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EARTH SATELLITE CORPORATION (EarthSat)
BEFORE THE JOINT HEARING OF THE
COMMITTEE ON SCIENCE, SPACE AND TECHNOLOGY
AND THE PERMANENT SELECT COMMITTEE ON INTELLIGENCE

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MILITARY, CIVILIAN AND COMMERCIAL APPLICATIONS OF THE LANDSAT PROGRAM

Panel III - Civilian/Commercial Applications

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 remarks 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:

- o Mapping,
- o Resource exploration, and
- o Global environmental monitoring.

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

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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.

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 2 (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-

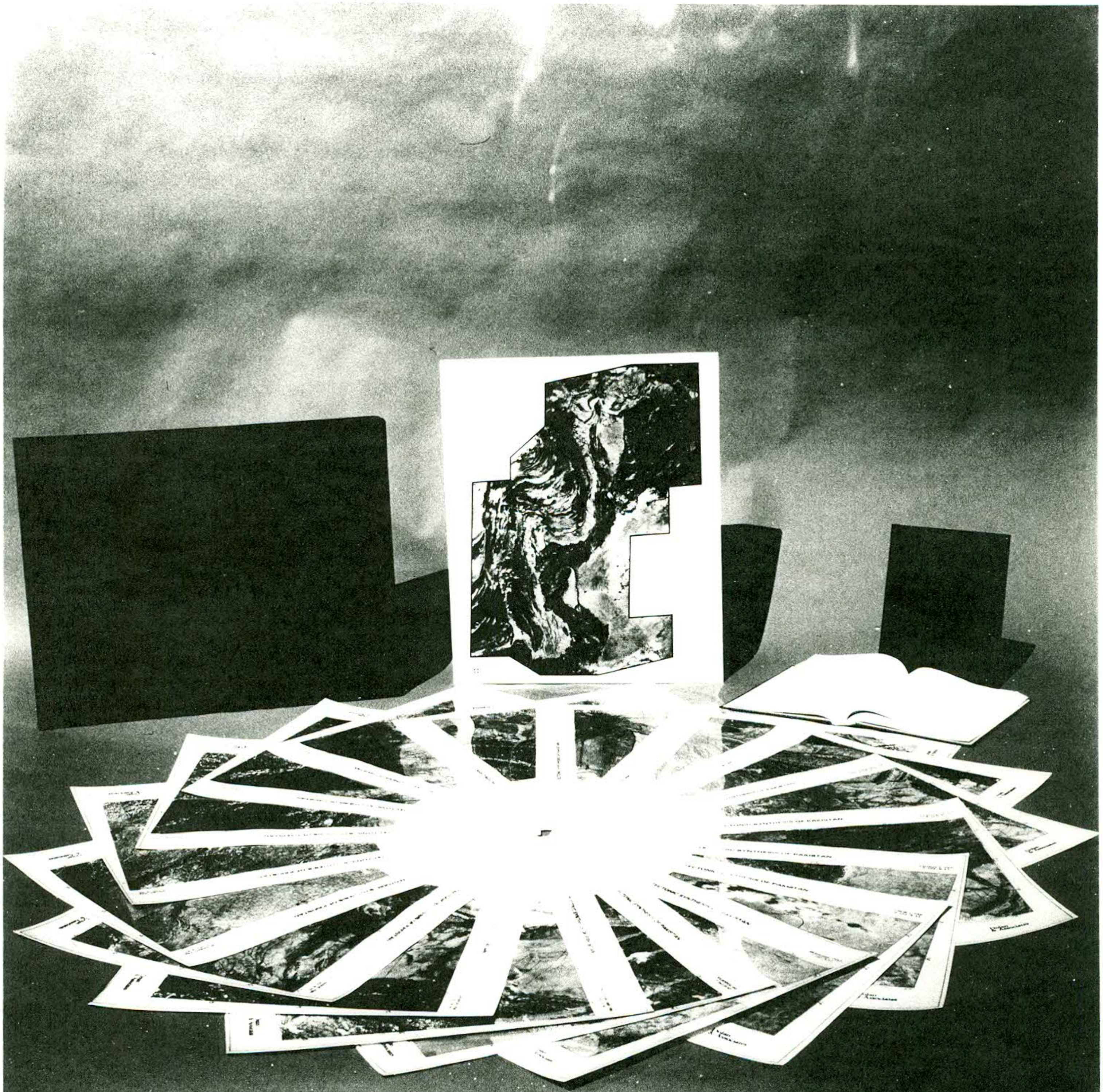
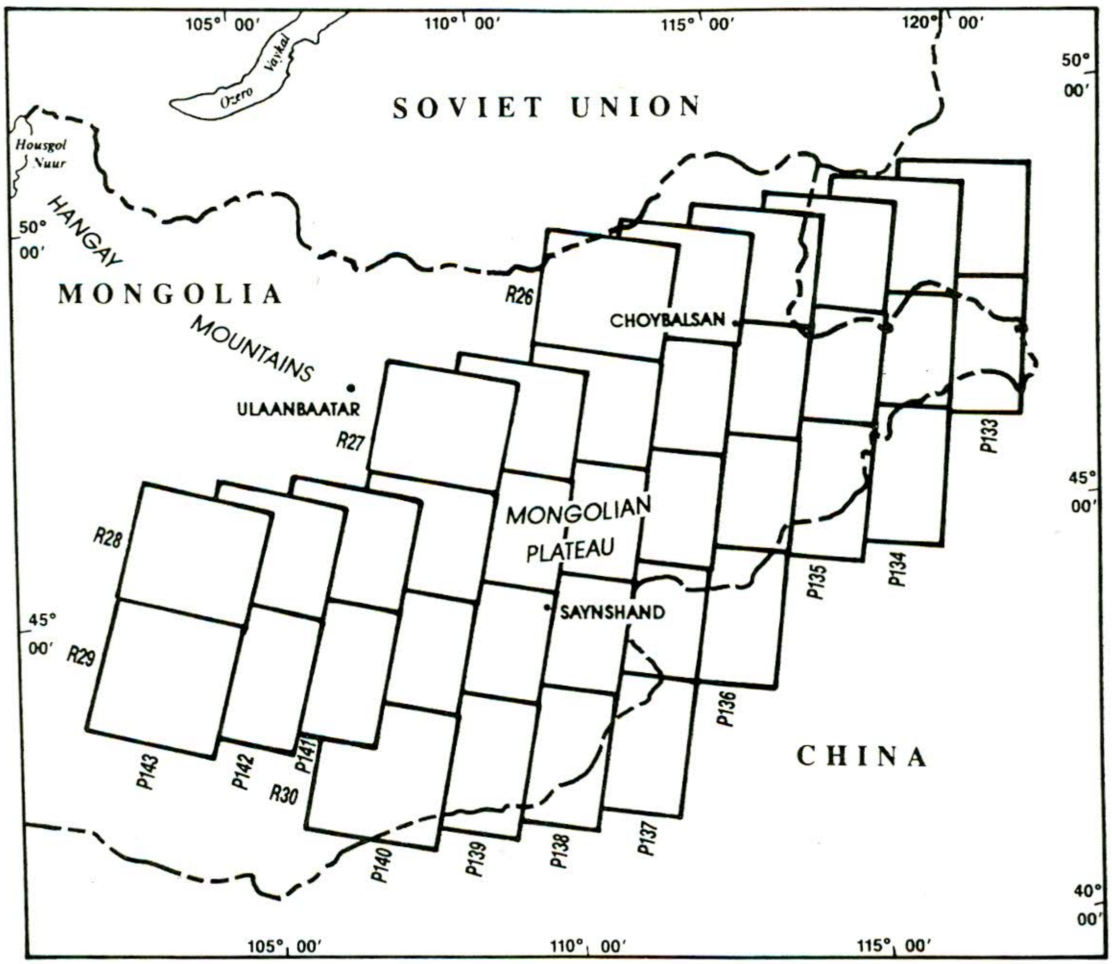


Figure 1



Location map of the Gobi Foldbelt and Basins, Mongolia

Figure 2

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.

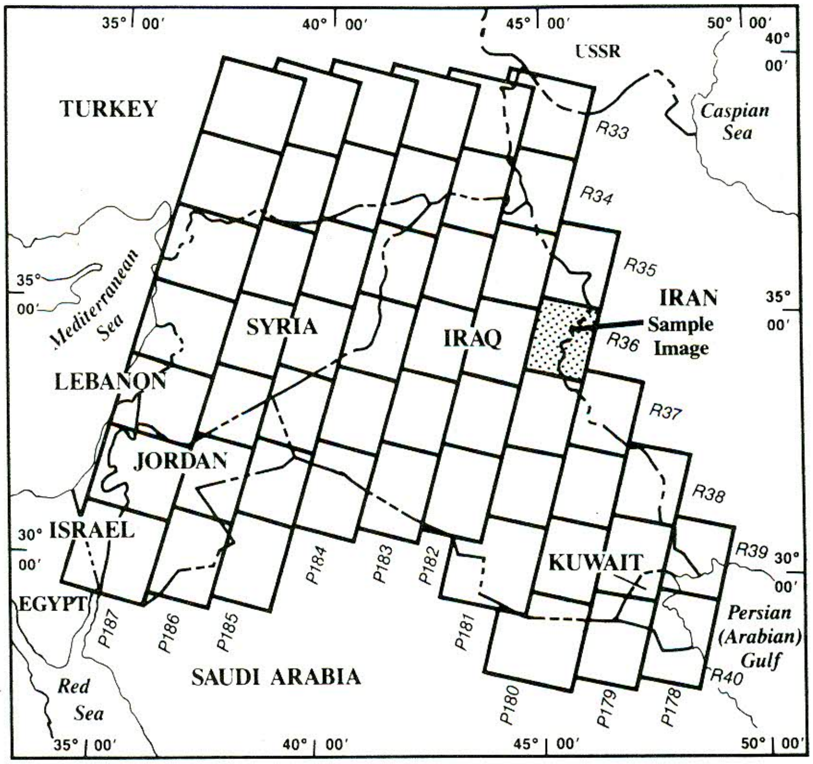
A regional geologic study such as the Mongolian study helps to focus the purchaser's attention on the most promising areas. As his focus narrows, exploration costs rise by orders of magnitude. Step 2 in the process is often a high resolution satellite study using TM or SPOT. The total cost of one of 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 2 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 3 (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 recent demand has been low. The imagery, if purchased separately from EarthSat or some other unsubsidized value-added producer, would cost $84,800.

Indochina, Figure 4 (scheduled for completion in 1991). Area covered more than 600,000 square miles at a cost to each subscriber of $67,500.

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



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

Figure 3

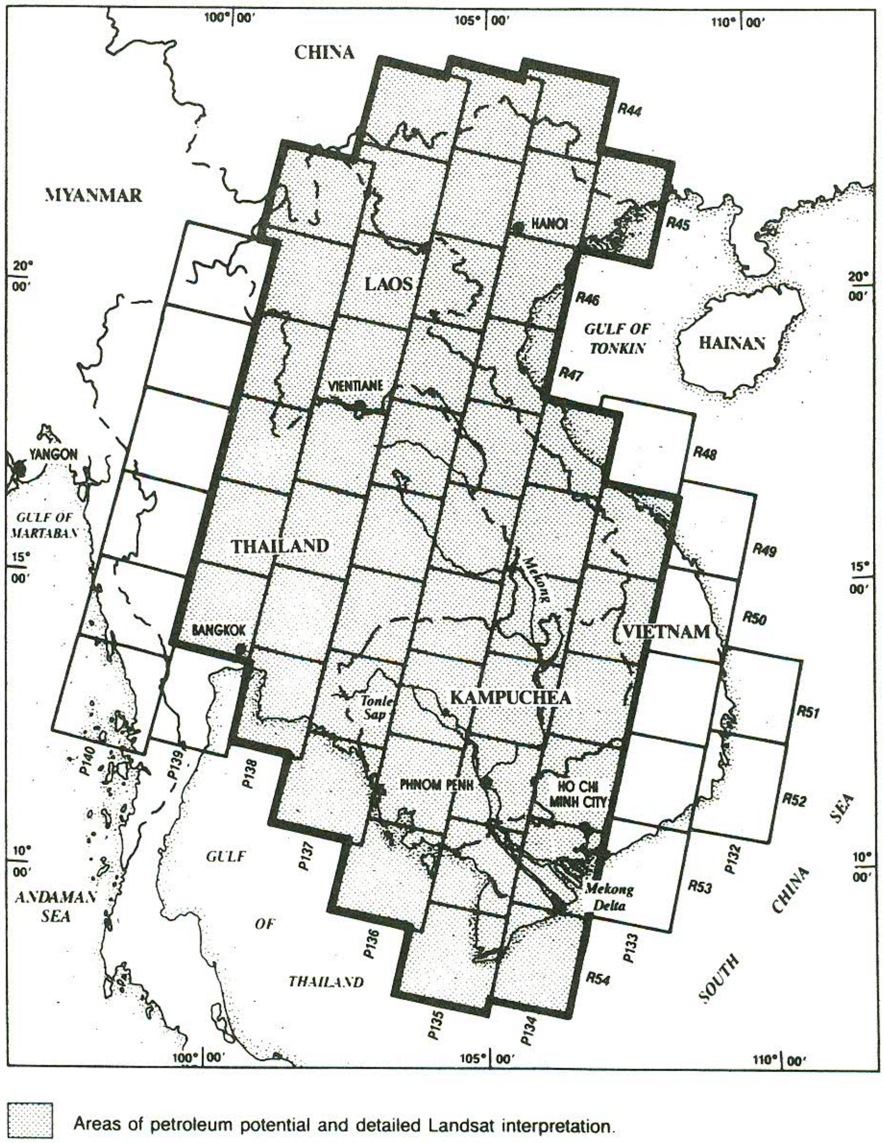


Figure 4. Indochina

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.

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.

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[2]. 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

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.)

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

- o 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.

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

- 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.

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[3] 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 those 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.[4]

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

[4] 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.

It is our understanding that among the issues which these committees and 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?

3. Which Federal agency is best suited for operational responsibility of the Landsat program assuming that it is continued?

We recognize that these and other issues may be the subject of more extensive policy hearings later this year, so 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 Budget.[5] 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

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

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:

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

- o Global and local environmental monitoring require repetitive observations.

- o 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.

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 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.

- Technological progress - In many respects, Earth sensing from space is an infant technology with seemingly infinite potential. Airborne studies have shown that increased spectral resolution will contribute significantly to environmental monitoring, geological exploration, and military intelligence. Increased spatial resolution will obviously contribute to mapping, as will stereo coverage. However, it is not sufficient to fund the development of new sensors and spacecraft. Without research funding, more and different will not provide better solutions. New generations of specialized processing hardware and software will be required in our universities and research organizations or the data will be under-exploited. Industry is prepared to share in the cost of this research, but the principal burden will again fall upon government, the principal beneficiary of these programs.

Federal Responsibility

The answer as to which Federal agency is best suited to operate the Landsat program is simple. That agency or organization which steps forward with the necessary funds for the program is clearly best suited. If ever there was a popular program without an ardent suitor, it is the Landsat program. Unwanted and seemingly unloved by NASA, USGS, NOAA and most of all OMB, this program more than anything else, needs a strong advocate in the Executive Branch. To EarthSat, the largest value-added commercial user of Landsat in the world, the only thing which matters when it comes to Federal responsibility is strict adherence to the principles which we have discussed above: open skies, non-discriminatory access, service, and technological progress.

Thank you.

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APPENDIX A

DEVELOPING COUNTRY INFORMATION NEEDS

DEVELOPING COUNTRY INFORMATION NEEDS

The information requirements of the developing countries may vary in form or emphasis, but basic needs are common.

- The principal need in the developing countries is for information which will support the production of food and fiber. This demand includes information on natural resources, soils, water, vegetation, climate; and on culture, infrastructure, population and growth.
- Information on current food and fiber production, and near-term forecasts, are essential if nations are to avoid the impact of catastrophic shortages.
- There is an increasing recognition by Third World countries that critical biological resources are threatened by uncontrolled development and that the long-term consequences of this process may irreversibly impact both the local and world environment. Understanding and managing these resources requires regular information on their extent and condition.
- Effective development planning requires basic maps of the physical environment, including planimetric base maps, current and potential land use, demography, current and planned infrastructure.

Satellite remote sensing can significantly contribute to meeting each of these needs, though it is a tool which must be used in conjunction with conventional survey and data collection techniques. While remote sensing is not a panacea, in the developing world where resource data are scarce and time and funding constraints severe, it is widely acknowledged as a valuable tool for filling the information gap. The following are the principal information requirements related to agriculture, natural resources and the environment which the investigators found in their discussions with local officials and donor organizations:

(1) **Geology and Soils**

- Basic geologic and geomorphic maps
- Soils maps
- Soil erosion and monitoring
- Desertification

(2) **Hydrology and Geohydrology**

- Maps of surface and ground water and aquifer recharge zones
- Ground water exploration maps
- Floodplains maps
- Drainage maps
- The current state of water resources

(3) **Agriculture and Livestock**

- Climatology and historical weather data
- Current soil moisture
- Timely weather reports and forecasts
- Timely information on moisture stress, disease, insect and other threats to current crops
- Frequent, regular, accurate and timely crop estimates
- Early warning assessments
- Range forage production and grazing capacity
- The current state grazing lands and trends

(4) **Forests and Woodlots**

- Historical distribution and species maps
- The current extent of wood resources
- The location, extent and rate of deforestation

(5) **Ecology**

- Vegetation maps
- Habitat maps
- Maps of fragile and threatened biological communities
- Periodic documentation and analysis of change

(6) **Land Planning**

- Historical demographic maps
- Current land cover maps
- Land potential map
- Periodic documentation and analysis of change
- Topographic maps
- Disaster information

2.1 Basic Resource Mapping and Assessment

Table 1 summarizes the information needs of the developing countries. The importance of each and the parameters of the information elements varies from region-to-region and country-to-country. Fortunately, for those who are or would be experts, man's knowledge of complex problems cannot be presented in a single chart or table nor can multivariate choices be reduced to simple yes or no answers. Table 1 is intended to provide unconditioned, highly qualitative judgements on information needs. The table does not distinguish those needs based on management objectives, environmental differences, or natural, human and fiscal constraints. Its utility is that it provides in a single place a framework which enumerates issues that must be considered in developing programs to meet resource information needs.

TABLE 1

	PERIOD						PRIORITY			MAPPING SCALE			SENSOR CHOICES [4]				
Information Elements and Sub Elements	Daily	Weekly	Monthly	Semi Annually	Annually	Single Survey [1]	1st	2nd	3rd	1:250 K to 1:1 million	1:50 K to 1:250 K [2]	1:25 K to 1:50 K [3]	ETM/TIR/WIFS	STAR	TOPO PAN	TOPO PAN /STAR	TOPO Multispectral
GEOLOGY AND SOILS																	
Basic geology and geomorphic maps						X	X			X	X		3		2		1
Soils mapping						X	X				X	X	3		2		1
Soil erosion monitoring					X			X				X	3		1		2
Desertification monitoring					X			X				X	3		2		1
HYDROLOGY AND GEOHYDROLOGY																	
Maps of surface and ground-water and aquifer recharge zones						X	X	X			X	X	3		2		1
Groundwater exploration maps						X	X				X		3		2		1
Floodplains maps						X			X			X	2		1		3
Drainage maps						X		X			X		2		1		3
The current state of water resources					X			X			X	X					
AGRICULTURE AND LIVESTOCK																	
Climatological and historical weather data						X	X			X	X		NA	NA	NA	NA	NA
Current soil moisture		X					X				X	X	1		3		2
Timely weather reports and forecasts	X	X	X	X	X		X			X	X	X	1		3		2
Timely information on moisture stress, other threats to current crops		X	X				X			X	X	X	1		3		2

TABLE 1 (cont.)

Information Elements and Sub Elements	PERIOD						PRIORITY			MAPPING SCALE			SENSOR CHOICES [4]				
	Daily	Weekly	Monthly	Semi Annually	Annually	Single Survey [1]	1st	2nd	3rd	1:250 K to 1:1 million	1:50 K to 1:250 K [2]	1:25 K to 1:50 K [3]	ETM/TIR/WIFS	STAR	TOPO PAN	TOPO PAN /STAR	TOPO Multispectral
AGRICULTURE AND LIVESTOCK (cont.)																	
Frequent, regular, accurate and timely crop estimates		X					X			X	X		1		3		2
Early warning assessments		X	X				X			X	X		2		3		1
Range forage production and grazing capacity		X	X				X			X	X		1		3		2
The current state grazing lands and trends		X	X				X	X		X	X		1		3		2
FORESTS AND WOODLOTS																	
Historical distribution and species maps						X		X		X	X	X	NA	NA	NA	NA	NA
The current extent of wood resources					X			X		X	X		2		3		1
The location, extent and rate of deforestation					X		X	X		X	X		1		3		2
ECOLOGY																	
Vegetation maps					X	X	X	X		X	X	X	1		3		1
Habitat maps					X	X		X			X	X	1		3		1
Maps of fragile lands					X	X	X	X			X	X	1		3		1
Threatened biological communities					X		X	X			X	X	1		3	4	1
Periodic documentation and analysis of change					X		X	X		X	X	X	1		3		1
LAND PLANNING																	
Historical demographic maps						X		X		X	X		NA	NA	NA	NA	NA
Current land cover maps					X	X		X			X		1		3		2
Land potential maps					X	X	X					X	2		3		1
Periodic documentation and analysis of change					X	X	X	X			X		1		3		2
Topographic Maps						X	X				X	X			2		1
Disasters						X	X					X		2		1	

TABLE 1 NOTES

1 Included in the single survey column are periodic updates occurring at 5 to 10-year intervals.

2 Mapping at the larger scale (1:50,000) is by definition for selected, small, project size areas.

3 Maps at these scales would likely be produced as a development project-by-project basis.

4 All sensor packages include the Enhanced Thematic Mapper, Thermal Infrared, and Wide Field Sensors suite which is the only sensor in the Column 1 option. The next 4 column headings identify the additional sensors included in alternate missions. The rankings (i.e., 1-5) represent the author's judgment as to the relative value of the alternatives given the application (1 is the highest ranking).

APPENDIX B

EARTHSAT PROJECT LIST

Afghanistan Agricultural Sector Support Project (AASSP) GIS Technical Assistance

Afghan CROPCAST™ Wheat Forecasting

African Subsistence Crop Assessments

Argentina Buenos Aires Province AVHRR Analysis of November 1985 Flood

Argentina Estancia Mauleon Flood Analysis

Argentina Multi-Date Landsat Imagery Analysis for Mapping Vinal and its Temporal Expansion

Argentina, Laguna Yema Floodplain Analysis

Argentina Pipeline Routing

Argentina Rio Pilcomayo-Banado la Estrella Surface Hydrology Analysis

Arizona Goldwater USMC Test Range Vegetation Mapping

Arizona Navajo Partitioned Lands Resources Assessment

Assessment of Third World Remote Sensing Applications and Technology Information Needs

Bahamas Map Mosaic

Bathymetry Studies

Belize, Colombia and Jamacia Mosaics

Bolivia Agricultural Land Use Inventory

Bolivia, Chapare Region Population Estimate

Bolivia Chapare Region Land Use Program

Bolivia Eastern Lowlands Resource Survey

Bolivia Landsat Training Program (CIASER/GEOBOL)

Bolivia Program Design for the Inventory of Coca

Brazil Project RADAM

California, San Bernardino and Riverside County Land Use Inventories (Separate Projects)

California Stanislaus Region Land Use Inventory

Central America Environment and National Resources Information Centers Design

Chesapeake Bay Submerged Aquatic Vegetation (SAV) Inventories

Chile Drainage Interpretation

Chile's National Resources Inventory Programming

China Tarim Basin

China Remote Sensing and Field Surveys

Colombia and Belize Mosaics

Colombia, Ecuador, Irian Jaya and Trinidad SLAR Interpretation for Geologic Mapping

Colombia Remote Sensing and Geographic Information System (GIS) Training

Colorado, San Luis Valley Groundwater Investigation

Colorado/Utah Paradox Basin Spectral Survey

Colorado/Utah Paradox Basin Tectonic Study

Commercialization of Landsat

Costa Rica Urban Growth Analysis

Cote d' Ivoire Remote Sensing Assistance

CROPCAST™ Agricultural Crop Production Forecasting

Crop Forecasting Knowledge-Based Expert System

Delaware Land Use/Land Cover and Ten-Year Land Use Change Analysis

Delaware, New Castle County Land Use Inventory

Desert Storm Image Analysis

Desert Storm Oil Slick and Oil Fire Monitoring

Djibouti, Structural Analysis for Geothermal Well Sitings (Republic of Djibouti)

Dominica Forest Aerial Photointerpretation

Dominican Republic Agricultural Lands Suitability Study

Dominican Republic Regional Geologic Mapping

Drought Index Enhancement

Ecuador Population Growth Impact on Sustainable Development and the Environment

Effects of the Coastal Zone Management Act (CZMA) on Access to Minerals

Egypt Agriculture-Urban Change Analysis

Egypt, Nile Delta Land Use Change Analysis

Egypt, Nile Valley Disease Incidence

Egypt Ras Gharib Area Tectonic and Hydrocarbon Analysis

Egyptian Remote Sensing Training Course for Mineral Geologists

Environmental Monitoring of the Silesia Region of Poland

Evaluation of Airborne Electromagnetic Survey Instrumentation for Buried Sand and Gravel Deposits

Evaluation of Airborne Imaging Spectroradiometer (AIS)

Evaluation of Aerial Remote Sensing for Defining Critical Geologic Features Pertinent to Tunnel Location and Design

Evaluation of Economic, Environmental and Social Costs and Benefits of Future Earth Resources Satellite (ERS) Systems

Evaluation of Electrically Scanning Microwave Radiometer (ESMR) for Classification of Ground Moisture Conditions

Evaluation of Improved Spatial Resolution Landsat Data

Evaluation of Landsat-4 Data for Hydrocarbon Exploration

Evaluation of Landsat-7 Sensor Options and Information Needs of Developing Countries

Evaluation of Landsat Spectral Inputs to Crop Growth Stage Condition and Field Models

Evaluation of Simulated SPOT and Landsat TM Data for Urban and Regional Planning Applications

Evaluation of Twelve (12) Channel Airborne Multispectral Scanner

Florida Eglin Air Force Base (AFB): Landsat TM Vegetation Analysis

Florida, Kissimmee Land Use and Economic Base Study

Florida Study to Evaluate the Feasibility of Using Landsat Thematic Mapper to Inventory Wildlife Habitats Statewide

Guatemala Chixoy Watershed Land Use/Cover Analysis

Guatemala Highlands Agriculture GIS

Guatemala Tropical Forest Action Plan Land Cover Analysis

Guayana Sling Mud Sediments Analysis

Honduras Forest Timber Volume

Idaho Powerline Corridor EIS Land Use/Cover Classification

Idaho, Smelterville Land Use/Land Cover Evaluation and Change Detection

Intermediate Cloud Imagery Reconstruction for Accurate Rainfall Assessment

Iran Range Productivity Improvement Survey and Agronomic Study

Iraq Petroleum Evaluation

Ivory Coast Change Detection Analysis and GIS Project

Ivory Coast Remote Sensing Assistance - I

Ivory Coast Remote Sensing Assistance - II

Jamaica Digital Change Analysis

Japan, Kyushu/Hokkaido Lineament and Geologic Analysis

Kenya, Tectonic Study of the Lamu Basin

Kenya Water Resources AVHRR NVI Mosaics

Latin American Agricultural Analyses

Latin America/Asia Landsat Photomaps

Latin America and the Caribbean Development Strategies for Fragile Lands (DESFIL)

Louisiana, Jefferson Parish Land Use and Natural Features

Louisiana Land Use/Crop Inventory of Red River Lock and Dam System

Libya National Landsat Photomap Series

Mali Range Survey for Livestock Improvement

Manual On Uses of Remote Sensing in Development Projects

Maryland Analysis of Economic Factors Affecting Retention and Conversion of Agricultural and Forestlands

Maryland Land Use Inventory

Maryland Land Use Inventory - 5 Year Update

Mexico Yucatan Archaeological Exploration

Military Terrain Analysis Mapping

Mississippi Delta Plain Region Ecological Atlas

Mississippi River Delta National Wetland Inventory

Missouri Flood Analysis

Morocco Agricultural Planning

Morocco Petroleum Exploration

National Land Remote Sensing Data Archive Needs and Requirements

New Jersey Evaluation of Proposed Sites for Ocean Sewage Outfalls

New Jersey Land/Water Interface Mapping in Fresh Water Marshes

New Jersey Wetlands Mapping

New York Historical Aerial Photointerpretation of Industrial Park

New York Tidal Wetlands Mapping

Nigeria, Kano State CROPCAST™ Analyses and Forecasts

Nigeria Remote Sensing Training

North Carolina and Virginia Aggregate Rock Exploration (Two Projects)

North Yemen Arab Republic - Landsat Processing

NWI Map Updating Via Change Analysis

Oman Land Capabilities Analysis

Oman, Dhofar Groundwater Exploration

Oman Mountains Groundwater and Mineral Exploration

Oman Rainfall Distribution Study

Oman Soils Mapping

Oman Vegetation Change Analysis

Pakistan Indus River Vegetation Classification

Pakistan, Peshawar Region Analysis of Cultivated Land Use

Pakistan Petroleum Exploration

Pennsylvania Abandoned Mine Land (AML) Inventory

United States Urban Land Use Indicators of Environmental Quality

United States Western Overthrust Tectonic Analysis

United States Wetlands Land Cover Change Analysis

Utah Lisbon Valley Microseepage

Virginia Surface Mine and Land Use Inventory

Water Resources and Land Cover Data Management System Development

West Africa (Sahel) CROPCAST™ Analyses and Forecasts

West Africa Regional Onchocerciasis Area Planning

West Africa (Sahel) Remote Sensing Applications for Resource Management Problems

West Africa Savanna Region Land Use/Land Cover Map

Western United States Land Use/Land Cover Evaluation

Western United States Land Use/Land Cover Evaluation

West Virginia Geological Structural Interpretation

Wide Area Land Resources Assessment System (WALRAS)

Worldwide Remote Sensing and GIS Consulting Services

Wyoming Powder River Basin Tectonic Study

Zaire Land Use/Land Cover Analysis

Zambia Geologic Structure Analysis for Petroleum Exploration Promotion