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Remote Sensing Systems, Applications

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Short Introduction to Nation's Remote Sensing Units

91FE0101A Beijing HUANJING YAOGAN [REMOTE SENSING OF ENVIRONMENT] in Chinese Vol 5 No 1, Feb 90 p 81

[Text] **The Shanghai Institute of Technical Physics Under the Chinese Academy of Sciences (CAS)**

This institute is engaged in research on infrared physics and infrared optoelectronic technology, with particular emphasis on photoelectric remote sensors. The following research laboratories of this institute are involved in remote sensing research: the aerial infrared remote-sensing research lab, the space infrared remote-sensing research lab, the infrared photoelectric detector research lab, the charge-coupled-device and special photoelectric device research lab, the heat-sensitive sensor research lab, the infrared optical thin-film and transparent material research lab, and the miniature cooling technology research lab. In addition, an infrared physics research laboratory and a research office for developing new infrared detector materials have also been established. The main research activities of this institute include: interaction between infrared radiation and matter, photoelectric physics, infrared detection and tracking, infrared heat imaging devices, infrared measurement techniques for temperature and humidity, infrared alarms, and development of new materials which have potential applications in infrared detectors. The institute has developed a number of remote-sensing components, e.g., infrared detectors at different bands, which are compatible with other system components. It has also established a highly qualified remote-sensing technical team which consists of 48 senior-level and 140 middle-level research personnel.

To carry out its tasks, the institute has the following pieces of major equipment: an IP 8500 image processing system which uses a MICRO VAX-750 computer as the host, an ARIES III aerial remote-sensing magnetic tape pre-processing system which uses a PDP11/24 computer host, an optical-transfer-function measurement system, an optical spectrum calibration unit, a multi-channel analog tape drive, a digital tape drive, a solar simulator, a coelostat, an infrared scanner performance evaluation system, and a satellite-borne instrument environment test unit.

The institute has also developed a number of new systems and devices on its own, which include: the detection system for the "Feng Yun 1" (FY-1) meteorological satellite, the very-high-resolution multi-channel radiometer and satellite optical horizon, the multi-spectral scanner and high-resolution aerial scanner, the scanner for detecting forest fires, the infrared fine-resolution spectral scanner, the scanner for monitoring ocean-surface pollution, the push-broom type aerial scanner. Other contributions of the institute include: application of infrared micro spectroscopy in geological exploration, application of fine-resolution spectroscopy in an aerial remote-sensing project (a joint Sino-U.S. project) to search for metal ore in the State of Utah, application research of remote-sensing techniques at Tengchong, integrated remote-sensing study of environmental pollution in the Tianjin-Bohai region, and applications of remote-sensing techniques in geological exploration, study of geological structure of coal fields, engineering geology, hydrology, oceanography, ocean-water measurements, agriculture and forestry, detection of forest fires, and in exploration of geothermal energy sources and underground water resources. Its major achievements include the design of seven different aerial scanners with specific performance requirements, a very-high-resolution multi-channel radiometer for meteorological satellites, a satellite infrared zenith sector, and four ground-object spectrometers from the visible-light band to the infrared band; the technical performance parameters of this equipment are comparable to those of similar products developed by other countries.

Currently, the institute has been tasked to develop a practical aerial remote-sensing system, a multi-channel scanner covering the visible-light band and the infrared band, a special-purpose scanner, an imaging spectrometer, an aerial remote-sensing magnetic tape pre-processing system, a high-resolution multi-channel detection system for geostationary meteorological satellites, and a detection system for sun-synchronous meteorological satellites to measure vertical atmospheric parameters; it has also been tasked to study the application of infrared remote-sensing techniques in geological exploration and oil exploration.

(Text furnished by Shanghai Institute of Technical Physics.)

The Guangzhou Geological New-Technology Research Institute Under CAS

This institute has a remote-sensing geological research office whose primary objective is to study earth mineral resources (solid and liquid) and the environment. This office was established in 1977, and consists of five research groups: the gold resource group, the solid mineral products group, the gas and oil resource group, the environment group, and the remote-sensing theory and system group. It is staffed by 30 technical personnel (eight senior-level and nine middle-level) with strong research capabilities. It has participated in the integrated remote-sensing tests at Hami, Tengchong, Ertan, Ningwu, and Guangzhou, and has applied remote-sensing techniques in the exploration of gold, oil, and gas in Xinjiang Province, and the exploration of gold in western Guangdong Province and Hainan Province. Currently, it has undertaken 10 major projects sponsored by the National Natural Science Foundation, the National Office of Critical Programs, the Provincial Foundation, and the Lateral Development Office. Over the past 10 years, this office has accumulated a large body of optical spectrum data and remote-sensing data on China's major rock formations and mineral resources; its research accomplishments have won numerous awards, and many of its technical papers have been presented at overseas conferences and published in foreign publications.

This office is equipped with indoor and outdoor test instruments for ground-object spectral research, remote-sensing image processing instruments, microprocessors, and ground-object data banks. The H-10 and H-20 ground-object spectral radiometer developed by this office has been widely used in scientific research and production, and has been favorably received by the users.

(Text furnished by Guangzhou New-Technology Research Institute.)

The Xinjiang Geographical Research Institute Under CAS

In 1979, this institute established a remote-sensing applications research office which today has 16 (three senior-level and four middle-level) technical personnel. Its primary tasks include theoretical research of remote-sensing applications, remote-sensing survey of regional resources, and environmental research. This office has various equipment for image processing, interpretation and mapping which are used in resource exploration and environmental research; it also has a number of field spectrometers (0.4-2.5 μm) and equipment for computer image analysis and graphics. The major tasks undertaken by this office include: survey of resources in the Bosten (Bagrax) Hu region, selection of optimum frequency band for ground-object remote sensing in Xinjiang Province, aerial remote-sensing tests and mapping along the Tarim River, application of spectral data in the study of desert formation, construction of 1:1,000,000-scale land-use map of Xinjiang Province from satellite images, application of remote-sensing techniques for gold exploration in the Tuoliyiyibi Lake region of Xinjiang Province, application of filtering techniques to extract geological structure information, conducting a detailed land survey of Hejing County using SPOT images, conducting soil and resource survey along the Aksu River basin for improving land use, establishing an automated soil identification and classification system and a mapping expert system, and conducting research of optical processing techniques and theory of integrating multiple remote-sensing data.

(Text furnished by Xinjiang Geographical Research Institute.)

Domestic Airborne Remote-Sensing System, Applications in Monitoring Natural Disasters

91FE0101B Beijing HUANJING YAOGAN [REMOTE SENSING OF ENVIRONMENT] in Chinese Vol 5 No 3, Aug 90 pp 187-194 [MS received 26 Mar 90]

[Article by He Xinnian [0149 2946 1628] of the Institute of Remote Sensing Application, Chinese Academy of Sciences, Beijing; presented at the 11th Asian Conference on Remote Sensing]

[Text] **Abstract**

This article describes the current situation of natural disasters in this country, and discusses the unique features of airborne remote sensing. In particular, it briefly discusses the important role of remote sensing in disaster prevention, mitigation and rescue, as well as in assessing the damages and effects of natural disasters. It also describes the technical capabilities of China's high-altitude airborne remote sensing system and illustrates the application of this system in monitoring floods and forest fires.

I. Monitoring of Natural Disasters

Natural disaster is an unpredictable natural phenomenon which causes enormous damage to human lives and properties, and may even threaten human survival. Its development is not only dictated by the laws of nature but also strongly affected by human activities. In recent years, the explosion of world population and the uncontrolled development and exploitation of natural resources have caused further damage to the fragile ecological environment, and upset the global equilibrium of the natural cycle; as a consequence, the occurrence of disasters has intensified. Statistics show that losses to the world economy caused directly and indirectly by natural disasters have reached $85-120 billion.

China is a country that suffers considerable damage from natural disasters; in 1989, direct losses to its economy caused by natural disasters totaled 52.5 billion yuan, and indirect losses were estimated to be three to five times of that amount. Table 1 shows China's annual losses due to natural disasters estimated from statistical data.[1]

Table 1

Type of disaster	Food loss (100 million kg)	Direct loss to the economy (in 100 million yuan)		Nature of disaster
		Statistics for each category	Subtotal	
Drought	400-500	150-200		Atmospheric disaster
Flood	200	150-200		
Tidal storm	5-10	50-60	420-510	
Hail and ice	30-50	20-30		
Forest fire		50-100		
Earthquake		10-20		Earth-related disaster

Table 1 (Continued)

Type of disaster	Food loss (100 million kg)	Direct loss to the economy (in 100 million yuan)		Nature of disaster
		Statistics for each category	Subtotal	
Avalanche, mud slide	5-10	20-30		
Soil erosion	30-50	20-30	80-100	
Sand storm and desert invasion	5-10	20-30		
Secondary disaster caused by human activities		10-20		
Diseases, insects, rats, weeds	20-30	10-15	10-15	Biological disaster
Total	695-780	510-640	510-640	

Natural disaster has become one of today's most important issues because of the enormous economic losses it inflicts; disaster prevention and mitigation is now considered by every country around the world as one of the most urgent tasks. The topic of fighting against disasters and disaster prevention has had a several-thousand-year-long history, but in the past man had always been a passive victim because the natural phenomena associated with disasters were never well understood. Since the beginning of the 20th century, the development of science and technology, particularly aerospace technology, has enabled us to observe our environment from a vantage point away from earth; this new ability has revealed a series of natural phenomena never before understood by man, and for the first time it has presented us the possibility of taking active measures against natural disasters. In applying remote-sensing technology, the United States has developed the capability to accurately forecast hurricane movement by flying an airplane into the storm to pinpoint the eye of the hurricane; accurate weather forecast has been made possible by using multi-band microwave radiometers to measure the moisture content in the clouds and the vertical pressure and temperature gradients. In 1962, the U.S. Department of Agriculture began research on infrared airborne remote-sensing techniques for detecting and mapping forest fires. In 1983, the Bureau of Forestry and NASA invested $77,000 to conduct a feasibility study of a next-generation fire-detection system; from 1984 to 1985, $300,000 were invested to proceed with the preliminary design, and a total of $1.698 million has been allocated for building the new system. During the 1980's, the French Matra Co. developed a three-channel, infrared scanning fire-detection system, which has been successfully used in monitoring forest fires in the Mediterranean.

In this country, the Chinese Academy of Sciences (CAS) and Heilongjiang Province began research in the 1970's on airborne remote-sensing techniques for detecting forest fires; they developed the capability of taking photographs of the fire scenes through smoke and fog. After the big 1987 Daxing Anling fire, CAS, with the support of the State Planning Commission, developed an airborne remote-sensing system for real-time monitoring of forest fires; this system has the capability of detecting and locating the fires and transmitting images of the fire scenes in real time. From 1987 to 1989, the State Science Commission organized a test team with members from the Ministry of Water Resources, CAS, and thc State Bureau of Surveying and Cartography to conduct tests of real-time aerial monitoring and transmitting of the images of floods along the Yongding River, the Yellow River, and the Yangtze River using microwave radars and television photographic techniques. In 1978, airborne remote-sensing techniques were used to survey damages caused by caterpillars in the pine forest around the Yunnan Tengchong region; during the Seventh 5-Year Plan, wide-area remote-sensing surveys were conducted to determine the state of soil erosion around the Huangtu highlands. In recent years, numerous tests have been conducted to monitor ocean pollution in the Bohai and Huanghai area, and airborne microwave radiometers have been used to monitor ice formation in the Bohai region; these tests have provided a large amount of scientific data which are used to ensure the safety of ocean transportation and offshore oil-drilling platforms.

The above discussion shows that remote-sensing techniques have been successfully applied in this country for monitoring disasters; significant progress has also been made in methodology research, equipment development, system development, and in building a capable remote-sensing research team. Therefore, China now has the technical capability to make a substantial contribution in disaster prevention and mitigation, and in fighting against disasters.

II. The Role of Airborne Remote Sensing in Disaster Mitigation

The wide variety of natural disasters span large dimensions in both space and time. For example, disasters which occur unexpectedly such as earthquakes may last only several seconds; on the other hand, drought can last several months or years, and soil erosion and desert invasion can continue for several years or several centuries. There are many factors that affect the occurrence and development of natural disasters. At the present time, man has not been able to prevent disasters from occurring, but he is able to predict them to a certain degree; this is where remote sensing can play an important role.

Remote-sensing information includes spaceborne, airborne, and ground-based environmental information; these complementary information sources provide a multi-dimensional information network. Specifically, the widely used airborne remote-sensing technique can play an important role in mitigating natural disasters because of its versatility, mobility, high resolution, and high operating efficiency.

(1) Disaster Prevention

The occurrence and development of natural disasters obey certain laws of nature; for example, the formation and movement of hurricanes, the precursors of earthquakes, the abnormal temperature variations associated with forest fires, and the occurrence of floods and mud slides are all governed by some natural laws. By using remote-sensing techniques to collect and analyze the information on the time-space characteristics and spectral characteristics of natural disasters, it is possible to predict them to a certain degree and issue warnings accordingly. In 1975, the heavy rain brought by an intensity-4 hurricane caused two large water dams to collapse, and the resulting 10-m-high flood killed more than 100,000, destroyed more than 15 million mu of farm land, and cut off railroad transportation in the province. On the other hand, in July 1981, during the flood of the Yangtze River (along the Jingjiang section), the arrival of the river crest was accurately predicted; as a result, flooding of 600,000 mu of farm land and relocation of 400,000 people were avoided; the saving in relocation costs alone was more than 100 million yuan.

As a means of achieving the goal of disaster prevention, remote-sensing techniques can be used for engineering construction, land-use planning, and scientific exploration of natural resources. For example, in selecting construction sites for large hydroelectric and nuclear power plants, the geological stability of the soil structure must be considered; in land use, care must be taken to avoid salt accumulation and desert invasion; in developing underground resources, precautions must be taken to prevent the ground surface from sinking and the sublayers from collapsing; remote-sensing techniques can plan an active and effective role in these areas for the purpose of disaster mitigation and prevention.

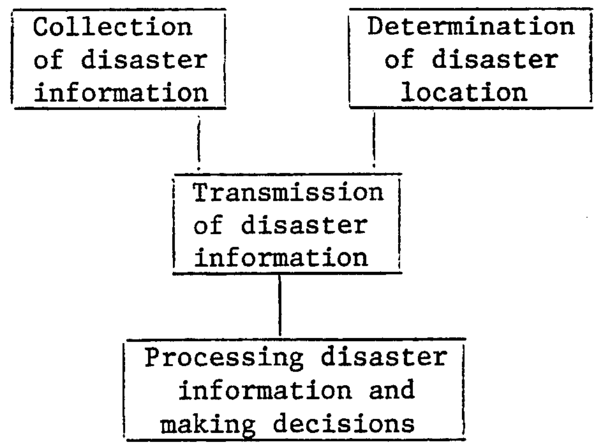

Figure 1

(2) Guarding Against Disasters

Certain types of disasters, particularly those that occur unexpectedly, are very difficult to guard against, but their effects can be greatly mitigated if the actual conditions of the disasters can be closely monitored and evaluated. Remote-sensing techniques have unique capabilities in performing real-time monitoring of natural disasters.

An airborne remote-sensing disaster-monitoring system generally consists of four main segments as shown in Figure 1.

1. Collection of Disaster Information

Table 2 lists a variety of remote sensors designed to collect different types of disaster information. These sensors cover a wide electromagnetic band including the ultraviolet band, the visible band, the laser band, the infrared band, and the microwave band. They can effectively measure the space, time and spectral characteristics of different types of disasters to provide the necessary information for disaster analysis.

Table 2

	Disaster type										
Measurement technique	Flood	Drought	Fire	Disease and insects	Atmospheric storm	Ice and snow	Mud slide	Soil erosion	Earthquake	Rats, weeds	Pollution
Color infrared picture pick-up	x	x	x	x		x	x	x	x	x	x
Television picture pick-up	x	x	x	x	x	x	x	x	x	x	x

Table 2 (Continued)

Measurement technique	Disaster type										
	Flood	Drought	Fire	Disease and insects	Atmospheric storm	Ice and snow	Mud slide	Soil erosion	Earthquake	Rats, weeds	Pollution
Multi-spectrum scanning	x	x	x	x		x			x	x	x
Microwave radar	x	x	x		x	x			x		x
Microwave radiometer	x	x				x					x
Spectrometer				x						x	x
Laser fluorimetry				x							x

2. Determination of Disaster Location

The location of disasters is very difficult to determine if it occurs in the ocean, the forest or desert, or under low-visibility conditions, because there are no landmarks for identification. To determine the disaster location accurately in these situations would require the use of advanced positioning systems such as the GPS, the LORAN-C, the XMS, the TRANSIT, the TACAN, and the GEOSTAR. Of these systems, the GPS has the greatest potential in terms of practicality and future development. It is a continuously operating global positioning system which consists of 18 active satellites and three back-up satellites in six different orbit planes. By collecting the navigation signals transmitted by the GPS and using the pseudo ranges from four of the satellites, it is possible to determine the location of the disaster area in a three-dimensional coordinate system; the real-time positioning accuracy is of the order of several meters or better.

Another type of practical positioning system is the airborne inertial navigation system (e.g., the U.S. LITTON-72); it can provide real-time latitude and longitude coordinates with a resolution of 6 seconds. Although the inertial navigation system typically has a positioning error of tens to hundreds of meters because of timing drift, it can still meet most of the requirements of disaster monitoring and location.

3. Transmission of Disaster Information

Generally, the transmitted information include pictures of disaster scenes, environmental data from remote sensors, and various data, reports, commands, and voice for disaster prevention and mitigation. The total information content transmitted can be as high as a billion bytes. There are three different modes of transmission.

(A) Real-Time Transmission

In this mode, the collected information is immediately converted into electrical signals (e.g., television signals or digital signals) and transmitted via satellite microwave relays and wired communications network to the disaster command center, or sent directly to the ground receiving station. The transmission distance depends on the earth curvature, the transmitter power, and the sensitivity of the receiver; for example, at an altitude of 7,000 m, the transmission distance is 250 km.

(B) Quasi-Real-Time Transmission

In this mode, the collected information is first recorded on a storage medium (film, magnetic tapes or disks, etc.), and then transmitted to the receiving station at the appropriate time. For example, the flood pictures collected by synthetic-aperture radar are transmitted in quasi-real time; typically, the time delay is approximately 3-5 hours.

(C) Record and Playback

In this mode, the medium containing the collected information is retrieved in the air or dropped to the ground, and then delivered by airplanes or automobiles.

4. Processing of Disaster Information and Decision-Making

The processing of disaster information consists of the following functions: data input, format conversion, mathematical operations, feature extraction, display, recording, and synthesis of multiple information and alignment; these functions are carried out using various disaster information systems, disaster models, expert systems, and command-support and decision-support systems. To achieve effective disaster mitigation requires the capabilities of high-capacity, high-speed and real-time processing, information extraction and interpretation, and map synthesis; in recent years, a number of hardware systems and parallel-processing techniques have been developed. In addition, disaster-fighting capability is further enhanced by using computer-aided decision-making techniques which make use of the disaster background data bank, the financial information system, the environmental information system, and the disaster information management system.

(3) Disaster Relief

With the support of the information systems, remote-sensing techniques can be used to collect the information for determining the magnitude and development trend of the disaster and taking the appropriate disaster-relief measures, commanding and coordinating the disaster-relief team, allocating relief materials, and planning evacuation routes for personnel and materials.

(4) Disaster Assessment

Assessing the losses to disasters is a complicated problem; remote-sensing techniques are very useful tools for obtaining scientific and objective assessment. By analyzing the remote-sensing data, it is possible to accurately determine the disaster location and estimate the damage of the disaster. In this country, the annual insurance payout for disasters totals 5.9 billion yuan, a large portion of which is due to the lack of scientific information. During the construction of the Longtan power plant, the use of remote-sensing techniques reduced the payout for flood losses by 100 million yuan. Remote-sensing techniques also play an important role in assessing the effect of disasters on the ecology and in planning the economic recovery and community reconstruction efforts after the disaster.

III. Airborne Remote-Sensing System[2-6]

Because of the unique features of airborne remote sensing, a majority of industrialized nations have developed various advanced airborne remote-sensing systems. For example, the United States has a system which uses high-altitude airplanes such as the U-2 and the SR-71 equipped with 22 different types of remote sensors and associated control and recording systems; the Soviet Union has a system which uses large airplanes such as the AN-30 and the TU-134 equipped with visible, infrared and microwave remote sensors; Australia and France have also developed airborne remote-sensing systems equipped with a variety of remote sensors.

In this country, research in remote-sensing technology began in the 1970's. During the Sixth 5-Year Plan, the development of a series of remote-sensing instruments and the application of these instruments established a solid foundation for future development. During the Seventh 5-Year Plan, strong support was provided by the state to develop a "high-altitude airborne remote-sensing system" and to carry out basic research in remote-sensing technology; the airborne remote-sensing system is an all-weather, multi-functional system which covers a wide spectrum including the ultraviolet band, the visible band, the laser band, the infrared band, and the microwave band.

The unique features of China's airborne remote-sensing system are as follows: 1) it has state-of-the-art remote sensors and system performance; 2) it is a practical system which can be used for various applications such as mapping, regional planning, resource exploration, environmental survey and disaster monitoring; 3) special efforts are made in designing the system components to achieve high reliability, interchangeability, and standardization, so that they are easy to operate and to maintain; there are also provisions for testing the hardware and software for quick diagnosis and troubleshooting; 4) the remote sensors cover a sufficiently wide spectrum to collect information on various ground objects and earth resources, as well as biological and environmental data; the system also has the capability of real-time collection, dynamic analysis, rapid processing and dissemination of information; 5) the system uses microcomputers to perform centralized monitoring and recording; by programming the computers, it is possible to perform different operations and to collect multi-band and multi-phase information to meet different requirements; 6) the system uses state-of-the-art technologies such as imaging spectrometers; laser remote sensors; and ultra-high-capacity, ultra-high-speed storage and processing units.

In short, the successful development of this airborne remote-sensing system indicates that China's remote-sensing technology has reached a new stage wherein different technologies can be united and integrated into an effective system design.

IV. Applications of the Airborne Remote-Sensing Disaster-Monitoring System

In an effort to apply airborne remote-sensing technology in disaster monitoring, two systems have been developed within a 2-year period: the real-time forest-fire-monitoring system and the flood-monitoring system.

(1) Real-Time Forest-Fire-Monitoring System

After the disastrous forest fire which took place in May 1987 in the Daxing Anling area, a real-time forest-fire-monitoring system was developed; its main capabilities are: a) real-time fire detection, b) real-time determination of fire location, c) real-time transmission of disaster information, and d) real-time information processing. Its system block diagram is shown in Figure 2.

A three-channel scanner is used for fire detection; it covers the visible band (0.4-0.7 μm) and the infrared band (3-5 μm and 8-14 μm).

The fire location information which includes the latitude, longitude of the fire region, the altitude of the airplane and time is provided by the inertial navigation system and is displayed and transmitted along with images of the fire scene.

Images of the fire scene are transmitted via television signals which are automatically tracked by the ground receiving antenna. The maximum transmission distance is 250 km; long-distance transmission can be accomplished using microwave-relay-type communications satellites.

An IBM-PC microcomputer and a high-speed image-acquisition unit, the FG-100, are used to collect the fire-scene images, and a computer program is used to determine the fire location and plot it on a map; the latitude and longitude coordinates are also printed out.

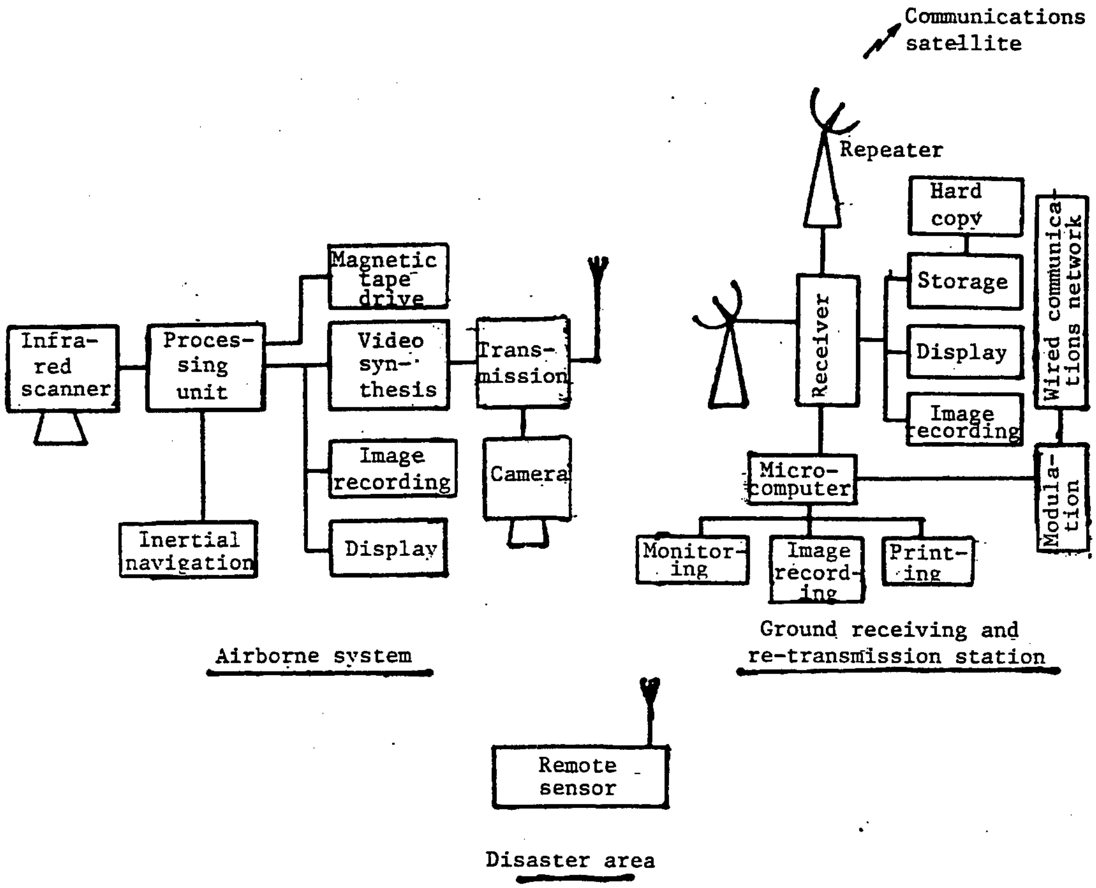

Figure 2. Airborne Remote-Sensing System for Real-Time Forest-Fire Monitoring

Test results show that this system is capable of detecting a fire several square meters in size from an altitude of 10,000 m; it has a scan width of 21 km from an altitude of 9,000 m, covering an area of 10,000 square meters per hour. Thus, the cost is only a fraction of a yuan per square meter.

(2) Flood-Monitoring System

1. Real-Time Flood-Monitoring System

The system block diagram is shown in Figure 3. It has a television camera and a true-aperture side-looking radar (K-band, resolution 20 m); the images are formed by a fiber-optic device and recorded on magnetic tapes. The signals are modulated and then transmitted to the ground via the airborne antenna system. The received signals are demodulated, recorded, and displayed; they can be re-modulated and transmitted via a microwave-relay-type communications satellite.

2. Quasi-Real-Time Flood-Monitoring System

This system uses a synthetic-aperture side-looking radar (X-band, resolution 10 m, scanning width 35 km). The coherent images collected by the receiver are first recorded on film by the onboard recorder. After the airplane has landed, the coherent images are converted by a radar-optical processor into video images and recorded on film; at the same time, they are CCD [charge-coupled device] converted into video signals which can be recorded or modulated for long-distance transmission.

The two monitoring systems have been tested at the Yongding River in 1987, at the Yellow River in 1988, and at the Jingjiang section of the Yangtze River in 1989; both systems received a citation from the National Flood-Prevention and Control Center for their outstanding test results. In August 1989, clear radar pictures of the Yangtze River flood scenes were obtained for the first time by a Chinese-built side-looking radar under nighttime and adverse weather conditions.

V. Development Trend of Airborne Remote-Sensing System and Its Potential Application in Disaster Mitigation

With the development of space technology, the design trend of modern remote sensors is toward an increasing number of bands and higher resolution. For example, the U.S.-built AIS and AVIRIS imaging spectrometers have 128 and 224 bands, respectively and a resolution of 10 m. CAS's Shanghai Institute of Technical Physics has

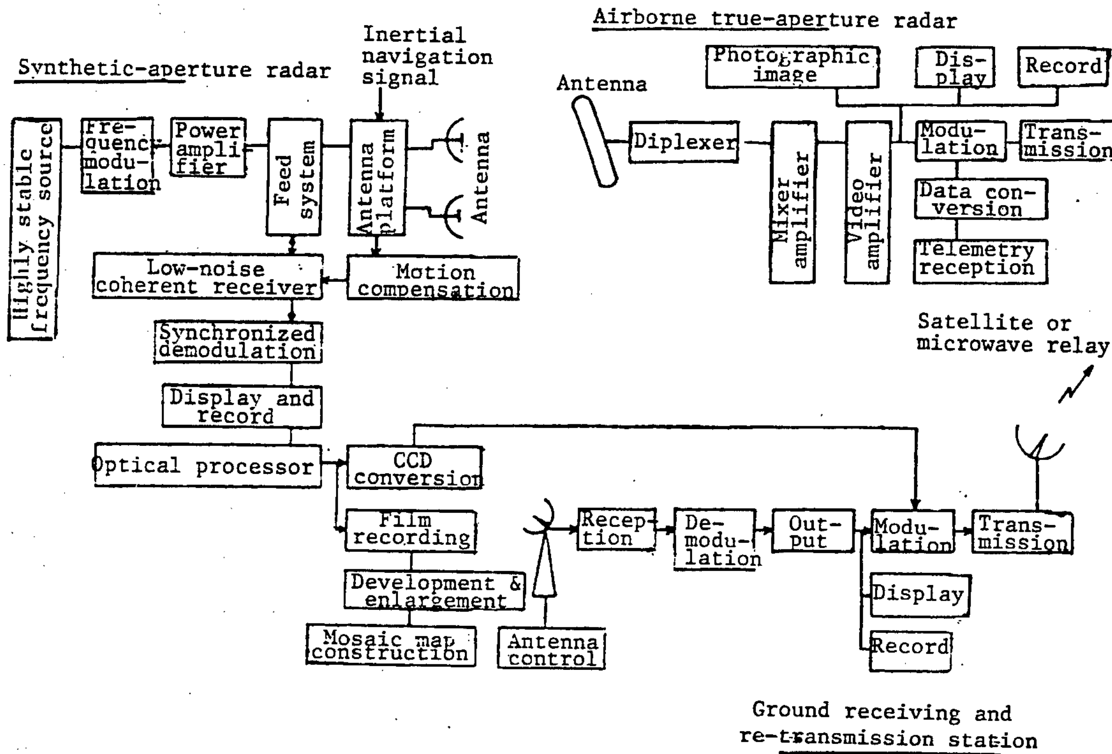

Figure 3. Airborne Remote-Sensing System for Flood Monitoring

developed a 71-band imaging spectrometer. Its potential application in resource exploration has attracted a great deal of attention from the remote-sensing community.

The larger number of bands and higher resolution result in significantly increased information capacity. For example, the information capacity of the imaging spectrometer exceeds 4 megabytes per second, or 14,000 megabytes per hour. Ultra-high-capacity, ultra-high-speed recording systems, interfaces, and processing techniques are also being developed; the conventional VHS recording system has a capacity of 5,400 megabytes, and its recording density is as high as 50,000 bits per inch. Significant progress is also being made in the development of various real-time high-speed processing techniques such as multi-channel parallel-processing and optical-digital-computer processing techniques.

The sudden surge in information capacity and the demands of real-time monitoring have stimulated rapid development of information transmission technology. The development trend of modern airplane-to-ground transmission is toward miniaturization, digitization, enhanced interference-rejection capability, narrow bandwidth and increased transmission distance. There is little doubt that this trend will also extend to transmission between airplane, satellite and ground.

The increased types of information sources in remote sensing also has accelerated the development of techniques in alignment, combination, multiple time-phase, multiple band, and multi-factor analysis, and the establishment of information systems, knowledge bases, model bases, and expert systems.

The recent development in remote-sensing technologies has further enhanced its potential application in disaster mitigation. It is suggested that during the 1990's, we should concentrate our efforts in building a multi-level remote-sensing disaster-monitoring network, establishing a national disaster center to coordinate and organize disaster-mitigation activities, promoting the research and development of national disaster-information systems and decision centers for disaster assistance, and establishing airborne rescue teams. The goal is to establish a highly mobile, highly responsive disaster-monitoring-and-rescue system with remote sensing as its core element.

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Applications of Imagery From Experimental Satellites Launched in 1985, 1986

91FE0101C Beijing HUANJING YAOGAN [REMOTE SENSING OF ENVIRONMENT] in Chinese Vol 5 No 3, Aug 90 pp 212-220 [MS received 27 Feb 90]

[Article by Fu Suxing [0265 5126 1840] of the Key State Lab for Resources and Environmental Information Systems, CAS Institute of Geography: "Study on Applications of National Satellite Imagery"; presented at the 11th Asian Conference on Remote Sensing]

[Text] **Abstract**

This article discusses the application of satellite imagery in a multi-disciplinary study of the natural resources and the environment of the Beijing-Tianjin-Tangshan region and in the study of high-level special-purpose map construction. In this study, the basic characteristics, the quality and technical indices of the images are systematically analyzed; the images are also evaluated in terms of accuracy, frequency of use, and effectiveness. In addition, a comparative study of computer image processing and optical processing was conducted to address the problem of geometric alignment of satellite images using polynomial and finite-element methods.

During the investigation of natural resources and environment of this region, the principles of remote sensing and earth science were used: 1) to analyze the hydrological subterranean elements, to classify the types of hydrological environment, and to calculate the water yield; 2) to analyze the relative proportion of non-agricultural land use versus the total land area and other types of land use, and to identify the regional differences in the types of land use; 3) to study the quantitative and qualitative characteristics and the environment of low-yield farm land; 4) to explore and study the forest resources of this country, including the ecology and site conditions of forest-compatible areas, and the ecological and economic characteristics of forest-compatible tree stocks; 5) to conduct a multi-disciplinary study of the functional division, the deposit mechanism of mineral resources, the stability of the earth's crust, the evolution of the environment over the past 10,000 years and their effects on land harnessing, urban planning and development of the tourist region centered around Beijing. Also, a series of high-level, special-purpose maps have been constructed, and estimates of various types of natural resources have been calculated. [end of abstract]

The rapid development of remote-sensing technology, particularly in the area of space-borne remote sensing, provides an opportunity to conduct in-depth study and gain better understanding of earth science. The areas of application of remote sensing have expanded from resource exploration, environmental monitoring and regional analysis to the study of global ecological systems.

In October 1985 and October 1986, two Chinese Land Satellites (China Landsats) were launched and a large number of black-and-white and color infrared pictures were taken. They provided important scientific data for studying national land-use planning, environmental clean-up and information systems for regional development.

Recently, space-borne remote technology was applied in a multi-disciplinary study of the natural resources and the environment of a region including Beijing, Tianjin, Tangshan, the Langfang district, and Qinhuangdao City from satellite imagery.

The main objectives of this study are to establish a land-use plan for the Beijing-Tianjin-Tangshan region, to evaluate the effectiveness of China Landsat imagery in various applications, and to promote research in the application of space-borne remote sensing. The key points of this study are as follows: 1) to analyze the basic characteristics of satellite imagery and the technical indices of image quality and utilization; 2) to extend the range of applications of satellite imagery in order to maximize the social and economic benefits derived from them; 3) to conduct multi-disciplinary surveys and analyses of the natural resources and the environment of this region in order to provide the scientific data for land-use planning, production management and the establishment of regional information systems.

After 3 years of hard work by the technical staff, most of the objectives of this study were achieved and significant results have been obtained. These achievements include the report "Survey of Natural Resources and the Environment of the Beijing-Tianjin-Tangshan Region" and a series of 1:500,000-scale high-level special-purpose maps (total of eight), which were published by the Science Publishing House.

I. Geometric Characteristics and Quality Analysis of China Landsat Imagery

The satellite imagery taken by China's retrievable Landsats has certain transitional characteristics. The pictures are panoramic images taken by the prism-scanning panoramic camera at an altitude of approximately 200 km. These images have a large scale and high resolution, but because of the relatively low altitude and poor attitude stability of the satellite, image distortions are quite large.

For this reason, a systematic analysis of the characteristics of the satellite imagery and the technical indices of image quality and utilization has been performed.

1. Analysis of Ground Resolution of China Landsat Imagery

The ground resolution of China Landsat imagery varies inversely with the scan angle and the altitude of the imaging platform. Theoretical calculations show that at zero scan angle, the ground resolution of the satellite imagery is 10.3 meters, but at scan angles of 55°-60°, the resolution at the edge of the imagery becomes 40-45 meters or even 50 meters. Studies show that by repeated point analyses to the center section of the first-generation photograph with the aid of a magnifying glass, it is possible to identify ground objects whose dimensions are comparable to the satellite resolution; but on a fourth-generation photograph that had been copied several times, the ground objects would be very difficult to identify. Object identification depends on the quality of film development, the generation of the photographic copy, the shape of the object and the contrast between the object and the background.

2. Analysis of the Scale of China Landsat Imagery

The scale of the panoramic imagery also varies with scan angle. At zero scan angle, which corresponds to the center section of the imagery, the scale is 1:200,000-1:220,000; at scan angles of 55°-60°, which corresponds to the edge of the imagery, the scale decreases. Scale variation has an effect on panoramic distortion, scan-position distortion, and distortion in image-displacement compensation. Scale variation in the panoramic imagery also depends on the satellite altitude. For example, at an altitude of 175 km, the scale of satellite-sub-point imagery is approximately 1:200,000; at an altitude of 200 km, the scale becomes 1:235,000. Therefore, scale variations must be taken into account when using China Landsat imagery.

3. Analysis of the Quality of China Landsat Imagery

The frame size of the China Landsat panoramic imagery is approximately 1.78 x 0.2 m^2; therefore, the image quality at the center section will differ from that at the edge because of differences in scan angle and altitude. In order to properly take this effect into account when using the imagery, a comprehensive analysis has been performed to identify a useful technical index.

By using a 1:250,000-scale terrain map as the reference, 19 ground object points were selected from China Landsat imagery of Beidagang (Beida Harbor), and a quantitative analysis was performed to determine the relationship between the scale of the imagery and the distance from the image center, and the azimuthal variation of the object points. The results are as follows: 1) the relative errors in the azimuthal angles of lines connecting the object points on the terrain map and on the satellite images are less than 2°, and the image quality is quite good; 2) an analysis of the rate of change of scale shows that at a scan angle of +/- 21°, the scale of the satellite imagery changes abruptly with the distance from the image center: below +/- 21°, the image quality is quite good; above +/- 21°, the image quality is fair; but above +/- 42°, the image becomes unusable (Figure 1).

II. Application of China Landsat Imagery in Surveys of Natural Resources and the Environment and in Map Construction

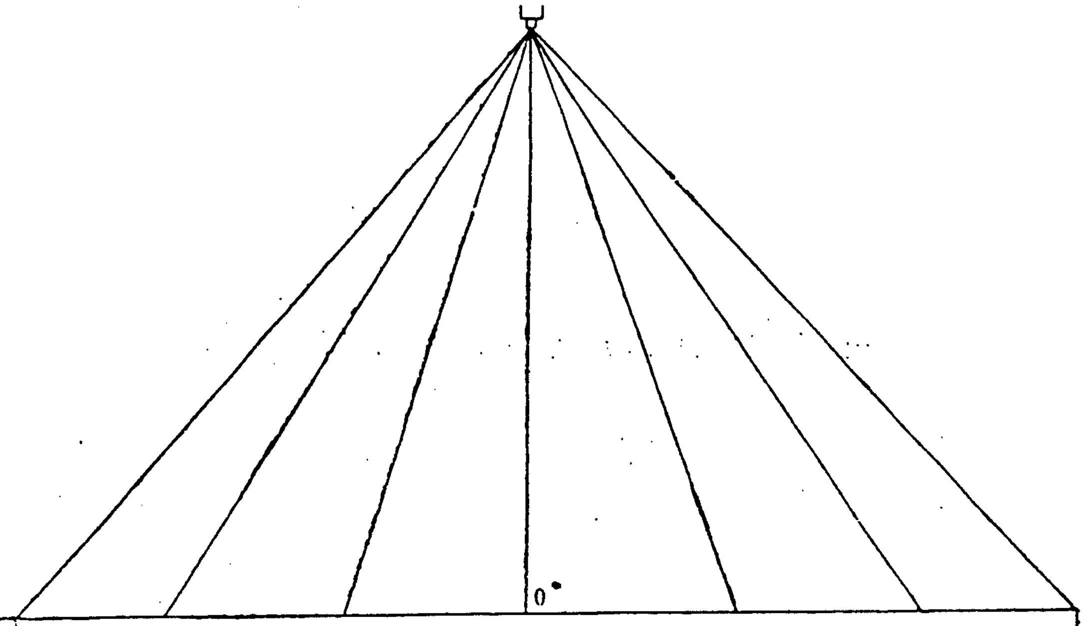
The analysis of image quality provides a useful technical index for resource and environment surveys and map construction. However, it is important to apply geometric alignment and other corrections to the panoramic imagery taken from a satellite whose attitude may be unstable in order to ensure the quality of the final product.

The main approach used in the analysis of image quality is the finite-element geometric correction method. In this approach, the spatial imagery is first pre-processed using the polynomial method or the light-beam method with auxiliary parameters in a bi-linear transformation of the rectangular element to remove large errors in the control-point data; then the image is divided into several rectangular elements based on the map coordinate system and geometric corrections are applied using the finite-element method. Test results show that this method meets the geometric accuracy requirements for 1:250,000-scale special-purpose map construction. The finite-element method is twice as accurate as the simple polynomial method.

The development of 1:250,000-scale China Landsat maps of the Beijing-Tianjin-Tangshan region provided the imagery data base for special surveys, construction of serial maps, and estimation of natural resources for this region.

In the areas of special surveys and special map construction, remote sensing is used in the following applications: 1) analysis of hydrological subterranean elements and estimate of water resources; 2) investigation of the relationship between non-agricultural land use and other types of land use, and the causal relationship of its dynamic changes; 3) study of the ecological balance of forest resources and forest-compatible land areas; 4) study of the quantitative and qualitative characteristics of degenerated land with poor soil conditions; 5) survey of resources of the tourist area centered around Beijing and partitioning of this area based on its tourist function; 6) analysis of the changes in environmental elements and study of the relationship between environmental evolution and land reform and community development; 7) analysis of multi-element data on the mechanism of mineral formation; 8) comprehensive analysis of the stability of the earth's crust in the region; 9) study of urban planning, management and clean-up of urban environment.

A brief discussion of each of the application areas is given below.



Scan angle	42°	21°		21°	42°
Film length (cm)	21	23	90	23	21
Image quality	Unusable	Fair	Good	Fair	Unusable
Applicability	Large distortions, difficult to interpret	Ground object identifiable, but map construction difficult	Special-purpose analysis and interpretation for map construction	Ground object identifiable, but map construction difficult	Large distortions, difficult to interpret

Figure 1. Quality Analysis of China Landsat Imagery

1. Analysis of the Hydrological Environment of the Region

The problem of water resources in the Beijing-Tianjin-Tangshan area is a key factor which restricts the economic development and affects the environment of the region. Therefore, it is of great importance to find an efficient and accurate approach to estimate the existing and future water resources in this region.

Current remote-sensing technology does not provide direct information for estimating water resources. However, it is possible to estimate the water yield using an indirect approach which involves using the multi-element features obtained from remote sensing, analyzing the hydrological subterranean elements, classifying the hydrological environment types, and applying the empirical formulas which contain parameters that reflect the combined features (e.g., the maximum possible loss averaged over many years).

Since the formation and run-off processes of surface water and underground water are identical for different types of hydrological environment which affect the formation, migration and accumulation of water resources, it is feasible to use the same parameters in identical element types to estimate water resources for the region.

Calculations from such an estimation process show that the total water resources in this region are approximately 13 billion cubic meters, which is in general agreement with conventional estimates. Thus, using remote-sensing techniques to analyze the elements of hydrological environment and to estimate regional water resources is a cost-effective and practical approach. The accuracy of this approach depends on knowledge about the hydrology and geology of the region, the fidelity of the empirical model, and the choice of the feature parameters.

2. Analysis of Land-Use Characteristics

The Beijing-Tianjin-Tangshan region is an area of large cities, dense population, and high concentration of towns and villages; it also has a good transportation system and well-developed industries and tourist attractions. These features of the region result in unique relationships between non-agricultural land use, agricultural land use, and total land area. The high resolution of China Landsat imagery provides the required information for obtaining more accurate estimates of different types of land use such as residential and non-agricultural land use. On the basis of the imagery data, an in-depth study of the key elements of non-agricultural land use has been performed to determine their discount coefficients, from which more accurate estimates of land use data can be derived. For example, the arable land in this region is approximately 44 million mu, which is 51 percent of the total land area; the net cultivated land is nearly 38 million mu, which is 45 percent of the total area. In addition, a series of related secondary data have also been obtained. For instance, it is found that the ratios between transportation land use, residential land use and cultivated land are 1:2.5:11.7. These data are useful for establishing a comprehensive developmental land-use plan for the region.

It is also found that a certain discrepancy exists between the estimates of cultivated land use based on the 1:250,000 special-purpose map and the statistical data provided by the regional government. Generally speaking, the estimates of cultivated land area are on the average 14 percent higher than the statistical data. Of course, the discrepancy varies with different sections of the region; for example, it is larger for counties located in the mountains than for those located on the plains. Therefore, accurate and timely determination of the discrepancy coefficients for different sections of the region and under different conditions is important in conducting an accurate inventory of land resources. Preliminary test results indicate that the discrepancy coefficients of cultivated land for different sections of the region can be obtained by a comprehensive analysis of the multi-element information over different time periods and by using typical estimates from maps and from statistical data. Clearly, this is a complicated problem which requires careful study of many factors such as the basic principles, methods, and policies used in map construction, and in conducting the surveys and statistical analyses. This information is very important for modern land management, and for urban and rural planners and policy makers.

3. Types of Low-Yield Farmland and Their Correlation Analysis

The quantitative characteristics described above can be used to study the nature and the degree of land use; however, they do not reflect the qualitative characteristics of different types of land use and the correlation between them. By using remote-sensing techniques, it is possible not only to determine the regional differences of land distribution based on quantitative characteristics, but also to analyze the geographical background, the ecological environment and the evolution trend based on qualitative characteristics.

In the case of low-yield farmland (which includes land with high saline and alkaline content, swamps, desert, eroded land and polluted land), it is possible to study the imagery characteristics and other indirect factors (e.g., terrain features, weather conditions, hydrological conditions and human activities) to determine the mechanism of land formation, migration and the evolution trend. For instance, if polluted water from urban or industrial areas were used for irrigation, it might provide partial relief to the water-shortage problem and clean up the polluted water, but it would cause secondary pollution of the soil and underground water. To address these types of problems, one can apply the principles of earth science, biology and remote-sensing analysis to provide the scientific data for improving the ecological environment of low-yield farmland.

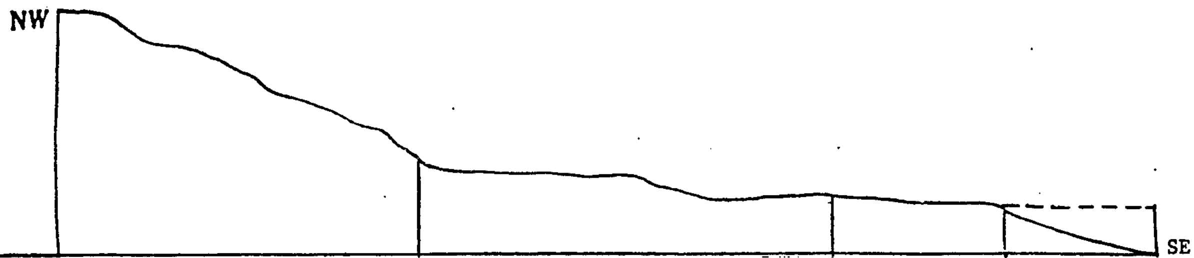
4. Survey of the Ecology of Forests and Vegetation of the Region and Study of Forest-Compatible Land

The vegetation of this region includes both natural vegetation and cultivated vegetation. Natural vegetation includes needle-leaf forests, broad-leaf forests, mixed needle-leaf and broad-leaf forests, shrubs, grassland, meadows, swamp-grown vegetation, saline-grown vegetation, sand-grown vegetation and water-grown vegetation. Cultivated vegetation includes artificially planted forests, orchards, gardens and lawns, and farm crops. Their distribution follows certain geographic patterns (Figure 2).

The ecological environment of the forest vegetation in this region has deteriorated over the years due to human activities and destruction. As a result, most of the existing forest vegetation and forest resources of this region consist of natural secondary forests and artificially planted forests. Therefore, the application of remote-sensing techniques to improve the ecological environment and site conditions of forest-compatible land will play an important role in developing future forest resources in this region.

The ecological distribution and vegetation characteristics of secondary forests in the mountain regions have clear vertical zonal patterns. For example, Chinese pine forests and mixed needle-leaf and broad-leaf forests are generally distributed in the lower-elevation hills and mid-elevation mountains. Cultivated vegetation is mostly in the plains. Meadows, swamp-grown vegetation and saline-grown vegetation are distributed in uncultivated river banks and depressions, swamps, and coastal areas. They are affected by many factors such as changes in the water table, the degree of salination, changes in river channels and human activities. The coastal region and flood region primarily contain sand-grown vegetation.

Based on estimates from the 1:250,000-scale forest resources map, the forest area in this region is approximately 600,000 hectares (not including crop land and combined forest and crop land), which is 10.83 percent



Terrain	Mountains and hills			Plains		Coastal region	Bohai
Vegetation	Mountains	Needle-leaf forest	Shrubs	Low-lying meadows	Swamp-grown vegetation		
	Meadows	Mixed needle-leaf and broad-leaf forest		Cultivated vegetation	Saline-grown vegetation	Water-grown vegetation	
		Broad-leaf forest	Grassland		Sand-grown vegetation		

Figure 2. Geographic Distribution of Vegetation in the Beijing-Tianjin-Tangshan Region

of the total area. The forest-compatible area is approximately 860,000 hectares which is more than 15 percent of the total area. Consequently, forest-compatible land is an important base for developing the future forest resources of this region.

Forest-compatible land in the mountains includes drop-leaf shrubs and grass and high-elevation meadows; they are suitable for developing temperate-zone forests. Forest-compatible land in the plains includes low-lying meadows, saline-grown and sand-grown vegetation.

The site conditions of forest-compatible land are studied by examining a number of factors such as terrain height and slope, soil thickness, moisture content and pH level; in addition, the ecological and economic characteristics of forest-compatible land are also analyzed.

On the basis of surveys and analyses of the forest resources of this region, the following observations can be made: 1) The western hills area around Zhongshan is the primary region where existing forests are found; it is an important base for rebuilding the forest vegetation, and should be the focal point of overall forest planning. 2) The forest-compatible wasteland covered by drop-leaf shrubs and grass is in the process of evolving into forests, hence should be the base for planting new trees and building forests. 3) The plains are areas where a protective forest system should be established.

5. Image Analysis of Scenic Areas and Available Resources

The formation of scenic areas in nature is a result of many special environmental factors including topography, geology, hydrology, vegetation and weather. Satellite imagery provides a new technique for studying scenic characteristics of the environment and identifying resources for developing tourism for the region. Specifically, satellite imagery provides the unique capability of constructing maps of scenic resources using earth science and graphic techniques.

This region is blessed with beautiful scenery such as mountains, rivers, open fields, beaches and lakes. Also, there are many hidden resources scattered around in the mountains, valleys, forests and rivers which can be developed for tourism; these new scenic spots can be discovered by satellite imagery.

In conducting surveys of the scenic resources for developing tourism, considerations have been given to the preservation of the administrative jurisdictions and the systematic nature of the local geography. For example, the tourist planning map of this region has been designed to cover a circular area centered around Beijing; it consists of a lateral tourist network connecting Beijing with Chengde, Qinhuangdao, and Tianjin. As the tourist resources gradually become developed, the tourist circle around Beijing will expand into an increasingly larger tourist region.

6. Analysis of Geological Characteristics and Study of the Mechanism of Mineral Deposits

The application of remote-sensing techniques in studying mineral resources involves first analyzing the imagery characteristics of the geological structures such as the earth layers, the rock characteristics, folded structures, linear structures, and ring structures. Different earth layers and different rock structures generally appear as different fringe patterns on the imagery; for instance, lattice-shaped and fan-shaped fringes represent the fourth-generation sediments; ring-shaped linear fringes represent ring structures. Mineral deposits are closely related to these geological characteristics. According to survey results, metamorphic iron deposits are correlated with the folding of metamorphic rocks; the main deposits are in compound synclinal and synclinal structures. Also, the presence of ring structures is correlated with that of metal ores; for example, in the western part of this region, where ring structures prevail, gold deposits have been discovered. Ring structures are also important indicators of iron, copper and molybdenum deposits.

7. Remote-Sensing Analysis and Assessment of the Stability of the Earth's Crust in This Region

The stability of the earth's crust is an important consideration in urban planning and development. To assess the stability of the earth's crust in this region, linear satellite images are analyzed to determine the distribution and intensity of active faults in the earth's crust, to study the correlation between the faults and past earthquakes, and to investigate the stress field that exists today.

On the basis of the deformation of the earth's crust, the slip angle of the faults, the damping effect of earthquakes, and liquification of the sandy soil, the Beijing-Tianjin-Tangshan region can be divided into the following classifications:

The Stable Region is classified by earthquake intensities less than scale-VI; it consists of the northern section and the southwest mountains of this region.

The Moderately Stable Region is classified by earthquake intensities equal to or higher than scale-VII but less than scale-VIII; it consists of the transitional foothills and plains and the alluvial fan areas of the major rivers.

The Sub-Stable Region is classified by earthquake intensities of scale-VIII; it consists of areas approximately 100 km from the epicenter of the 1976 Tangshan Earthquake.

In addition, stability analyses have also been performed for key project areas such as iron mines, railroad lines, and community construction sites.

8. Dynamic Analysis of Changes of the Natural Environmental Elements

The natural environment of this region was formed during the Cenozoic era more than 10,000 years ago. Since that time, major changes have occurred in the water/land distribution, the river and lake systems, and the forest vegetation. Within the past 2,000-3,000 years, particularly the last 400-500 years, the natural environment has suffered considerable deterioration because of human activities.

Remote-sensing imagery can be used effectively to study the natural environmental elements (e.g., the dynamic analysis of land topography and the water environment) that had been formed over the past 10,000 years because the relationships between these elements are clearly shown on the images. Specifically, they can be used to analyze and identify the time and spatial distribution, the evolution and the growth pattern of these elements.

Most of the hills in this region are distributed in the form of terraces; the plains are distributed in the form of divided strips of diluvial-alluvial inclined plains, alluvial plains and coastal plains which extend from the foothills to the seashore. Their formation is the result of the rise-and-fall movement of the earth's crust over an extended period of time.

Each type of plains which had been formed since the Cenozoic era has its unique features.

The diluvial-alluvial plain which is covered with layers of loess soil is the region of early industrial and agricultural development. The cities of Beijing and Tangshan are both located on this plain. The alluvial plain is a fan-shaped accumulation area formed by sand deposits carried by rivers of ancient times; it is a region of medium-to-low agricultural yield, and primarily affects the economic development of medium and small communities of this region. The lake-fed alluvial plain is a troubled region with numerous floods; the sea-fed alluvial plain is a region which used to be submerged under water several thousand years ago. Agricultural production and community development in these regions are quite limited. Therefore, establishing an ecological buffer zone on the alluvial plain between Beijing and Tianjin will have a far-reaching effect on regulating the resources, the environment and the population of the region.

9. Application in Urban Regional Planning

Urban planning generally consists of regional planning, overall planning and detailed planning. In order to determine at which level of planning remote-sensing techniques can be applied, a study has been conducted on the typical cities of Changping, Qinhuangdao and Tangshan.

(1) Background analysis of urban regional planning. Studies show that the China Landsats have sufficient resolution to be used for urban regional planning and for the construction of background maps; they provide the necessary information for establishing policies for urban regional planning.

(2) Dynamic analysis of urban structural variation. The structure and proportions of urban land use is changing constantly. The ability to keep up with these changes is a prerequisite to overall urban planning. For example, in the city of Qinhuangdao, changes in the commercial district, the residential district, the harbor district, the tourist district, the retirement district and the new district are clearly visible on the satellite images. By

comparing the images with terrain maps, city maps and aerial photographs, it is possible to obtain information that describes the structural and dynamic changes in the city.

(3) City layout, coordination and environmental research. The layout and coordination of a city is an important issue for the overall design of a modern city. It is also an important consideration for urban environmental research.

For the city of Qinhuangdao, one can use the 1:250,000-scale China Landsat images for the overall design of transportation stations at the harbor district, the placement of bridges and the layout of other facilities. In another example, urban environmental clean-up is a particularly important issue for Tangshan because it is an industrial base for developing coal and iron resources. As a result of the mining operations, there are many land depressions scattered around in the areas to the south and northeast of the downtown section. Some of these depressions are filled with water and others are covered with weeds and debris; they appear as blue or brown spots on the satellite images. Therefore, satellite imagery can play an active role in assessing the conditions of the depressions and re-developing them accordingly into farmland, fish ponds, construction sites, or parks. In short, the use of remote-sensing techniques for conducting a comprehensive survey of these wastelands will clearly produce significant social and economic benefits.

III. Concluding Remarks

For the first time in this country, we have used China Landsat imagery in wide-area applications research. Through comprehensive studies of multi-element information using different scientific disciplines, a series of basic maps and resource data have been generated that can be used in information systems for regional development. Test results show that panoramic China Landsat photographs have a sufficiently high degree of detail, clarity and resolution for effective use in a variety of applications such as agriculture, forestry, water and land development, mining, environment assessment, dynamic analysis, tourist resource development and urban planning.

In addition, we can make the following concluding remarks. 1) In the application of China Landsat imagery, it is necessary to have a good understanding of the geographic background and the structure of the region under study, and be well armed with knowledge in earth science. 2) The application of satellite imagery and multi-disciplinary information should be supplemented with expert knowledge bases for specialized analysis in order to broaden the scope and enhance the depth of the applications. 3) The standards of remote-sensing technology and the applications research of China's resources satellites can be enhanced by taking advantage of specialized knowledge and developing high-level, special-purpose maps and establishing regional resource and environmental information systems and data bases.

Current Status, Future Prospects for Domestic Remote-Sensing-Satellite Ground Station

91FE0101D Beijing HUANJING YAOGAN [REMOTE SENSING OF ENVIRONMENT] in Chinese Vol 5 No 3, Aug 90 pp 241-242

[Article by Wang Xinmin [3769 2450 3046] of CAS Remote-Sensing Satellite Ground Station]

[Text] **Abstract**

This article gives a description of the major components and equipment of China's remote-sensing-satellite ground station; it also discusses the recent expansion of its capabilities and system improvements, and the prospects for its future development. [end of abstract]

China's remote-sensing-satellite ground station has been part of the international Landsat operational network since December 1986. Over the past 3 years, through continuing improvement and upgrading with new technologies, it is now capable of routinely producing high-quality TM [Thematic Mapper] digital and video information and developing new products. Specifically, it has been able to satisfy the needs of domestic users for remote-sensing data by providing satellite digital and video products which cost considerably less than comparable foreign-made products.

I. Current Status of the Ground Station and Recent Enhancement of Its Capabilities

The ground station consists of three main segments: the receiving station, the digital processing lab, and the optical processing lab.

The main function of the receiving station is to acquire and track the satellite, and to receive and record the remote-sensing data. The receiving station covers 85 percent of China's landmass, but currently it can only receive data from Landsat-5. On the average, it can receive 60 MSS [Multi-Spectral Scanner] scenes and 60 TM scenes daily, or a total 120 TM scenes if nighttime receptions are included. It can also receive SPOT data as well as domestic and foreign aerospace data if equipped with the proper demodulators.

The main functions of the digital processing unit are to play back the data recorded on the high-density magnetic tapes, to synchronize the constant-amplitude formats of the branch circuits, to extract and process PCD data used for geometric correction and radiation correction, to perform the corrections, and finally to create the digital products and photographic films. This unit has the following pieces of hardware: the high-density tape drive, the format synchronizer, the processing and correction system which consists of two VAX 11/780 computers and two AP 180V array processors as well as peripheral equipment, and an independent film production system which consists of two VAX 11/750 computers and two black-and-white and color FIRE 240 scanning imagery devices. In addition, it has four sets of I^2S [International Imaging System] image analysis and processing equipment which can be used for image analysis, quality assessment, development of special products, and system quick-look. This unit has the capability of pre-processing more than 44 MSS scenes or more than four TM scenes every 12 hours. Calculations based on the international standards of 1:1,000,000-scale terrain maps show that the Chinese landmass can be covered three-five times per year using MSS geographic coded data, and once every 2-3 years using TM products. Recently, this station has added a cluster of four VAX 11/780 and VAX 11/750 computers and peripheral equipment; the four computers can share all the resources of the system to further improve its processing capability.

The optical processing lab has a facility for developing color films and photographs; it also has equipment to perform the tasks of color synthesis, enlarging and duplicating, as well as various quality-control and test equipment. The largest photograph that can be produced is 1.2 meters.

The conventional digital and imagery products of the ground station are processed frame-by-frame using the WRS [Worldwide Reference] system of Landsat. The conventional products are PS-class products with system corrections. The AA type products with radiation corrections and the PG-class products with ground-control point corrections are provided to the users as special products. In response to user requests, other special products can also be provided; they include: geographic coded products, political or terrain maps, digital enlargements, wide-area digital mosaics, cloud removal, special enhancement and stretching, high-precision multi-band synthesis, and integration of multiple sets of remote-sensing data.

Since the ground station first became operational, a series of technical improvements and capability enhancements have been implemented; they are:

(1) Hybrid digital and optical amplification;

(2) TM and MSS geometric corrections without using array processor;

(3) Development of TM products with AA line-displacement radiation corrections;

(4) High-speed precision TM processing;

(5) Wide-area digital mosaic and large-scale cloud-removal techniques;

(6) Geographic coded data;

(7) Geographic coded products divided into political or terrain maps;

(8) Photoelectric search tables of remote-sensing imagery designed for the Chinese geographic environment;

(9) Optimum optical color-synthesis technique;

(10) Special enhancement techniques for photographic products;

(11) High-quality 1:50,000 TM imagery data.

In addition, progress has been made in developing a pre-processing system for SPOT remote-sensing satellite data; production techniques for quick-look, O-class, 1A-class and 1B-class products have also been developed and are expected to be certified in the near future.

II. Near-Term Development

The ground station is a service organization which has been established to provide remote-sensing data and other products to the users. At present, this station only receives and processes TM data in accordance with user requests. Statistical records show that the number of TM scenes processed by this station is four to five times that sold or disseminated to the users. Its sales volume also ranks among the highest of all Landsat ground stations.

Currently, geographic coded products are distributed as special products; however, this capability can be readily expanded to meet increased user demands. If in the foreseeable future, the demand for large-scale or geographic coded products does not increase, and the production of conventional data can be maintained at the current level, with the only assurance that once every 2 years, the entire country would be covered using TM 1:1,000,000 international mapping standards, then it is sufficient to augment the current capability of the VAX 11/780 and the AP 180V system, so that it can be integrated into the cluster network to share all its existing software and hardware resources. Clearly, this is a low-cost and high-payoff option of near-term capability enhancement for the ground station. Similarly, the system can also be augmented to process SPOT satellite data if the need arises.

In order to ensure that China's development plan of earth resource satellites be carried out, we must develop the required capability for pre-processing satellite data. Based on the current status of this ground station, this capability can be achieved with a moderate expansion of existing facilities. Currently, this station has an operating system for processing TM/MSS data, and the capability to perform research and development of a SPOT data-processing system. It has also established from more than 3 years of operation and production experience a well-trained research and production team with excellent technical qualifications. By expanding this capability instead of building a new system it is possible not only to save more than half of the investment cost, but also to avoid many of the operational and technical problems that may rise due to lack of operational experience. Therefore, expanding the capabilities of China's remote-sensing satellites and ground stations is a low-cost, reliable and efficient way to accomplish the task of pre-processing earth-resource-satellite data.

Radar Remote-Sensing Technology Used to Monitor Yellow River Delta

91P60073 Beijing ZHONGGUO DIANZI BAO [CHINA ELECTRONICS NEWS] in Chinese 9 Dec 90 p 1

[Article by Zhu Xiaodong [2612 2556 2639]: "Remote Sensing Technology Displays Prowess in [Mapping] Yellow River Delta Area"]

[Summary] Since 1988, experts from the Beijing Kehai High-Tech Group and other institutions have been utilizing radar remote-sensing technology to carry out a fixed-term survey of the Yellow River Delta area in Shandong Province—a project which has provided much data and maps invaluable in the management and technological transformation of the region. This area contains one of the nation's 10 largest enterprises: the Shengli Oil Field, and the observation has centered around monitoring the impact on the Shengli Field of silt flows that have altered the river's channel over the past few years. This airborne radar remote-sensing technique is different from conventional airborne remote-sensing techniques in that the received signal consists of microwave radiation bouncing off the Earth, rather than photographic imagery.

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