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TO
THE SCIENCE, TECHNOLOGY, AND SPACE SUBCOMMITTEE
OF THE
COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION

May 6, 1992

Land Remote Sensing - An Emerging Technology

This testimony is presented in two parts: the first offers our views on the legislation before the Congress, S. 2297 and H.R. 3614; the second provides a review of the last 20 years of space and airborne remote sensing and a view of the future from the perspective of a value-added company.

I. The Legislation

There are five principles which we believe must be embodied in a land remote sensing act:

1. Open skies as provided in the Land Remote Sensing Commercialization Act of 1984.

2. Non-discriminatory access to data.

3. Program continuity.

4. Service (to the extent that this principle can be mandated, it is we believe covered by non-discriminatory access).

5. Technological progress.

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[1] Mr. Thibault joined EarthSat in 1971 and has been involved in all aspects of the Landsat program since 1972. From 1984 to 1987, he was assigned to EOSAT and served as International Vice President, traveling abroad extensively promoting the U.S. Landsat commercialization program. He has visited most of the foreign Landsat receiving stations.

We believe that S. 2297 deals fairly and effectively with each of these principles. By suggesting discriminatory pricing and data access, H.R. 3614 threatens the viability of a small but growing value-added industry for the sake of a failed initiative (commercialization) and a mythical revenue windfall.

Commercialization

The Land Remote Sensing Commercialization Act of 1984 was a desperate and effective means of saving the Landsat program. It worked. However, our forecasts of commercial viability erred greatly. Experience disproved the commercialization theory. The retention of some elements of commercialization in H.R. 3614 is difficult to support. The government may, if it chooses, have a commercial organization or organizations involved in any or all aspects of the program, but it cannot choose to make the program commercially viable. It is not. And, save an act of the Almighty, it will not be in the next 10 years. The reason it cannot be viable in the near term is simply one of profits. If we assume the life of a satellite to be five years, and the cost $500 million, and profits on data sales to be 10% of revenues, commercial users will contribute about $600,000 (sales to commercial organizations are less than $6 million) a year in profits toward the building of new satellites (assuming that all profits are reinvested). Commercial users will contribute less than 1% to the cost of new satellites. The obvious truth is that in the next 10 years, commercial users will not contribute significantly to the cost of future Landsat's.

Marketing of Unenhanced Landsat Data

S. 2297 provides for Federal "ownership of all unenhanced data acquired by the Landsat system...and that (2) no exclusive marketing rights are extended to any contractor;" Title I, Sec. 202(b)(1)(2). This provision makes good sense. As we have seen with census data, competition in the repackaging, marketing and sale of the raw census data has offered consumers a wide variety of products at very competitive prices. A government sanctioned monopoly will assure high prices, poor service and limited products. Competition is healthy. The government should provide minimally processed data to all purchasers and not restrict the marketing of those data as provided in S. 2297.

Value-Added Services

In tacit recognition of the failure of Landsat commercialization and explicit acknowledgement of the bankrupt economics of two-tiered pricing, H.R. 3614 invites the Landsat program managers to "explore revenue-enhancing activities" in its negotiations with the Landsat-6 contractor. Title I, Sec. 203(b)(5).

Included in this "exploration" is the possibility that the Landsat-6 contractor "may include value-added services" in these revenue enhancements. The Landsat Commercialization Act of 1984 does not preclude the operator from value-added activities. It attempts to provide, as does H.R. 3614, safeguards against the contractor using its extraordinary position to unfairly compete with other value-added users. In fact, the safeguards have failed. EOSAT offers value-added products, and has done so in a manner that contravenes the intent of the 1984 Act. It's unlikely that given the self-acknowledged economic shortcomings of H.R. 3614, that the contractor will behave differently in the future. But, there's more than economics to concern us.

Since the contractor schedules satellite data acquisitions, he may favor his data needs for value-added services over his competitors. Such a threat imperils every value-added company. The contractor also has the names and geographic areas of interest of all purchasers of government provided Landsat data and may use this information to market value-added services to those purchasers. This information has never before been disclosed outside of the EROS Data Center and EOSAT and failure to honor the proprietary nature of this information carried serious penalties. Since we testified to the House on June 21, one of EOSAT's parents has acquired a value-added company and has moved aggressively into the value-added market. The possibility for abuse by the contractor of its unique position is real. H.R. 3614 encourages the establishment of a government-sanctioned vertical monopoly which will hurt consumers, the value-added industry, and the government.

S. 2297 deals with this potentially destructive provision simply and effectively by not granting "exclusive marketing rights...to any contractor." Title I, Sec. 202(b)(2)

We believe that expansion of the commercial market is best served by non-discriminatory access to minimally processed Landsat data at marginal cost.

Multi-Tiered Pricing

H.R. 3614 proposes that unenhanced Landsat data may be offered for "non-commercial" uses at one price (i.e., "the marginal cost of fulfilling a specific user request..."), and at another price to "commercial" users of the data. Let me be clear, H.R. 3614 does not mandate multi-tier pricing, it simply authorizes the Landsat Program Manager to negotiate this matter with the Landsat-6 contractor. EOSAT has made it clear in congressional testimony[2] and in its advertising that it favors multi-tiered pricing.

S. 2297 wisely recognizes the long established and well founded principle of "nondiscriminatory access to data."

We support the argument that Landsat data should be provided to organizations participating in global environmental research at a low or marginal cost. We believe further that all land remote sensing research would be stimulated by lower data prices and support this concept.

The suggestion embodied in H.R. 3614 that these high public purposes be met by a multi-tiered discriminatory pricing scheme is, however, a fatally flawed concept. It fails on economic, operational, and equity grounds.

Since H.R. 3614 begins with definitions, let me begin with a request for a definition of commercial use. While it is easy to identify a government agency or a nonprofit corporation, it's not so easy to define commercial use. If research has no commercial objective, why should we be interested in subsidizing it? In fact, all research has a commercial objective--sometimes that objective is primary and is obvious. A better means of finding oil or managing private forests is clearly commercial. But let's assume for a moment that Exxon contracts with the University of Texas to conduct research on the spectral signatures of naturally occurring oil slicks in the coastal waters of the United States (EarthSat is currently conducting such research). This research may lead to improved methods of finding oil from natural seeps (clearly a commercial purpose) or may be used to mitigate the effects of oil spills (a public purpose with a strong commercial component). When the

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[2] Silvestrini, A. "The Landsat Program: Management, Funding and Policy Decisions" presented to the Committee on Science, Space, and Technology, U.S. House of Representatives, 26 November 1991.

research begins, the course and the benefits of that research are hypothesized, but they are not known.

The definition of commercial use is, I believe, further clouded by the economic nature of private nonprofit organizations. Such organizations provide employment, purchase goods and services, provide goods and services, contribute to the economy and to the balance of payments. They distribute their income to their employees, rather than to stockholders, and they don't pay taxes. Only in their legislative exemption from taxes are these organizations commercially different from profit making organizations. I believe that the handful of tiny for profit corporations which make up the value-added remote sensing industry will be destroyed by this provision of H.R. 3614. For every segment of our business, EarthSat must compete with government and nonprofit organizations. If commercialization remains a purpose of a new Land Remote Sensing Act, then discrimination against commercial organizations is at least inappropriate. Because such definitions are difficult, enforcements will be cumbersome and costly, leaving the beneficiaries of the lower price, those discriminated against, and the administrators unhappy.

The language of H.R. 3614 suggests that public purposes have a higher calling for data than private for profit purposes. This is not explicit, though a lower price for "state and local government agencies..." is suggestive of this conclusion. Favored treatment for Federal agencies might also be argued on a different basis. But, regardless of the justification for this discrimination, it presents problems. If the Corps of Engineers, pursuant to the National Environmental Policy Act, were to prepare an environmental impact statement for a waterway improvement project, and chose to use Landsat data, they would get the data at marginal cost. A worthy public purpose, a good use of the data, a benefit to the program and society. If, however, EarthSat and Dames & Moore (a large engineering company) should use Landsat data to prepare an environmental impact statement for the Idaho Power Company for a 1,500 mile transmission line in the western United States, they would pay full price for the data (perhaps 5-10 times what a favored user would pay) to serve the same public purpose. This project did take place, and because of the use of satellite data, the licensing time was cut in half. These applications may be discouraged by unfair pricing because value-added companies will not be competitive with favored institutions.

Having defined commercial use, the question which follows will be: What regulatory assurances will the Congress provide those few users who must pay full price that they are not being competitively disadvantaged by well or ill-intentioned academics or nonprofits?

As a commercial user, EarthSat will insist upon meticulous accounting of non-commercial data, and we will use all available legal means to assure compliance with the "non-commercial use" mandate. EarthSat's principal competition for commercial products and services comes from nonprofit institutions and organizations, and government agencies, so our vital interest is affected by this provision of H.R. 3614.

Enforcement is further compromised by two provisions of H.R. 3614:

1. "the term United States Government and affiliated users means---...
   1) international entities who have signed with the United States Government a cooperative agreement involving the use of Landsat data for non-commercial applications," Title I; Sect. 101; 12(D), and
   2) "(b) Considerations - In carrying out negotiations under this section, the Landsat Program Management shall...
      "(3) ensure that the United States and its affiliated users shall not be prohibited from reproduction or dissemination of unenhanced data to other such parties as long as the unenhanced data will be used solely for non-commercial purposes;" Title I; Sec. 203(b)(3).

I am sure that the absurdity of restricting use while allowing unrestricted copying and worldwide dissemination of the unenhanced Landsat data is apparent to all who give this issue a moment's thought. I might note that the memoranda of understanding between the United States and foreign governments which license the direct receipt of Landsat data have been widely dishonored by our foreign partners.

There are other operational realities of multi-tiered pricing:

1. The contractor must establish a procedure for assuring compliance, and put in place a staff to deal with the record keeping.

2. The government must establish an enforcement office.

3. Recipients of non-commercial data must establish procedures to assure compliance, and assign staff to prepare compliance or audit reports. The sanctions are severe and leakage very possible, so it would be highly imprudent for an institution not to go to great lengths to protect itself.

4. Everyone will have to hire lawyers (I do not consider this a benefit, though some may).

Multi-tiered pricing will be an operational disaster.

We know from experience that other governments share data that has commercial intelligence value (and Landsat certainly qualifies) with commercial organizations. This is particularly true of the Japanese who do not distinguish between the government and private sectors when the objective is the exploitation of another nation's natural resource wealth. I support the Japanese cooperation between government and industry in international trade. Indeed, I am envious. Failing such cooperation from my government, I hope that you will at least not provide commercial intelligence to our international competitors at one-tenth the price American companies must pay.

There are other arguments against multi-tier pricing. Gresham's Law will surely apply. The low priced product will drive out the high priced product. One of the values of high priced data is that it dampens demand. When the data were free to ERTS-1 and 2 Principal Investigators (1972-1975), we ordered thousands of scenes. EarthSat alone ordered more data than the Landsat-6 facility can produce. As the price goes down, demand will go up, revenues will go up, and system costs will go up, but it's not likely that benefits from research will grow proportionately.

We have tried to construct alternatives to the non-discriminatory access provision of the current Act. There aren't any. They fail on economic and operational grounds. The concept is inequitable and unenforceable.

If the purpose of multi-tiered pricing is to buy out EOSAT, as might well be inferred from the Committee Report on H.R. 3614, then we must ask why a few Landsat data users must pay the full price for the failure of the commercialization initiative.

S. 2297 deals simply and effectively with the pricing problem by providing that "Any unenhanced data...shall be made available to all users on a non-discriminatory basis...." Title V, Sec. 501(a).

Pricing

If we reject multi-tiered pricing, we must then decide whether the single price should be high, low, or somewhere in between. Let me first say that the Congress should not attempt to be too specific on this matter. The market and operational costs should be considered in price setting. We believe that prices should reflect the marginal cost of producing the product. Since both S. 2297 and H.R. 3614 recognize the failure of commercialization, commercial prices are inappropriate, unless the intent is to provide windfall profits to the contractor. If the government's objective is a social one as with most public programs, then the price should be low enough to assure broad distribution and use of the data with perhaps some partial cost recovery above and beyond reproduction cost. Data from the Decennial Census, which cost $2.6 billion, are distributed to public and commercial organizations at a nominal, uniform price. Revenues fall far short of paying the cost of the Census, but it is clear to most that there are public benefits in addition to the Constitutional requirement which warrant Federal expenditure. The fact that commercial organizations (i.e., in marketing and direct mail sales) are major beneficiaries of this Federal data collection and dissemination effort does not weaken the argument for public funding. The analogy to the Landsat program is a good one.

In 1982, the Land Remote Sensing Satellite Advisory Committee, chaired by Michael T. Halbouty, in its report to Secretary Baldrige stated that the key to successful commercialization "...is data availability...." Clearly, if the government wishes to encourage the use of Landsat data, price is a key. We support the provision of S. 2297 which calls for the cost to users "...not exceed the marginal cost of filling a specific user request." Title I, Sec. 202(a)(1).

Finding (9) of H.R. 3614 "the high cost of Landsat data has severely impeded the use of such imagery for scientific purposes" might also read, "the high cost of Landsat data has severely impeded the use of such imagery for commercial purposes." Perhaps the stimulus the commercial market needs is marginal cost data.

Technological Progress

Both S. 2297 and H.R. 3614 address the important matter of Research and Development. Land remote sensing is young technology with much promise for both public and commercial applications. Potential private industry potential contributions are not simply limited to commercial applications. On large construction projects, industry is required to comply with Federal and State environmental regulations and to mitigate the adverse environmental impacts of these projects. Satellite data are contributing to these projects. More is possible. The research has both public and commercial benefits. That research may suggest new sensors, changes in the spatial or spectral resolution of sensors, and different acquisition and processing parameters. H.R. 3614 provides for a biennial review of the Landsat program which would receive the comments of industry, government and academia. We believe this review is essential and the Landsat Advisory Council provided for in H.R. 3614 could make significant contributions to the advancement of land remote sensing technology.

Federal Responsibility

We believe that the arrangements proposed in S. 2297 and H.R. 3614 for managing the Landsat program can succeed if the Executive continues to back its advocacy of the program with adequate budget requests.

II. Land Remote Sensing - An Emerging Technology

The Gulf War demonstrated to the military and intelligence communities what the civilian commercial users of Landsat data have known for more than a decade. Landsat and SPOT can provide accurate, current information on land cover, natural and cultural resources for large areas, for inaccessible remote regions, and can do so quickly and inexpensively.

My testimony will focus on three commercial activities which we believe will be at the center of commercial applications of earth resource satellite applications in the next decade:

1. Global environmental monitoring
2. Mapping
3. Resource exploration

I have also included information on developing country use of satellite data because of the economic and social importance of these activities.

Each of these activities will rely increasingly on satellite data and each offers substantial benefits to the U.S. economy. Before examining these applications, I would like to briefly recount EarthSat's Desert Shield and Desert Storm experiences because our contributions were made possible by vigorous technological developments spurred by private sector business. In 1990, less than 8 percent of EarthSat's business was with the Federal Government.

Desert Shield and Desert Storm

On July 15, 1990, EarthSat completed a major petroleum exploration study for the Northern Arabian Platform which includes all of Kuwait and Iraq, and parts of Iran, Saudi Arabia, Turkey and Jordan. Our clients for this study were international oil companies. On August 3, 1990, following the Iraqi invasion, we offered to provide the U.S. Government with current satellite-derived image maps of the Gulf area within 48 hours using SPOT and Thematic Mapper data. Our proposal fell on deaf ears. It apparently failed for two reasons: (1) the government was satisfied that it had adequate maps, or that it could produce them, and (2) the government experts were convinced that what we proposed could not be

accomplished in time to be useful, let alone in 48 hours. Having failed to uncover an interested agency or official, EarthSat abandoned its marketing efforts about a week after they began, and refocused on its commercial markets.

In early September, early on a Monday morning, we received a telephone call from one of those government officials we talked to in the first week of August asking whether we were available to produce image maps and could we do so quickly. Apparently, existing maps were not entirely adequate. What followed were several projects in which we produced:

(1) 46 image maps (scale 1:50,000) from pre- and post invasion SPOT 10 meter panchromatic data. One of EarthSat's staff went to France to pick up the SPOT data to accelerate the process. The maps, along with stereo imagery for terrain analysis and trafficability studies, were produced within 48 hours of receipt of the data and in less than one week, including the trip to France.

(2) 33 multispectral image maps (scale 1:100,000) from Landsat Thematic Mapper data. These maps were produced in 36 hours.

(3) 100,000 lithographed copies of the 33 multispectral image maps. Production time: 4 days.

The capacity to respond quickly to the government's requirements was developed in response to the civilian commercial market demand for rapid service, complex products, and the highest possible quality. Apparently, none of the existing government contractors or responsible agencies were able to meet the operational requirements of the Desert Shield forces. Let me add that our efforts received the strongest support from the government, and without this active participation, we could not have met our objectives. Examples of these products are on display.

EarthSat's support of Desert Storm included rapid turnaround (6-12 hours) of satellite images utilizing a variety of proprietary processing techniques and algorithms developed for commercial applications. While all the image processing involved interactive computer

analysis by geologists, geographers and other earth scientists, final photographic products were produced for the client's interpretation and analysis. (164 images were produced from SPOT and Landsat data during the war.)

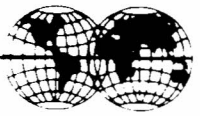
My purpose in recounting this experience is not to call attention to our accomplishments vis-a-vis the government, though I am certainly proud of these accomplishments. My purpose was to note the benefits the country may derive from vigorous private sector activity and to caution against condemning future Earth observation programs to public agencies by discriminatory data access.

Global Environmental Monitoring

If the EOS program goes forward as it is currently planned, it will in time provide essential data on the health of the planet. From these data, scientists will construct mathematical models which will describe global environmental processes, and we will be capable of predicting the long-term effects of man's activities on the environment. This necessary basic research will almost certainly provide significant benefits to mankind in the 21st Century, but it will not deal with the serious and persistent environmental problems which today plague the Earth. Fortunately, Earth sensing from Landsat, SPOT, MOS and a host of satellites to come, will fill that need, provided that government has that wisdom to retain these instruments which have served well and can continue to do so. Much of the environmental work with which EarthSat is involved utilizes satellite data to monitor change in land use. We know that if forests are being cleared in the humid tropics for timber or agriculture, there will be local and global environmental consequences. Today, regulation of this one activity relies upon satellite data in a number of countries. Urban pressure on agricultural land is routinely observed by development planners in Asia, Africa, Latin America and governments in the industrialized countries. Vegetative stress from air pollution is monitored in Europe and North America. Environmental planners utilizing geographic information systems employ satellite data in their models to anticipate the impacts of change and infrastructure investments. Most of the hardware and computer software for these applications was developed by private companies in the United States. This development has created a growing market for satellite data, and growing benefits to society.

If the global environmental monitoring program envisioned by NASA, NOAA and cooperating domestic and foreign organizations succeeds in increasing our knowledge of the Earth's environment, in educating the world's population on the necessity for conservation, and in motivating our political institutions to make the hard choice between near-term economic advantage and a better environment, we will still need land satellites to support the job of cleaning the environment.

The following examples of recent environmental work completed by EarthSat suggest the great potential of land remote sensing for understanding and ameliorating the problems which increasingly plague our planet.

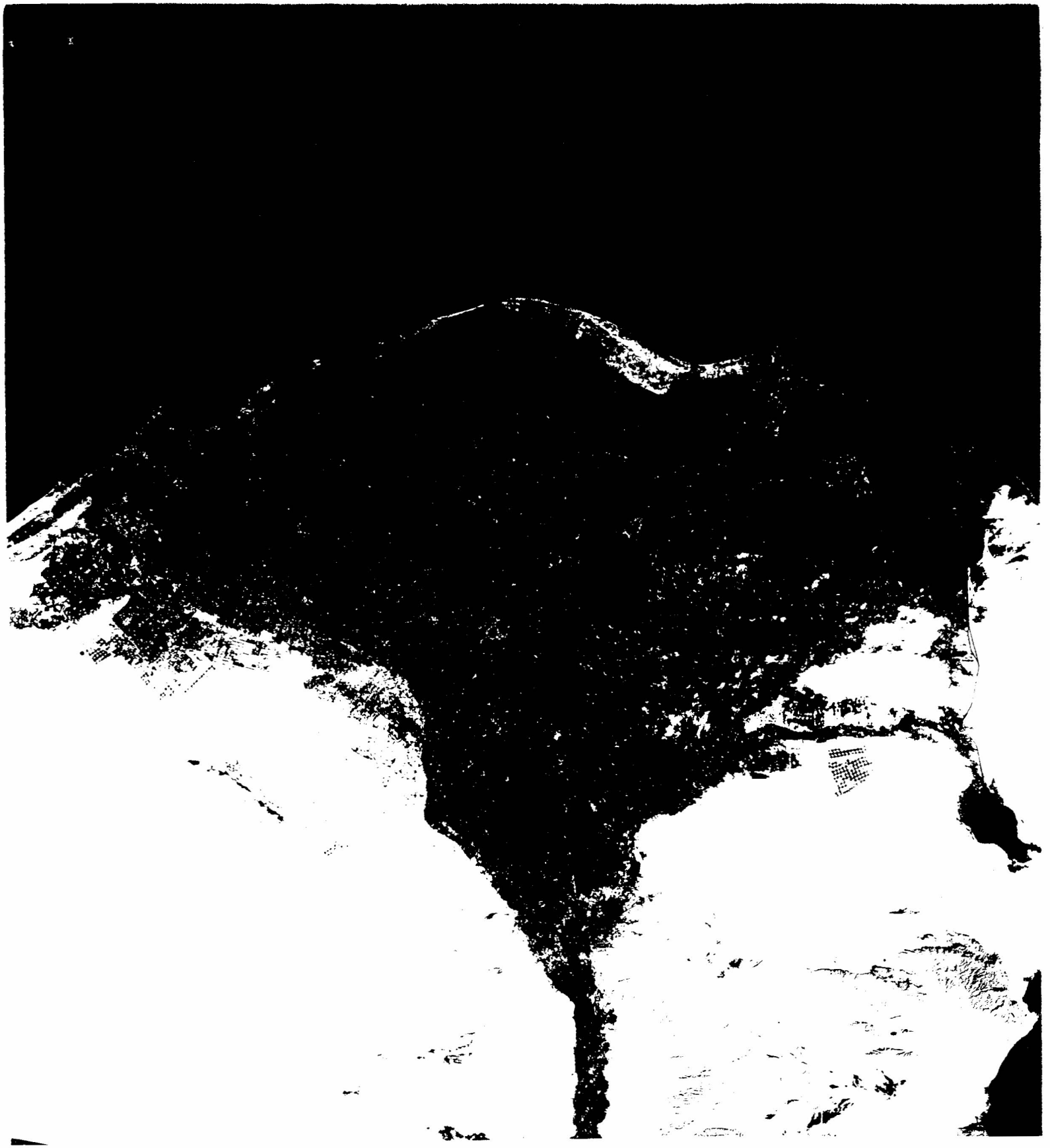


EGYPT, NILE DELTA LAND USE CHANGE ANALYSIS

Extensive land use changes in the Nile Delta region were identified from an analysis of enhanced, multi-date satellite images by Earth Satellite Corporation. A dramatic visual records the impact of population growth on land use patterns, specifically on the loss of agricultural land. It also depicts the effects of urban expansion on agriculture, desert and water, over an eighteen year period. Land classification and change analysis techniques were applied to processing a six-scene mosaic.

COLOR KEY:
From Agriculture to Urban - Yellow
From Agriculture to Desert - Dark Blue
From Desert to Urban - Magenta
From Desert to Agriculture - Light Blue
Wet to Dry & Dry to Wet - Green

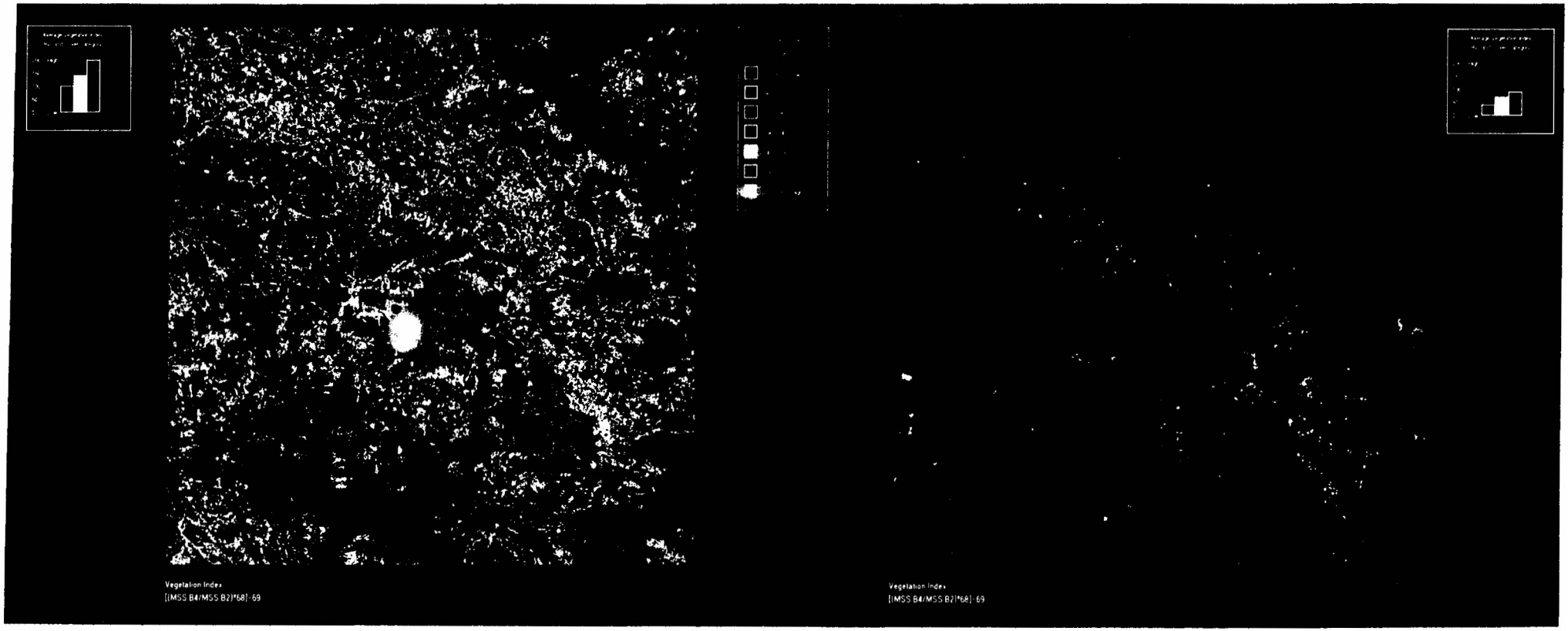
IMAGE: This image is a six-scene mosaic which presents land use information recorded during two time periods; 1972 and 1990. Changes in land use are shown in color.



POLAND, ENVIRONMENTAL MONITORING OF THE SILESIA REGION

In an effort to study the effects of airborne pollutants on vegetation in the Silesia Region, Earth Satellite Corporation processed and analyzed Landsat TM and MSS imagery. This small, heavily industrialized region produces 98% of Poland's coal which, when burned and combined with water, produces acid rain. The effects of this and other airborne pollutants are especially evident in Poland's forests. Over one-half of Poland's forests are dead or dying. Earth Satellite Corporation developed vegetation indices which show a decline in biomass and vegetation vigor in forested areas. Land use/land cover and change images also show a high correlation between declining biomass and proximity to industrial areas. Analytical results of this study were presented in a SPANS-Geographical Information System (GIS) format.

IMAGE: These vegetation indices show the dramatic result of airborne pollutants on land cover. The left image depicts conditions in 1981. The brighter colors reflect healthier biomass and vegetation vigor. The image on right is predominantly blue, which shows the decline in biomass and vegetation vigor eight years later.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[(MSS B4/MSS B2)*68]-69
Vegetation Index
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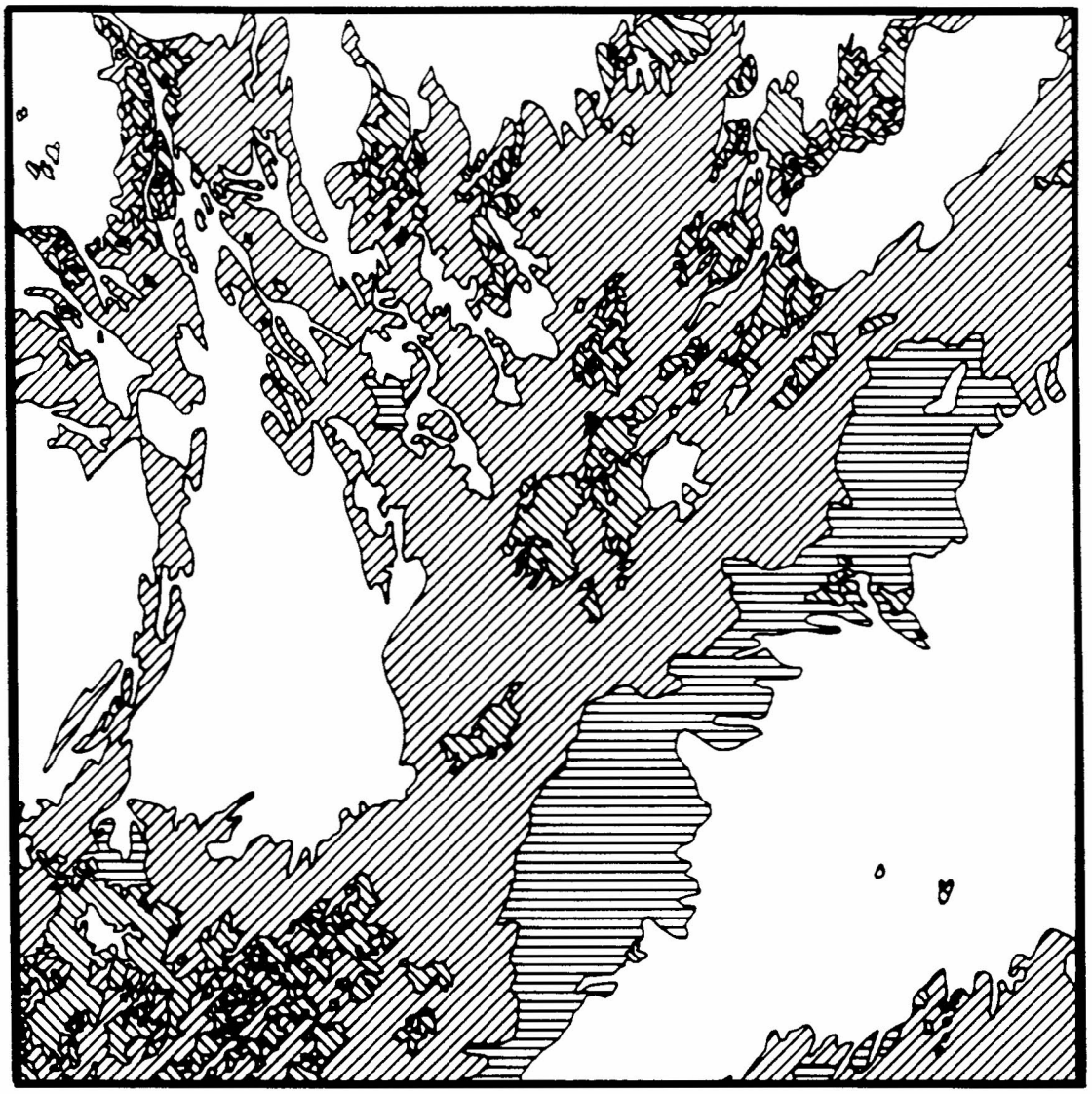
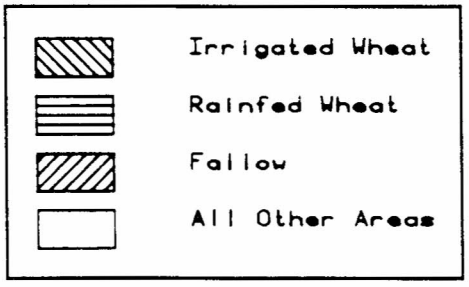
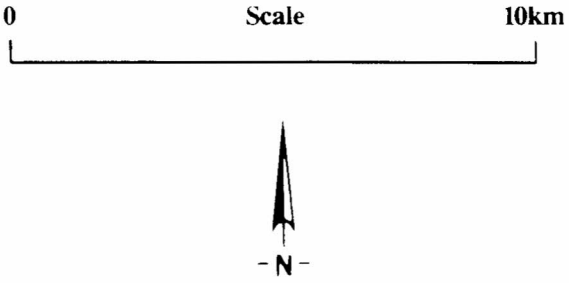
EXISTING AGRICULTURAL INVENTORY

MOQUR, AFGHANISTAN



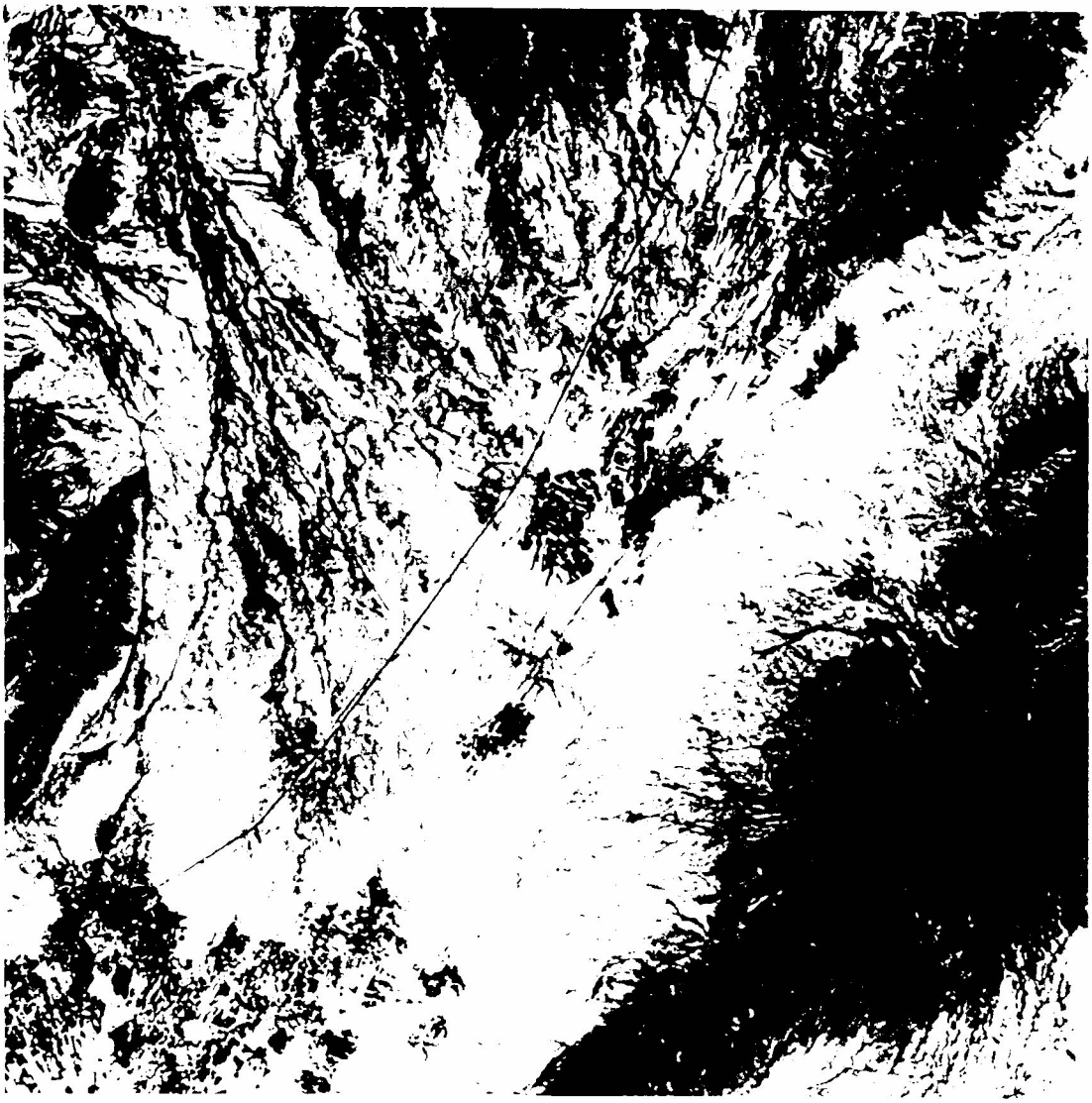




Agricutural Inventory created from current Landsat Thematic Mapper satellite imagery for National Food Production Planning.

EarthSat

GIS ARC/INFO FILE



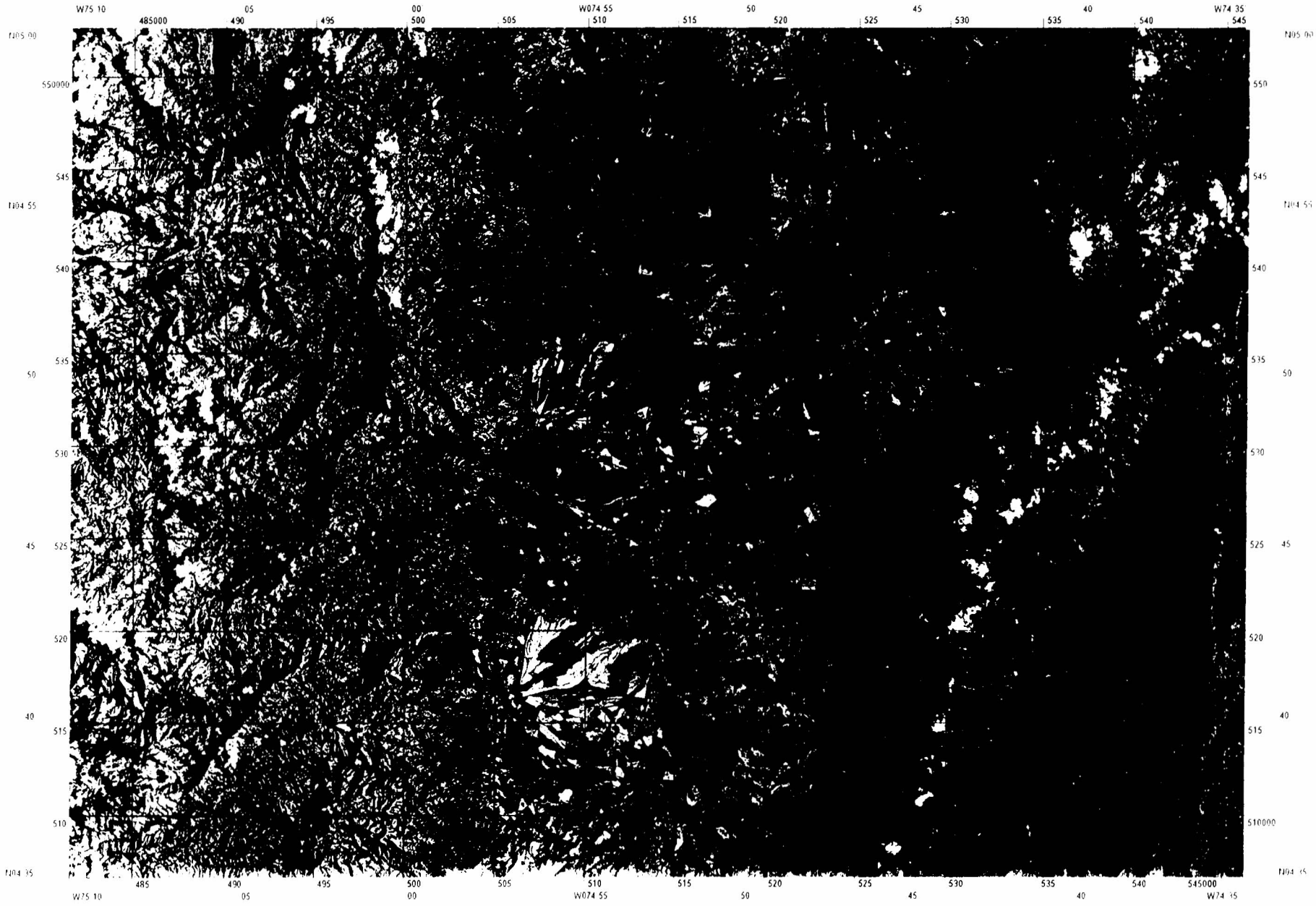
COLOMBIA, INSTITUTO GEOGRAFICO AGUSTIN CODAZZI (I.G.A.C.)

Successful applications of remote sensing and GIS technology require well-trained local scientists. The I.G.A.C., in an effort to strengthen its remote sensing program, has retained the experience and expertise of Earth Satellite Corporation. EarthSat scientists are providing training and technical assistance for post-Masters level scientists in Colombia. The project has three major components: 1. University training of ten Colombian scientists. 2. Procurement of state-of-the-art digital remote sensing and GIS hardware and software. 3. Implementation of pilot GIS project in the Department of Tolima, Colombia, which is currently being used in a landmark project for its level of sophistication and funding.

IMAGE: Landsat TM data was processed as a TruVu Map and was digitally enhanced for easy incorporation into a Geographical Information System (GIS) database.

LIBANO

COLOMBIA 1: 100,000



INFORMACION DE LA IMAGEN

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Proyeccion UTM Zona 18
Esferoide Nuevo Internacional 1967

Escala 1: 100 000

INSTITUTO GEOGRAFICO AGUSTIN CODAZZI

UTM Grid North

MAPA DE LOCALIZACION

Preparado por Earth Satellite Corporation

Mapping

Map requirements vary widely. It would be an error to conclude that developed countries are well mapped and that developing countries are not. It depends upon the requirements of the users, and not some theoretical definitions of scales and accuracies, themes and presentations. Many map user requirements can be met by Earth satellite data, or a combination of satellite data and existing maps. Standard 1:24,000 scale USGS topographic maps of the southeastern U.S. updated in the last 10 years may be useless to a public utility which needs current information on land use, urban and rural development, and the location of new roads. EarthSat is producing such updated maps from 10 meter SPOT panchromatic data at a cost to our commercial customers of $500/map. The update is produced in 2 weeks and relies on the existing USGS map for geodetic accuracy. An update by the government would take 3 to 5 years and cost about $10,000. In many respects, it would be a better product, perhaps better beyond the needs of a particular user. In one respect, it would be a poorer product; it would be 3 years out of date by the time it was released. A nation may be mapped in days with satellite data as was done during Desert Shield or in weeks as we are currently doing for the government of Afghanistan. For the FAO, EarthSat is producing a national map series from Landsat TM data; 83 image maps at a scale of 1:100,000 covering the entire country will be produced in 5 weeks. These maps will be lithographed at 1:250,000 scale for wide distribution. The cost of this national map series will be less than $2,000/map. Lithographed copies will cost less than $3.00. The maps will be used for damage assessment, redevelopment planning, and agricultural development. These are just two examples of the dozens of different kinds of satellite-derived maps being used by public and private organizations in the U.S. and abroad. While these image maps are not an adequate substitute for medium to large scale topographic maps, they service many purposes well, can be produced instantaneously, can be directly imported into computer data bases, and are very cheap.

Resource Exploration

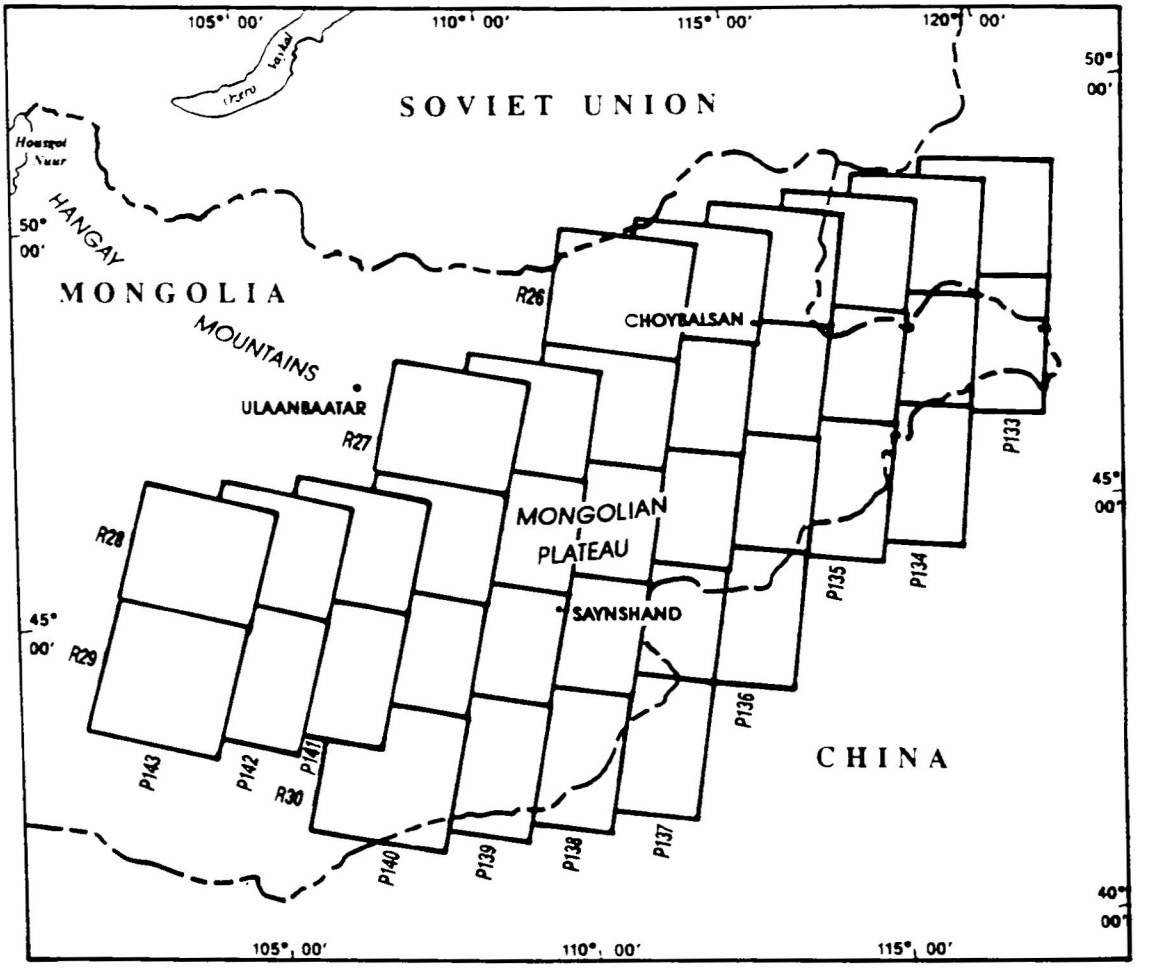
Of all the commercial applications of Landsat data, resource exploration is probably the best known, most widely discussed, and least understood. The perception that satellite data alone can locate minerals, hydrocarbons, ground water or arable soils is at best an over

simplification. Satellite data are powerful and valuable tools serving a growing community of users in what has recently become a rapidly expanding world. Political developments in the Eastern Bloc have highlighted one of the great values of satellite data; the ability to provide extensive information on large areas quickly and inexpensively. Regional resource exploration in the Soviet Union and China has relied heavily on Landsat data for geologic mapping, regional tectonic analysis, and exploration planning. While satellite data represent a very small percentage of the information the explorationist must consider before purchasing mineral rights or drilling a hole, they may represent the most cost-effective exploration expenditures. The following are two examples of recent hydrocarbon studies completed by EarthSat, and one about to be initiated. The economics speak for themselves. Figure 1 is an example of one of these studies.

Mongolia, Figure 1 (completed, June 1991). Opportunities for western investment in Mongolia are most recent. This geologic study, which covered an area of 245,000 square miles, relied heavily on Landsat data. It was completed in 6 months. Clients for this non-exclusive study received a detailed technical report, satellite imagery, geologic interpretative overlays, a detailed bibliography, and supporting geologic data. The information presented is the first of its kind for this distant, inaccessible and resource rich country. Soviet geologic data for the country are sparse, of questionable quality, and in Russian. The cost of this study to subscribers is $45,000. If the participants were to do this study in house, their cost for the imagery alone would be $57,600.

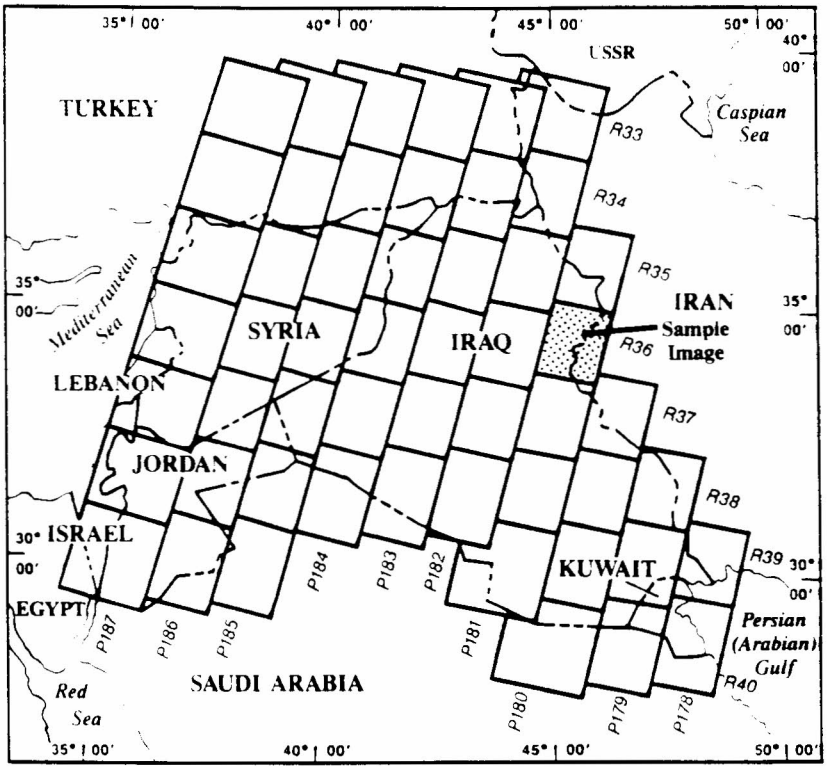
A regional geologic study such as the Mongolian study helps to focus the purchaser's attention on the most promising areas. As his focus narrows, exploration costs rise by orders of magnitude. Step 2 in the process is often a high resolution satellite study using TM or SPOT. The total cost of one of these smaller area studies to a single purchaser may be equal to or greater than the regional study; however, the total cost of satellite data and studies represents far less than 1% of the pre-drilling exploration cost. Their value is that they have eliminated 90% of the study area from further and far more costly consideration. Figure 1 shows a typical regional study. The exhibit provides examples of the products and a world map showing the location of recent projects.

Northern Arabian Platform, Figure 2 (completed in 9 months on July 15, 1990). The area covered was more than 650,000 square miles. Cost of the study is $55,000, though



Location map of the Gobi Foldbelt and Basins, Mongolia

Figure 1



Location map of the Northern Arabian Platform project area showing Landsat coverage.

Figure 2

recent demand has been low. The imagery, if purchased separately from EarthSat or some other unsubsidized value-added producer, would cost $84,800.

Mineral exploration. The minerals industry is a highly sophisticated and discrete user of satellite imagery. Most companies conduct studies in house and do not disclose areas of interest or techniques. EarthSat's support to these companies is in custom image processing which utilizes a variety of proprietary techniques for enhancing surface geological features, lithology and weathering. These techniques proved useful in image processing for the government during the Gulf conflict.

Water exploration. EarthSat is currently involved in water exploration using satellite and other data in southern California. This work is supported by private investors and is for the commercial sale of water. We have also been involved in water exploration for agricultural development in Africa and the Middle East. The well documented use of satellite data in ground water exploration has established this application as one of the most beneficial to society. Unfortunately, it is yet to be widely exploited.

Developing Country Use of Satellite Data

I am including in these remarks observations presented in a Landsat 7 study in which we participated in 1988[3]. Its relevance is multifold:

- o the demand for resource and environmental data in the next two decades will be greatest in the developing world

- o the civil sector, commercial and academic, will provide much of the technical assistance required to adequately exploit satellite technology

- o global environmental monitoring without local remedial programs is futile - such programs demand high resolution Earth satellite data

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[3] E. Merritt, D. Thibault, "A Study of Landsat 7 Sensor Options and Information Needs of Developing Countries, February 1988.

The exploitation of satellite data by the developing countries requires far more than the timely delivery of the appropriate data to the proper place. (Appendix A contains specific information on the requirements of the developing countries.)

Technical Constraints (These can be effectively mitigated in many instances between now and 1994 by the effective intervention of data providers, hardware manufacturers, and donors.)

- There is a gap between information needs and data. The technology to enable data purchasers to extract the required information from available data exists in some areas but not in others. The science may exist, but the methodologies for many operational information needs do not exist.

- By the mid-90's, digital satellite data will be the principal product employed in the industrial countries. Image processing and geographic information systems and the ability to effectively employ and maintain these systems must become commonplace in the developing countries if the potential of the data is to be approached.

- The need and perceived need for near real-time access to some satellite data will require the construction of additional earth receiving stations or the expanded use of satellite data relays.

- There are far too few trained scientists, technicians and support personnel in Asia, Africa and Central America to effectively exploit these data. A ten to one hundred-fold increase is required.

- There are too few demonstrations of the use of satellite data for operational programs in the developing world, and few, if any, cost-benefit studies. Without these tools, political leaders and administrators are unlikely to risk employing these technologies.

Economic Constraints

- The developing countries do not have the capital to acquire the tools required to process and analyze satellite data, and these systems will remain a low budget priority until relevant (i.e., local) cost-benefit analyses are available. Donor support is required.

- Ground receiving station construction and operation can not now be self-amortizing or supporting. Regional cooperation and donor support are required.

- Data are perceived as being too costly, or stated another way, they are under-valued. Cost comparisons to conventional methodologies can help, but unfortunately, at least in the near-term (i.e., the next 20 years), the data are too costly for many applications. Third World countries cannot on their own regularly subscribe to or purchase these data, even though we may demonstrate the value. Donor support and creative pricing may offer solutions.

- The receipt, processing, marketing and distribution of satellite data by foreign earth stations presents a number of problems. Perhaps the most important to the satellite owner/operator is that income from the sale of data must be shared with the station operator; with low access fees (i.e., less than $2.5 million per year), there is little left to invest in future satellites. Future access agreements must encourage the station operators to dramatically increase marketing and one would expect sales, so that EOSAT's income is significantly increased.

Political Constraints

- In the Third World, only governments are clients for data. The process to establish institutional use of satellite data is a slow one which must compete for scarce funds with programs which daily demonstrate that they are vital to human survival.

- Successful remote sensing programs in the developing world have tended to be in centralized planning, budgetary, or development agencies. Opposition to the gathering of sensitive resource data by these civilian super agencies is often an impediment to the centralization of remote sensing activities.

Positive Forces in the Marketplace

- Resource information needs are real, well recognized, and amenable to remote sensing solutions.

- The technology to meet data needs exists in the suite of sensors EOSAT is considering.

- Operational uses of satellite data for resource development and management exist in the developing world.

- Image analysis and geographic information systems are being purchased by Third World agencies at a steadily increasing rate. These systems require digital data.

- TM and SPOT data have created renewed interest in satellite data and suggested a large market for higher resolution data for mapping and monitoring.

- Donor organizations are showing new interest in these data.

Conclusion

Policy Issues: Landsat's 6, 7 and Beyond

The following opinions are those of a single commercial value-added user of Earth observation satellite data. EOSAT's Directory of Landsat-Related Products and Services, U.S. Edition[4] lists 120 private, public and nonprofit organizations; fewer than 10 of these offer a full range of image processing, analysis and geographic data base building services. EarthSat, founded in 1969, is one of the largest and oldest of these organizations. Our business is worldwide. As mentioned earlier, our clients are primarily commercial organizations, though as with many new-start, high technology businesses, we relied heavily on government research contracts in our formative years. Our opinions are based upon a long and positive experience in the application of remote sensing technologies to a wide variety of natural resource issues.[5]

It is our understanding that among the issues the Congress must address are the following:

1. Should the taxpayers continue to provide financial support, on the order of $100 million annually, for the Landsat program? Do the public benefits justify the expenditure?

2. What issues would be paramount in the minds of the commercial users of Landsat data should the Federal operational responsibility be changed or the Land Remote Sensing Commercialization Act of 1984 amended?

We recognize that there are many other issues, but we have focused our remarks on the most compelling.

Taxpayer Support

In 1974, EarthSat and Booz-Allen & Hamilton conducted a cost-benefit study of the ERTS program for the U.S. Department of the Interior and the Office of Management and

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[4] Directory of Landsat Related Products and Services, United States Edition, EOSAT, 1988.

[5] EarthSat, which was founded in 1969, has conducted hundreds of remote sensing surveys, produced more than 20,000 maps, and processed more than 15,000 satellite images from digital satellite data.

Budget.[6] This was a rigorous economic study. Each ERTS investigation was examined, costs analyzed and benefits calculated. A major assumption was that only continuing applications of the data (i.e., those that required repetitive coverage) qualified for inclusion in the benefits equation. Geologic exploration and periodic mapping (i.e., infrequently updated) were excluded. The conclusion of this study and of several conducted since by EarthSat and others do not show a positive benefit to cost ratio. Obviously, the decision to exclude exploration and some mapping adversely affected the results. The question today is whether the public benefits of Earth sensing technologies are catching up with the costs. They unquestionably are. This is in part a result of the following factors:

- The technology has matured; there are more users; more hardware and software; more trained scientists; and greater institutional acceptance.

- Global and local environmental monitoring require repetitive observations.

- Geographic Information Systems have an insatiable appetite for digital information on the land and seas.

Please note that we are referring to benefits and not to simple cash flow from data sales. It is highly unlikely that the civil sector will purchase enough Landsat 6 or 7 data to cover the cost of operations, marketing and future satellites. Present consumption of 20% to 25% by the private sector may grow, but without an agricultural or environmental market for repetitive coverage, this percentage will change but slowly. Government is and will continue to be the principal procurer, user and beneficiary of Earth satellite data. Use by government should accelerate more rapidly than private sector use because of the demands of environmental monitoring, and the increasing reliance of government on Geographic Information Systems.

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[6] Booz-Allen Applied Research Corporation, Earth Satellite Corporation, Earth Resources Survey, Benefit-Cost Study, November 1974.

Public funding for the Landsat program should be continued for the following reasons:

1. The civil sector is broadly based involving many large and small organizations which could neither individually or collectively support such a program, and private use continues at about 25% of the total use. The benefits to the U.S. economy of the commercial activity are substantial. Resource intelligence on remote and inaccessible regions of the world provides U.S. companies a competitive advantage over Japan and Europe. Reliance on Japanese and European remote sensing programs will most assuredly result in a decline in U.S. leadership in remote sensing and related technologies, and the skill essential to deriving the maximum benefit from satellite information. Hardware and software sales are an important component of this economic activity with sales likely exceeding both Landsat data sales and value-added services. These markets will also decline if the U.S. is unable to continue to support the Landsat program.

2. We believe the public sector benefits are compelling. Desert Shield and Desert Storm demonstrated the rapid mapping potential of Landsat and SPOT which complement existing Defense Department programs. Environmental monitoring will require increased reliance on satellite data to observe the health of the planet. Landsat is the cornerstone of the U.S. program and an essential element of any mitigation efforts. Environmental degradation is usually the result of specific human practices which must be located, identified, and observed. Low resolution satellites which may tell us the patient has a fever, are not sufficient for regulation and remediation. In the areas of global and local environmental monitoring, land satellites are essential; without a vigorous and technologically advancing land observation program, the enormous investment in EOS will be wasted.

Issues of Concern to Civilian Landsat Data Users

Recently, there has been much said and written about the future of the Landsat program. Actually, on reflection, it seems that these debates have raged since 1975 and perhaps earlier. Our concerns are several, they are simple, and they have been often voiced by the community of Landsat data users - public, private and academic. Here, I will claim to represent the vast majority of data users. These principals are embodied in the Land Remote Sensing Commercialization Act of 1984:

- Open skies as provided in the Act.

- Non-discriminatory access to data - Non-discriminatory access must apply to both price and system availability (i.e., one user must not be allowed to command full system capability to the exclusion of other users except for national security reasons).

- Continuity - Here perhaps we speak for ourselves. We favor general continuity but not a one-for-one copy of the existing system. Spectral bands may be changed so long as the general spectral regions covered by Landsat 6 are included. Slight changes and even elimination of some bands are acceptable if the users have an opportunity to comment and the decisions represent a consensus of the users. It is convenient to have similar coverage patterns from one satellite to the next, but not essential. Today's computers allow us to combine disparate data sets. When continuity and technological advancement conflict, we favor progress. If funding realities mandate that Landsat 7 be a clone of Landsat 6, we will be terribly disappointed, but we view program continuation without interruption as essential to the commercial market.

- Service - Regardless of the application, customers' needs must be met quickly, efficiently and consistently. Without service, there can be no growth.