557	1%	968	0%	19,281	1%	4,225	3%	78,327	3%
Academic	10,222	9%	159,379	8%	14,742	11%	235,231	11%	12,977	10%	202,401	9%
Industrial	21,321	19%	469,924	24%	25,903	19%	508,792	24%	24,723	19%	614,400	26%
Individuals	5,537	5%	73,808	4%	9,247	7%	102,854	5%	8,147	6%	96,982	4%
Non-U.S.	46,409	41%	630,700	32%	53,912	39%	764,441	36%	56,581	43%	1,003,866	42%
Total data	113,576	100%	1,976,068	100%	137,464	100%	2,131,813	100%	132,572	100%	2,388,567	100%

Customer category	FY 1981 Items	Item (%)	Dollars	Dollar (%)	FY 1982 Items	Item (%)	Dollars	Dollar (%)	FY 1983 Items	Item (%)	Dollars	Dollar (%)
Federal Government (less N.I.'s)	29,177[a]	22%	481,067	19%	24,000	20%	571,807	20%	29,804[b]	47%	5,269,741[b]	75%
State/local government	3,470	3%	107,667	4%	5,251	4%	146,897	5%	1,268	2%	70,263	1%
Academic	11,401	9%	198,611	8%	7,753	7%	201,577	7%	2,536	4%	210,790	3%
Industrial	29,821	22%	758,245	31%	23,078	19%	924,540	31%	6,341	10%	632,369	9%
Individuals	9,292	7%	117,642	5%	5,953	5%	126,565	4%	1,902	3%	70,263	1%
Non-U.S.	49,965	37%	832,036	33%	53,964	45%	969,893	33%	21,560	34%	772,895	11%
Total data	133,126	100%	2,495,268	100%	119,999	100%	2,941,279	100%	63,413	100%	7,026,895	100%

[a]Landsat imagery only—no CCT customer profiles available for 1973 and 1974 (minimal data).
[b]Includes special acquisitions and acquisition charges.

SOURCE: National Oceanic and Atmospheric Administration.

Figure 8.— Deliveries of Landsat MSS Data to Federal Users by NASA-GSFC and DOI-EDC



NOTE Breakdown of purchases by Federal users in fiscal year 1983 unavailable at present

SOURCE National Oceanic and Atmospheric Administration and Off Ice of Technology Assessment

sales evidence. The technical staff continue to see large potential benefits for their agency operations from the systematic application of Landsat data, if the system could be depended on to supply data dependably and promptly. The Bureau of Land Management (BLM), for example, has primary responsibility for monitoring vast tracts of western U.S. range and forest lands. The Denver Office of BLM made major investments in data-processing equipment in order to take advantage of the lower costs of Landsat data before prices rose and special acquisition surcharges were instituted. BLM currently is restrained in placing future orders for data because of insufficient funds and uncertainty over the future of the program.

Table 9.—U.S. Government Purchases of Landsat Data (in dollars)

Agency	CY 1982	CY 1983 (to 8-17-83)
Department of Commerce	$ 26,531	$ 14,006
Department of Agriculture (USDA)	100,101	70,986
USDA— Foreign Agricultural Service	N.A.	2,375,437[a]
Department of the Interior	402,232	181,016
National Aeronautics and Space Administration	55,967	29,108
Department of State (including AID)	11,682	380
Department of Defense	122,013	74,076
Central Intelligence Agency	41,435	1,390,650a
Other Federal agencies (12)	41,558	10,390
Total dollars	$801,519	$4,416,049

[a]Increased income in calendar year 1983 attributed largely to charges for special acquisition, i.e., customer-stipulated area covered, timing, and condition of cloud cover

SOURCE EROS Data Center, National Oceanic and Atmospheric Administration

Table 1O.—U.S. Government Purchases in Number of Digital and Photographic Scenes

	CY 1982		CY 1983 (to 8-17-83)	
Agency	Digital	Photographic	Digital	Photographic
Department of Commerce	52	486	2	0
Department of Agriculture (USDA)	118	2,492	71	933
USDA—Foreign Agricultural Service[a]	N.A.	N.A.	N.A.	N.A.
Department of the Interior	1,038	13,314	121	2,059
National Aeronautics and Space Administration	128	682	28	602
Department of State (including AID)	5	325	0	5
Department of Defense	217	4,984	38	1,634
NSC/CIA [b]	7	433	0	5,293

[a]Acquisition charges of $2.4 million calendar Year 1983

[b]Acquisition charges of $14 milllion in calendar year 1983

SOURCE EROS Data Center, National Oceanic and Atmospherlc Administration

Table 11 .—U.S. Government Purchases of Landsat Data for Domestic and for Overseas Purposes
(in dollars)

	CY 1982	CY 1983 (to 8-17-83)
Domestic agencies:		
Department of the Interior	$402,232	$ 181,016
Department of Agriculture	100,101	70,986
Department of Commerce	26,531	14,006
Total	$528,864	$ 266,008
Agencies with overseas responsibilities:		
Foreign Agricultural Service	N.A,	$2,375,437
Department of Defense	$122,013	74,076
Department of State (AID)[a]	11,682	380
NSC/CIA	41,435	1,390,650
Total	$175,130	$3,840,543

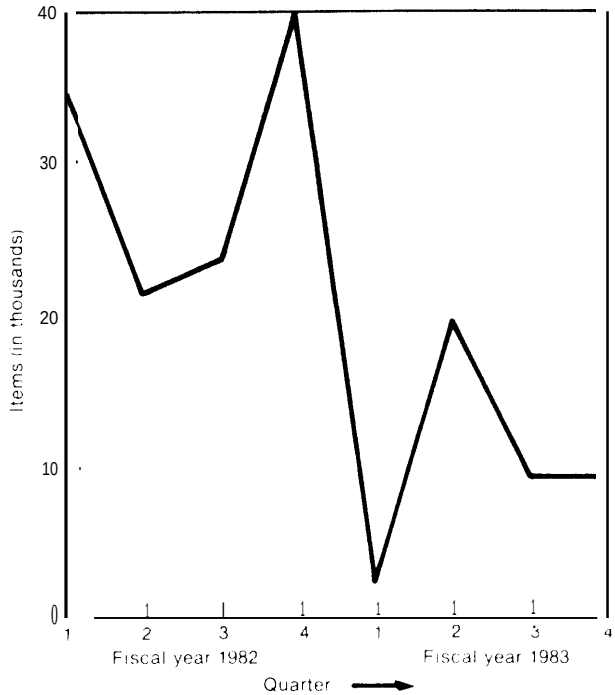
[a]Aid Stipulates Landsat Imagery In many overseas contract areas not

SOURCE EROS Data Center National Oceanic and Atmospheric Administration provided to OTA on Sept 20 1983

While USDA is making operational use of the data, the Department is now paying for data that it previously received practically free through the Johnson Center for Manned Space Flight in Houston, Tex. The volume of data purchases reflects the agencies' ability to pay for them in the context of an overall budget. This, in turn, is attributed by some agency analysts to interventions by OMB which overrode agency desires.

Information on recent overall sales trends based on latest EDC reports as provided in table *8* is confirmed by detailed information supplied in the NOAA Landsat statistical summary for fiscal year 1982 and fiscal year 1983 (table 12 and figs. 10 and 11), Figure 11 shows that in terms of dollars spent, USGS and the category of non-Federal users have maintained a fairly constant dollar level of orders. The number of images and computer-compatible tapes purchased has decreased sharply for all purchasers outside of the Federal Government. For the first time, sales to Federal agencies have exceeded sales to the non-Federal U.S. community (table *8)* and by a significant amount. "This appears to be a result of the directive by OMB that each agency would account for its actual use of Landsat data, and therefore may not reflect a real trend.

Figure 9.—Quarterly Sales of MSS Imagery and Digital Frames (total sales, including non• Federal and foreign customers)



SOURCE National Oceanic and Atmospheric Administration

Relationship Between Federal Users of Data and Agency Mission

The remote-sensing requirements of Federal agencies as well as State and local governments were examined in exhaustive detail by an interagency task force in *1978* and 1979. > Among other uses, the report served to help justify continued funding of the TM Landsat sensor. * Although it was not distributed beyond NASA and DOD, an unclassified section of the report listing the requirements for civilian agencies yields the data of figures 11 and 12. It states the requirements of eight Federal agencies as well as State and local uses, posed against a set of physical quantities or

'Integrated Remote Sensing System Study (IRS').
*TM development actually began in 1976

Table 2.—NOAA Landsat Statistical Summary

	FY 1982 1st qtr.	FY 1982 2nd qtr.	FY 1982 3rd qtr.	FY 1982 4th qtr.	FY 1982 Total	FT 1983 1st qtr.	FY 1983 2nd qtr.	FY 1983 3rd qtr.	FY 1983 4th qtr.	FY 1983 Total
Frames in EDC [illegible] base[a]	1,689,792	1,721,991	1,738,971	1,768,542	1,768,542	1,810,565	1,835,689	1,863,857	1,891,002	1,891,002
Revenue[a]	$846,679	$593,970	$714,112	$818,484	$2,973,245	$245,244[d]	$1,718,937	$2,649,290	$2,412,850	$7,026,321[e]
Imagery	$430,096	$376,144	$400,034	$484,845	$1,691,119	$103,538	$ 444,685	$ 500,442	$ 577,347	$1,626,012
Digital	$391,100	$216,000	$312,070	$330,990	$1,250,160	$ 86,893	$ 241,205	$ 304,350	$ 235,080	$ 867,528
Accession aids	$ 25,483	$ 1,826	$ 2,008	$ 2,649	$ 31,966	$ 2,183	$ 1,349	$ 17,359	$ 1,126	$ 22,017
Other data[b]	N.A.	N.A.	N.A.	N.A.	N.A.	$ 52,630	$ 114,218	$ 113,509	$ 138,732	$ 419,089
Acquisition charges/cloud cover surcharges	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	$ 917,480	$1,713,630	$1,460,565	$4,091,574
Items shipped/acquisitions[f]	34,760	21,806	23,748	39,685	119,999	3,282	26,253	17,694	16,184	63,413
Imagery frames	32,927	21,055	22,649	38,394	115,025	2,394	19,460	9,324	9,125	40,303
Digital scenes	1,833	751	1,099	1,291	4,974	193	486	525	377	1,581
Other data items[b]	N.A.	N.A.	N.A.	N.A.	N.A.	695	1,859	1,572	1,578	5,704
Acquisitions	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	4,448	6,273	5,104	15,825
Customer contacts[c]	12,267	12,189	11,737	11,854	48,677	10,145	25,521	11,781	9,771	57,218
Orders received[c]	5,621	4,814	4,745	4,493	19,673	4,765	4,227	3,921	4,486	17,399

July-September 1983 data

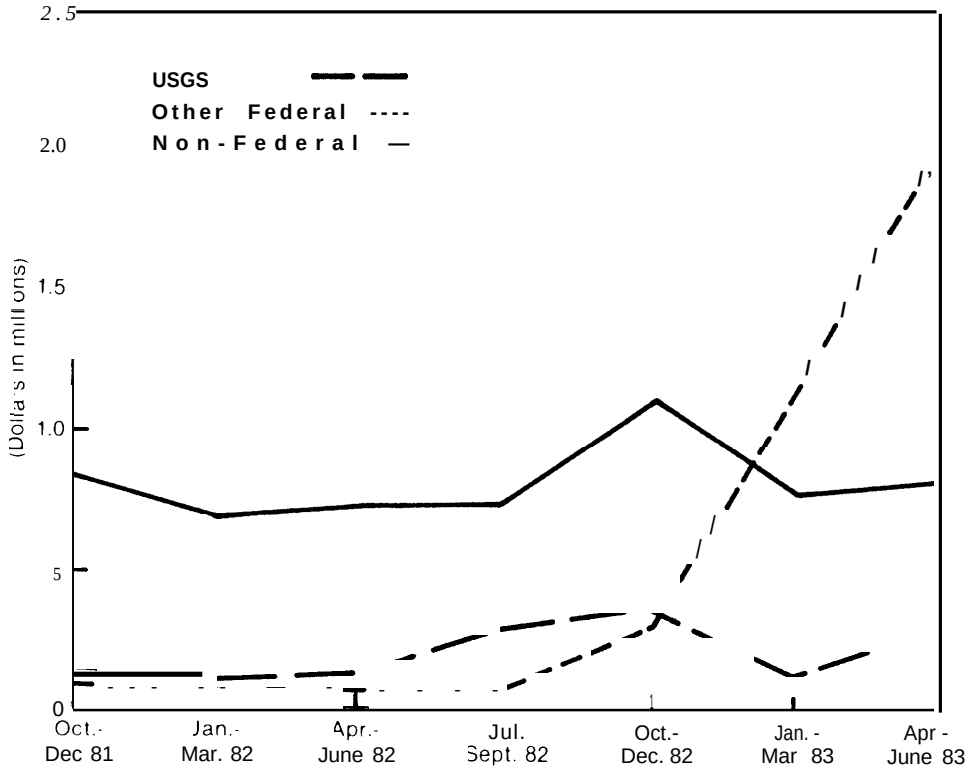
Profile of total Landsat shipped sales (based on dollars)[e]	
Federal Government	56%
State/local government	4%
Academic	.4%
Industrial	17%
Individual[g]	.2%
Non-U.S.[f]	17%

Type of Landsat business	
Imagery B/W frames	.60%
Imagery color frames	.40%
Imagery B/W dollars	.75%
Imagery color dollars	.25%

[a] Landsat only
[b] Includes Landsat 4 MSS sample CCTs.
[c] Includes aircraft and other data.
[d] Excludes $1,112,239 carryover from fiscal year 1982.
[e] Excludes acquisition charges and cloud cover surcharges.
[f] Based on address, not geographic coverage.

SOURCE: National Oceanic and Atmospheric Administration.

Figure IO.— Grand Total of Shipped Sales From EROS Data Center in Dollars (mainly Landsat data but also includes other satellite imagery, aircraft imagery, and miscellaneous services)



Source EROS Data Center Product Summary Statements for seven quarter 1982 and 1983

qualities that must be known in order to meet or satisfy agency missions or objectives. Of the *62* measurement classes listed, 43 can be met at least in part by the TM, or in some cases by the MSS. The numbers applied in the matrix of figure 12 are simple additions and do not reflect importance attached to one agency's mission over another's. They do tend to emphasize subjects of greater coincidence of interest.

Review of Department of the Interior Requirements

The Department of the Interior has maintained a special interest in land remote sensing. A study produced by Interior in partial response to the IRS interagency study contains a comprehensive listing of uses to which the data could be applied (table 13). Table 14 provides a summary list of the various Bureau data needs which can be met by remote sensing.

Survey of Relevant Legislation

The major assessment of desertification in the United States, prepared by an interagency task force, included a list of pertinent legislation (table 15) that requires periodic surveys and measurements. This list supplements information from an earlier study (table 16). Both lists reflect the increasing demands placed on Government agencies during the decade of the 1970's for types of information that can be appropriately satisfied by remote-sensing techniques.

Concerns of Federal Landsat Data Users

The apparent discrepancy between the present relatively modest level of Landsat data sales and

Figure 11 —Abilities of Current, Funded, and Future Systems to Meet Requirements, by Agency

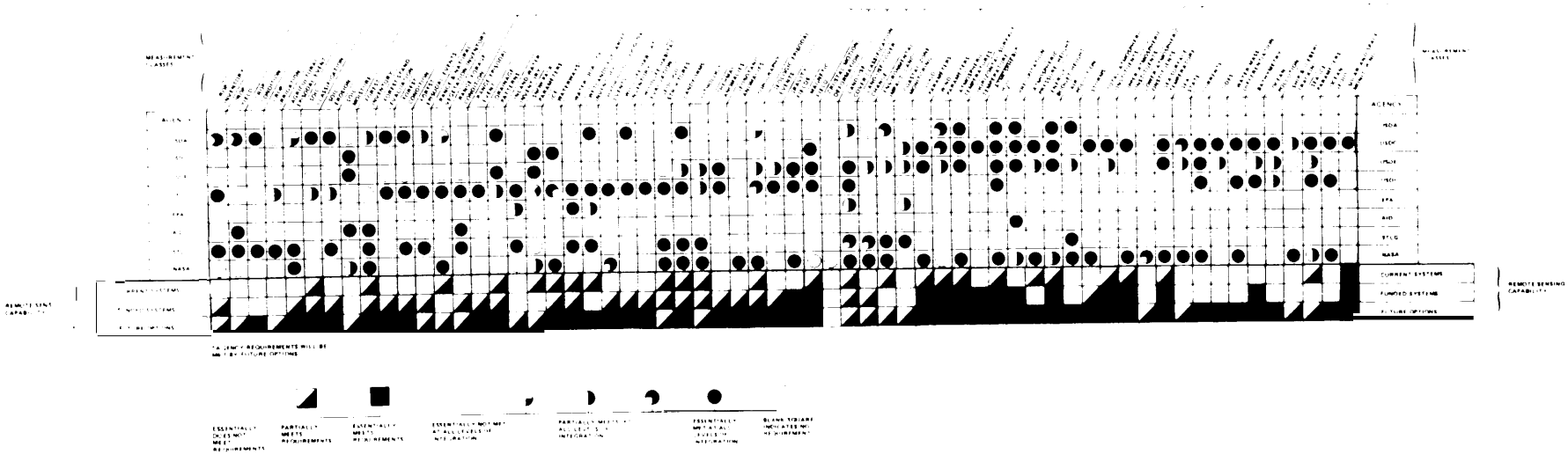
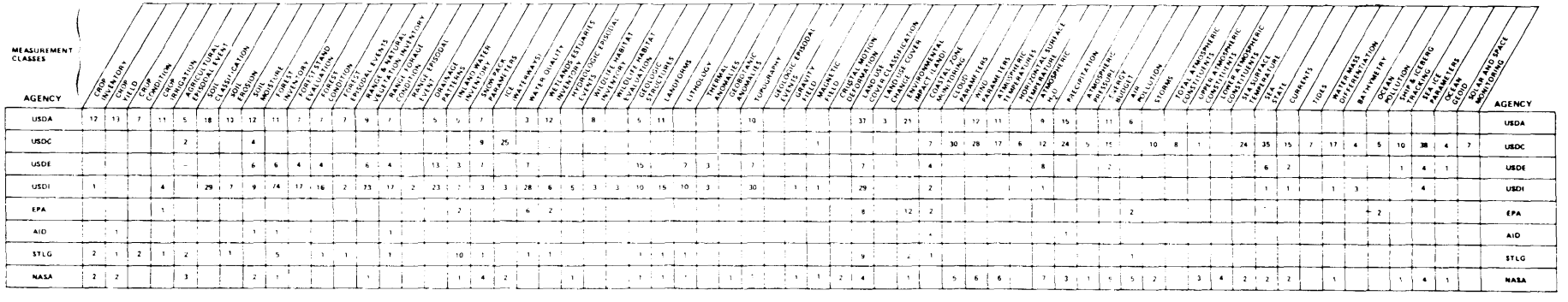


Figure 12.— Number of Requirements in Each Measurement Class, by Civil Agency



*Details of Analysis are in Appendix B, Volume III. The numbers in the table are simply tabulations of its requirements submitted by the agencies. The relative importances of its requirements are not evaluated.

Table 13.—Operationai Uses That Can Be Implemented With Existing or Planned Satellite Technology

- Mapping geologic structure for mineral and fuel exploration (GS, BLM)
- Digital enhancement and analysis of altered and potentially mineralized zones and altered areas (GS, BLM)
- Monitoring seasonal consistencies and variations in the Beaufort OCS sea ice (BLM, GS)
- Regional environmental surveys for preparation of environmental impact statements (LBR, BLM, F&WS, GS, BIA, NPS)
- Detection and monitoring of surface mining and mine reclamation activities (OSM, F&WS, Mines, BLM, BIA, GS)
- Monitoring snow cover accumulation, melt, and change in irrigation and hydroelectric catch merits in the Western United States and adjacent areas of Canada in order to contribute to predictive hydrologic models and runoff calculations (LBR, GS)
- Surface water inventory (LBR, F&WS, GS, BLM, BIA)
- Real-time analysis of mesoscale cloud systems (LBR)
- Water and wetland measurement to assess the amount and type of waterfowl habitat and the impact of irrigation (F&WS, LBR)
- Inventory of irrigated cropland, including acreage under irrigation and a breakdown by crop type (LBR, BIA)
- Mapping of flooded areas, estuaries, and shallow sea features (BLM, LBR, GS, BIA)
- Assessment of salinity problems in major watersheds (BLM, GS, LBR)
- Assessment and monitoring of physical water quality. water turbidity, and algae blooms (GS, F&WS, NPS, BLM, LBR)
- Monitoring ice conditions in Arctic goose nesting grounds to aid in the prediction of waterfowl populations. (F&WS)
- Vegetative cover mapping (BLM, F&WS, LBR, GS, BIA, NPS)
- Mapping extent of fire scars and rate of revegetation (BLM, F&WS, BIA, NPS)
- Contribute to land use/land cover mapping and land use/land cover change detection and statistical analysis of nonurban areas at scales of 1:250,000 and smaller (GS, NPS)
- Monitoring with Landsat to supplement and update orthophoto coverage of Indian lands (BIA)
- Mapping and classification of forest lands for the northwest Indian tribes to produce updated land-use plans (BIA)
- Publication of Landsat image maps at 1:250,000, 1:500,000, and 1:1,000,000-scale of unmapped or poorly mapped regions of Antarctica and other regions in support of national and international cooperative efforts (GS)
- Route selection for utility corridors (BLM, BPA)
- Monitoring ephemeral rangelands for drought and overgrazed conditions (BLM, BIA)
- Geographic positioning using doppler satellite (BLM, GS)
- Environmental data collection and relay (GS, NPS, BLM, LBR, F&WS, BIA)
- Teleconferencing and emergency communications (NPS, BLM, BIA, TA)

KEY

BIA" Bureau of Indian Affairs	F&WS Fish and Wildlife Service	NPS National Park Service
BLM Bureau of Land Management	GS Geological Survey	OSM Off Ice of Surface Mining
BPA Bonneville Power Administration	LBR Bureau of Reclamation	TA Territorial Affairs

SOURCE U S **Department of the Interior Secretary's initiative Use of Aerospace** Technology Draft Mar 30 1978.

Table 14.—Current and Projected High-Priority Interior Applications Amenable to Landsat Technology

Bureau applications	Departmental activities					
	Onshore Energy and Minerals	Offshore Energy and Minerals	Water Resources	Land Resources	Fish and Wildlife	Telecommunications
Bureau of Reclamation:						
Water Management			x	x		x
Irrigated Land Inventory			x	x		
Agricultural Crop Inventory			x	x		
Hydrometeorological Data Relay			x			X
Mesoscale Cloud Analysis			x			x
Bureau of Land Management:						
Natural Resource Inventory	x	x	x	x	x	
Natural Resource Monitoring	x	x	x	x	x	x
Telecommunications Improvement						x
Geographic Positioning				x		
Fish and Wildlife Service:						
Migratory Bird Management .,			x	x	x	x
Habitat Inventory and Analysis			x	x	x	x
National Park Service:						
Vegetation/Land Cover Inventory				x		
Resource Condition Monitoring			X	x		X
Environmental Quality Monitoring			x	x	x	x
Geological Survey:						
Land Cover Mapping			x	x		
Water Management			x	x		x
Cartographic Mapping	x		x	x		
Geologic and Mineral Assessment	X	x				x
Conservation and Regulation	X	x	x	x		x

SOURCE U S Department of the Interior, Use *of Aerospace Technology* **in** ***Interior*** *Department Programs,* March 1978

Table 15.—Existing Legislation Requiring Monitoring

Name	Reference	Agency	Data required
Mining Law of 1872	Public Law 42, Ch. 152	DOI	Develop mining resources of the United States
Desert Land Act 1977,	Public Law 44, Ch. 107	DOI	Desert lands in certain States and territories
Carey Act of 1894	Public Law 53, Ch, 301	DOI	Reclamation of desert lands
National Irrigation Act of 1902	Public Law 57-161	DOI/USDA	Construction of irrigation works and land reclamation
Weeks Act of 1911	Public Law 61-435	DOI/ACE	Watershed and river navigability
Stock Raising Homestead Act of 1916,	Public Law 64-290	DOI	Unappropriated Federal land to stock-raising
Mineral Leasing Act of 1920	Public Law 66-146	DOI	Promote mining of coal, oil, phosphate
Recreation and Public Purposes Act of 1926.	Public Law 69-386	DOI	Federal public lands to States and cities for recreational purposes
Fish and Wildlife Coordination Act of 1934	Public Law 73-121	DOI	Conservation of wildlife-fish games
Taylor Grazing Act of 1934	Public Law 73-482	DOI	Prevent injury to public grazing lands
Soil Conservation and Domestic Allowance Act of 1935	Public Law 74-46	USDA	Protection of lands against soil erosion
(and amendments of 1936).	Public Law 74-461	USDA	Protection of lands against soil erosion
Watershed Protection and Flood Prevention Act of 1954	Public Law 83-556	USDA	Works of improvement to prevent soil erosion
Multiple Mineral Development Act of 1954	Public Law 83-585	DOI	Multi-mineral mining of public lands
Great Plains Conservation Program Act of 1955	Public Law 84-1021	USDA	Great Plains Programs
Food and Agriculture Act of 1962	Public Law 87-703	USDA	Conservation of national resources
Clean Air Act of 1963	Public Law 88-206		
and Amendments of 1977	Public Law 95-05	EPA	Regional air pollution control locations
Wilderness Act of 1964	Public Law 95-05	DOI	Regional air pollution control programs
Land and Water Conservation Act of 1965	Public Law 88-578		
and Amendment of 1977	Public Law 95-42	DOI	Water conservation and outdoor recreation
Water Resources Planning Act of 1965. ,	Public Law 89-90	DOI	Development of water and related land
Community Planning and Resource Development Soil Surveys of 1966	Public Law 89-560	USDA	Soil Survey Program
Wild and Scenic Rivers Act of 1968	Public Law 90-542	DOI	Preserve selected rivers
and Amendments of 1976	Public Law 94-486	DOI	
Endangered Species Act of 1973	Public Law 93-205	DOI	Preserve endangered fish and wildlife
Colorado River Basin Salinity Control Act of 1974	Public Law 93-320	DOI/ACE	Construction of public works on the river
Federal Land Policy and Management Act of 1976	Public Law 94-579	USDA/DOI	Public lands inventory
Water Bank Act of 1970	Public Law 91-559	DOI	Conservation of surface water
Mining and Mineral Policy of 1970 ....,	Public Law 91-631	DOI	Reclamation of mined land
Soil and Water Resources Conservation Act of 1977	Public Law 95-192	DOI	Further the conservation of water and related resources.
Clean Water Act of 1977	Public Law 95-217	DOI/USDA/ EPA/ACE	Improve biological integrity of the Nation's water
Endangered American Wilderness Act of 1978	Public Law 95-237	DOI	Protect wilderness preservation areas
Renewable Resource Extension Act of 1978.	Public Law 95-306	USDA	Protect forest rain products
Surface Mining Act of 1977	Public Law 95-87	DOT	Protect society and environment from suface operations

Abbreviations ACE — U S Army Corps of Engineers
USDA — U S Department of Agriculture
DOI – Department of the Interior
EPA – Environmental Protection Agency
DOT — Department of Transportation

SOURCE Office of Technology Assessment

Table 16.— Federal Statutes Pertinent to Remote Sensing

Name	Reference	Agency	Data requirements
Cotton Act	Public Law 92-331	USDA	Estimates of cotton crop and acreage
Bankhead-Jones Farm Tenant Act	7 USC 1010	USDA	Land inventory and monitoring of erosion, sediment, flood plain, land use
Agricultural Marketing Act.	7 USC 1622	USDA	Statistics on agricultural product supplies
Halogeton Glomeratus Control Act	7 USC 1652	DOI/USDA	Surveys of presence and effect of Halogeton Glomeratus, a weed
Weather Bureau	15 USC 313	DOC	Enabling legislation
Soil Conservation Act	16 USC 590	USDA	Surveys and studies of soil erosion
Forest Pest Control Act	16 USC 594	USDA	Detection of forest insect pests on wildlife
Wildlife Protection ,	16 USC 665	DOI	Studies of effect of pollutants on wildlife
Fish and Wildlife Act	16 USC 742	DOI	Studies of fish and wildlife
Fishery Resources Act	16 USC 744	DOI	Studies of food, fish populations
Fish Resources	16 USC 758a	DOI	Studies of fish resources in South Pacific possessions
Fish Resources	16 USC 759	DOI	Studies of Atlantic coast shad
Fish Resources	10 USC	DOI	Studies of the Atlantic coast
Watershed Protection and Flood Protection Act	16 USC 100-1009	USDA/ACE	Investigations and surveys for flood prevention and watershed program development
Coal Mine Fire Safety Act	Public Law 83-738	DOI	Surveys and research outcrop and underground fires
Geological Survey	40 USC 641	DOI	Mineral exploration
Flood Control Act	Public Law 86-645	ACE	Identification of flood plain areas, damage assessment
Housing Act	Public Law 90-448	HUD	Technical assistance to local planning agencies
Bureau of Land Management	43 USC 2	DOI	Enabling legislation
Geological Survey	43 USC 31	DOI	Enabling legislation
Taylor Grazing Act.	43 USC 315f	DOI	Land classification
Federal Reclamation Law.	43 USC 485g	DOI	Land classification
Forest Resources Act	16 USC 581	USDA	Survey of forest supplies
Admission of New States	43 USC 857	DOI	Survey of public lands in a State prior to its admission to the Union
Land Use.	43 USC 1181	DOI	Land classification and management
Outdoor Recreation Act	Public Law 88-29	DOI	Inventory of outdoor recreation resources
Food and Agriculture Act.	Public Law 89-321	USDA	Commodity acreage and land use
Water Resources Planning Act	Public Law 89-80	DOI/USDA/ HEW/FPC	Studies of water supply adequacy
National Flood Insurance Act	Public Law 90-448	HUD	Establishment of flood risk zones, estimates of flood losses
Dam Safety Act	Public Law 92-367	ACE	Inspection of dams, Landsat data used to locate them
Federal Water Pollution Control Act	Public Law 92-500	EPA/DOC	Oil spill surveillance, violation detection, pollution surveys and research
Clean Air Act	—	EPA	Studies and detection of pollution
Hazardous Waste Management Act	NYP	EPA	Surveys of effects of hazardous wastes on the environment
Toxic Substance Control Act	NYP	DOI	Research and monitoring of extent of toxic substances
National Resources Land Management Act	NYP	DOI	Land inventory and land-use classifications
Land Use Policy and Planning Assistance Act	NYP	DOI	Comprehensive land-use planning
Marine Pollution Dumping Conservation	NYP	EPA	Monitor seas for pollution
National Environmental Policy Act.	—	EPA	Environmental impact statements
Surface Mining Reclamation Act of 1973.	NYP	DOI	Surveys of land-use and surface mining operations
Surface Mining Reclamation Act	NYP	DOI	Surface mining operations survey

Abbreviations" ACE — U S Army Corps of Engineers **DOI — Department of the Interior** **HEW** — Department of Health, Education, and Welfare
USDA — U.S. Department of Agriculture **EPA — Environmental Protection Agency** **HUD** – Department of Housing and Urban Development
DOC — Department of Commerce **FPC — Federal Power Commission** **NYP** – Not yet passed in 1974

SOURCE General Electric, *Definition of* Total **Earth** Resources System *for the* Shuttle *Era,* vol 1, NASA contract, 1974

the need postulated in earlier official Government projections of demand is striking. In discussions with remote-sensing specialists from several Federal agencies the difference has been attributed to several technical and policy factors:

- Considerable modification in Landsat performance characteristics between I.andsat 1 and I.andsat 4, and the likelihood that future changes could seriously perturb the ways in which data must be processed in the future.
- Technical difficulties> experienced in the landsat 4 system.
- Initial slow production rate (one scene per day) of the improved resolution TM scanner, The X-band transmitter used to transmit data from the TM failed only a few months after launch.
- Delay in design and procurement of a more advanced solid-state and higher resolution scanner comparable to the scanner to be employed on the French SPOT spacecraft in 1985.
- Anticipation of a gap in data flow between the failure of Landsat 4 and launch of Landsat D) '.
- Continuing delays in delivering data to customers.
- Uncertainty over Federal policy regarding a continuing role for a [U.S. space remote-sensing system.
- The experimental phase of MSS is nearly over.

The Federal user community has generally concluded that experimental and demonstration projects carried out using the data products of the system have been successful in showing potential cost-effective applications to agency missions. These have included utility for a substantial] number of national resource, environmental, and land management purposes. On the other hand the Landsat system, they note, had not been run as an operational system until 1983. It has not provided the Federal user community with the assurances needed by managers of standardized data flow available over an extended period.

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