Paper presented at the 22nd Asian Conference on Remote Sensing, 5 - 9 November 2001, Singapore.
Copyright (c) 2001 Centre for Remote Imaging, Sensing and Processing (CRISP), National University of Singapore; Singapore Institute of Surveyors and Valuers (SISV); Asian Association on Remote Sensing (AARS)

CHINA'S SATELLITE REMOTE SENSING TECHNOLOGY AND ITS APPLICATION IN 20TH CENTURY

[1]Dayao Li [1]Shaochun Cui [2]Shiju Jiao
[1]Beijing Institute of Space Machine and Electricity
No 1Nandahongmen Rd, P O Box 9210, Beijing 100076
Tel: (86)-010-68382803 Fax: (86)-010-68382807
Scui @maibo.com.cn
[2]Chinese Academy of Space Technology
31 Zhongguancun Avenue South, P O Box 2417, Beijing 100081
CHINA

KEY Words: Remote Sensing, Remote Sensor, Satellite, Application System

ABSTRACT: This paper introduces optical earth observing satellites developed and launched by China in past 30 years, and optical remote sensors boarded on these satellites that are researched and manufactured by Chinese space industries, also the satellite earth observing application systems constructed by relative Chinese agencies at the same period. Through this paper, show the great progress in satellite remote sensing field of china in the 20th century.

1. INTRODUCTION

Along with the development of Chinese space cause, the satellite remote sensing technology in China has been making progress greatly. Over last 30 years, Chinese aerospace establishments have successfully developed and launched near 50 satellites of various kinds, halves of these are earth observation satellites. By through research and development of these types of satellites, China's satellite remote sensing technology, especially satellite optical remote sensing technology has been developed from film recovery photographic type to optical-electrical transmitting type, and from visual remote sensing to visual-infrared remote sensing. This paper presents review of the progress in satellite remote sensing field of China over three aspects, i.e.. optical earth observing satellites launched by China in 20th century, space-born optical remote sensors and ground satellite application systems.

2. CHINA OPTICAL EARTH OBSERVATION SATELLITE

There are three kinds of Chinese optical earth observation satellites launched by China: recoverable remote sensing satellite, meteorological satellite and earth resource satellite. Among these, meteorological satellite was made by Shanghai Academy of Spaceflight Technology (SAST). Chinese Academy of Space Technology (CAST) made recoverable satellite and earth resource satellite.

2.1 Recoverable Remote Sensing Satellite

There are three classes of recoverable remote sensing satellites been launched by China, namely film recovery photographic satellite 0 (The code name FSW-0), film recovery photographic satellite 1 (FSW-1), and finally film recovery photographic satellite 2 (FSW-2). FSW-0 is the first generation of earth observation (territory survey) satellite, FSW-1 is the map cartography satellite, and FSW-2 is the second generation of territory survey satellite. FSW-0 was divided into two batches, i.e. FSW-0-01 and FSW-01-02.

All FSW-0, FSW-1and FSW-2 are low orbit 3-axis stabilization satellites, which are oriented to the center of earth and bear their recovery modules. Their primary orbit are 170 ~ 500 km high near-circular orbit with orbital inclination 57º~63º. All recovery modules return to the ground by ballistic reentry method. The final landing tool is parachute. The main payloads of these recoverable remote-sensing satellites are visual photography system with one film type terrain camera and one stellar camera. The sensed film is deposited in the recovery cassette, which is mounted in the recovery module and returne to the ground with it.

The terrain camera of FSW-0 is prism scanning panoramic camera. FSW-0-02 also has a CCD camera being used for testing image transmission technique. The terrain camera of FSW-1 is frame metric camera. The terrain camera of FSW-02 is node-point panoramic camera.

2.2 Meteorological Satellite

There are two classes of meteorological satellites been launched by china, i.e. FENG YUN 1 satellite (the code name FY-1)(FENG YUN = "Wind and Cloud"), the first generation of sun synchronous meteorological satellite, FENG YUN 2 satellite (the code name FY-2), the first generation of geostationary meteorological satellite. FY-1 was divided into two batches, i.e. FY-1-01 and FY-1-02.

The satellite meteorological sensor loaded at the FY-1-01 is two 5-channel (visible and IR) scanning radiators, at the FY-1-02, two 10-channel (visible and IR) scanning radiators. The attitude control methods of these two batches of FY-1 satellite are 3-axis-stablization and oriented to the earth..

FY-2 satellite adapted bi-spin stabilization methods, the satellite–borne meteorological sensor is one 3-channel (visible IR vapor) scanning radiator.

2.3 Earth Resource Satellite

The earth resource satellite launched by china are ***ziyuan*** earth resource satellite 1 (code name ZY-1)(ZY="ziyuan", means resource), and ***ziyuan*** earth resource satellite 2 (code name ZY-2). The former also named Chinese/Brazil Earth Resource Satellite 1 (CBERS-1). It is a jointly developed satellite by China and Brazil. These two kinds of earth observation satellite are all with attitude of 3-axis stabilization and orientation into the center of earth, running at low altitude sun-synchronous orbit.

Apart from the above-mentioned remote sensing satellites, Tsinghua -1satellite(the code name HTQH-1) jointly made by China Aerospace Mechanics and Electronics Corporation, Tsinghua University and Surry University. It also has the ability of optical remote sensing. The satellite can be used at communication, earth observation and science research.

The specifications and launching aspects of above satellites are presented in Table 1.

Table 1 Launching Events of China Optical Earth Observation Satellite and Its Main Specifications

Type	Code Name	Years of Launching	Total of Launched Sat	Launching Mass (kg)	Design Lifetime	Orbit Altitude (km)	Note
Recovery Remote Sensing Satellite	FSW-0-01	1974~1978	4	1800	3days	170~500	*1
	FSW-0-02	1982~1987	6	1800	5days	170~420	
	FSW-1	1987~1993	5	2100	8days	200~330	*2
	FSW-2	1992~1996	3	2600~3000	15days	170~360	
Meteorological Satellite	FY-1-01	1988, 1990	2	750	0.5~1years	901	*3
	FY-1-02	1999	1	960	2years	870	
	FY-2	1997, 2000	2	1370	3years	36000	

Earth Resource Satellite	ZY-1	1999	1	1540	2years	778	
	ZY-2	2000	1				
Micro Satellite	HTQH-1	2000	1	50			*4

*1. No1 did not into orbit *2. Last one return failure *3. Real lifetime 8months (longest)

*4. Launched by a Russian Carrier Rocket as a piggyback payload

3.CHINA'S SPACE OPTICAL REMOTE SENSOR

There are three kinds of satellite-borne optical remote sensors made by China in the 20th successfully. They are film type visible camera, transmitting type visible and infrared multi-spectral scanner and CCD camera. Multispectral scanner used on Meteorological satellite was made by Shanghai Institute of Technical Physics/CAS. Beijing Institute of Space Machine and Electricity/CAST made all other remote sensors.

3.1 Film type visible camera

The film type visual camera is main payload of recovery remote satellite. The succeeded sensors developed by China are: FSW-0 prism scanning panoramic camera, FSW-1 frame metric camera., FSW-2 node-point panoramic camera and stellar camera. The focal length and swath width of FSW-1 frame camera is to be compared favorably with American Space Shuttle's Orbiter-borne Metric Camera., the functional performance of FSW-02 node-point camera gained the rank within the level that similar foreign product should achieved., for stellar camera , the capability of star discrimination achieved high level that 6-grad star is measurable , 7-grade star is visual and 8-grad star is reflectable.

3.2 Multi-spectral scanner

Multi-spectral scanner is used at meteorological satellite and earth resource satellite. The successful units of this type scanner are: FY-1 Satellite (01 batch) Multi-spectral Scanning Radiometer, 02 batch FY-1 Satellite Multi-Spectral scanning Radiometer, FY-2 Satellite Multi-spectral Scanning Radiometer, and ZY-1 Multi-spectral Scanner. The specifications of these scanners and the performances comparison with similar foreign products listed in table 2,3,4..

Table 2. Performance Comparison of Sun-synchronous Meteorological Satellite Multi-spectral Scanner

Project	FY-1 Sat (01 batch)	FY-2 Sat (02 batch)	US NOAA 9~12 Sat	US NOAA 15 Sat
Years of Launching	1998 1990	1999	1984~1991	1998
Orbital altitude (km)	901	870	820~850	820~850
Spectral band (μm)	0.48~0.53	0.43~0.48	0.58~0.68	Same as left add 1.58~1.64μm band
	0.53~0.58	0.48~0.53	0.725~1.1	
	0.58~0.68	0.53~0.58	3.55~3.93	
	0.725~1.1	0.58~0.68	10.3~11.3	
	10.5~12.5	0.84~0.89	11.5~12.5	
	~	0.900~0.965	~	
	~	1.58~1.64	~~	

		3.55~3.95	~	
		10.3~11.3		
		11.5~12.5		
Sub-satellite point pixel resolution (km)	1.1	1.1	1.1	1.1
Swatch width (km)	3200	3100	3000	3000

Table 3. Performance Comparison of Geostationary Meteorological Satellite Multi-spectral Scanner

Project	FY-2 Sat	Japan GMS 5	US GEOS 8~10
Years of Launching	1997 2000	1995	1994~1998
Spectral band (μm)	0.5~1.05 6.3~7.6 10.5~12.5	0.55~0.90 6.5~7.0 10.5~11.5 11.5~12.5	Visible bands ~3.7 ~6.7 ~10.7 ~12.0
Sub-satellite point pixel resolution (km)	1.25(visible band) 5(other band)	1.25(visible band) 5(other band)	1(visible band) 8(6.7μmband) 4(other band)

Table 4 Performance Comparison of Sun-synchronous Earth Resource Satellite Multispectral Scanner

Project	ZY-1 Sat	US LandSat 4/5 TM	US LandSat 7 ETM$^+$
Years of launching	1999	1983 1984	1999
Orbit altitude (km)	778	705	705
Spectral band (μm)	0.50~0.90 1.55~1.75 2.08~2.35 10.4~12.5	0.45~0.52 0.52~0.60 0.60~0.69 0.76~0.90 1.55~1.75 2.08~2.35 10.4~12.5	0.45~0.52 0.50~0.90 (panchromatic) 0.52~0.60 0.60~0.69 0.76~0.90 1.55~1.75 2.08~2.35 10.4~12.5
Sub-satellite point pixel resolution (m)	156(far IR) 78(other bands)	120(far IR) 30(other bands)	60(far IR) 15(panchromatic) 30(other bands)
Swatch width	119	185	185

3.3 CCD Camera

CCD Camera is one of the main payloads of ZY-1 Earth Resource Satellite. The specifications of CCD Camera of ZY-1 and performances comparison with advanced similar foreign products listed in table 5.

Table 5 Performance Comparison of Sun-synchronous Earth Resource Satellite CCD Camera

Project	ZY-1 Sat	France SPOT 1 2	France SPOT 3 4
Years of launching	1999	1986 1990	1994 1998
Orbit altitude (km)	778	825	825

Spectral band (μm)	0.45~0.52 0.51~0.73 0.52~0.59 0.63~0.69 0.77~0.89	0.51~0.59 0.51~0.73 0.61~0.69 0.77~0.89	0.50~0.59 0.51~0.73 0.61~0.68 0.79~0.89 1.58~1.75
Sub-satellite point pixel resolution (m)	20(all bands)	10(panchromatic band) 20(other bands)	10(panchromatic band) 20(other bands)
Swatch width	113	60x2(two sets)	60x2(two sets)

4 CHINA'S SATELLITE EARTH OBSERVATION INFORMATION APPLICATION SYSTEMS.

In last three decades of the 20th century, China had constructed three kinds of satellite earth observation information application systems, namely satellite territory surveying system, satellite meteorological observation system, and satellite earth resource surveying system.

4.1 Satellite territory-surveying system

China territory surveying system has been developing gradually by self-reliance since middle of 1970's. Ten thousands meter's photographs produced by recovery satellite and other ground information obtained by all other satellites which analyzed and processed by national economical military and science research department, have gotten valuable information, it is hardly to get and even very hardly to get by common means. It provides important basis for territory planning and macro ecnomic decision-making. It promotes national defense modernization. Taking the two terrain surveying satellite launched at 1985 and 1986 as an example, using the terrain pictures gained by these two satellites, the government department concerned had organized special sessions of regional resources and environment surveying over seven regions concluding Beijing-Tianjin-Tangshan Area, Talimu Basin and Yellow River Delta etc regions, and gained rich fruits. For the whole area of 55000 km^2, utilizing the picture got by recovery remote sensing satellite, The data and information about water resource, land utilization, forestry resource, railway-line choosing, city environment and planning, tourist scenic resources, solid mine resource, cost-line conditions, inferior degradation land, natural environment vicissitudes, stabilization of earth crust, etc. and 150 frames theme maps were provided The area and distribution of territory land, cultivated land, water area, residential land, communication land, forestry, Saline–alkali soil, wind-sand soil, erosion soil, and tourism scenic land had been investigated thoroughly.

Above seven fairly larger scale and well organized application testing works, and other special theme application works conducted by the department concerned since 1975 have manifested that the terrain images obtained by recovery remote sensing satellites have good quality of enlarged viewing field, rich quantity of information, good direct visibility, higher definition, and capability of providing practical first hand surveying formation. Satellite surveying means not only great saving of manpower and material resources but also the very distinct results.

4.2 Satellite meteorological observation system

Construction and developing of satellite meteorological observation system had been carried out the policy of self-reliance developing with technical introducing. The national satellite meteorological center was founded in 1971. Starting at receiving and utilizing foreign weather satellite data and cloud images, China have constructed the weather satellite receiving and processing system which have compatibility for internal and external weather satellites. In August 2000, world meteorological organization, declared that the one China's FY-1 satellite launched at May of 1999 was put to the ranks of business type sun-synchronous weather satellite.

The cloud images and other meteorological data etc. obtained by China's satellite meteorological system have provided efficient services to china's weather forecast, water flood and waterlogging monitoring, forestry and grass land fire monitoring, crops estimating, fishery industry production, port construction, military maneuver, and the meteorological guarantee task for the testing works of national defense affairs, and so that raise the accuracy of China's weather forecast apparently.

In May 6 to Jun 2, 1987, when extraordinary forest fire taking place in the Northeast Daxinganlin area, by through satellite Meteorological Observation System and Satellite Earth Resource Surveying System, china had been monitoring the whole process of this vast fire from taking place to expanding and to continuing, It provided very important basis for Fire Fight Headquarters finding out the real situations and directing fire fighting and providing disaster relief.

4.3 Satellite earth resource system

The development of satellite resource system is similar with satellite meteorological observation system, China Remote Sensing Satellite Ground Station had established in December of 1986. In later of 1990's, China Earth Resource Satellite Ground Station had established. In Oct.1999, China launched its own first Earth Resource satellite, ZY-1, also named CBERS-1. Before launch of ZY-1 satellite, China has already utilized the data issued by foreign earth resource satellite to conduct satellite resource works. Up to 1997, China had been able to receive and processing satellite data from US LandSat, France SPOT, and Canada RadSat. Government department and provinces and counties all over the country using these satellite resource data have been doing many fruitful works in the fields of natural resource investigation, environment monitoring, land renovating and planning, land utilization and survey, crops estimation, geological examination, judgment of significant disaster. In 1998, at the time of the summer water flood at the middle and lower reaches of Changjiang River valley, when situation was getting worse and ever worst, Chinese Government using Earth Resource Satellites' images from foreign satellites Chinese Government had been making all-time all-weather monitoring over the worst area of Hubei, Jiangxi and Hunan provinces, it provided significant basis for disaster fighting and relief.

After running of ZY-1 satellite (CBERS-1) and ZY-2 satellite, China's Earth Resource System might use own source of resource information.

REFRENCES

1. Jiao, S., Li, D., 1994. Progress of space visual photography system in China. China Space, 1994(1).
2. Li, D., 1999. IR camera and CCD camera of ZY-I satellite. China Space, 1999(11)
3. Xu, J., 2000. Development of meteorological satellite in internal and external. Chinese Journal of Space science, Vol.20, Supplement(?), pp104-115.
4. Jiao, S., Cui, S., 1998. Achievement and prospect of satellite remote sensing technology in China. In: Imaging System Technology for Remote Sensing, Proceedings of SPIE, Beijing Volume 3505, pp.26-30.
5. Jiao, S., Cui, S., 1998. Opportunity for cooperation in space remote sensing technology between ESA and CAST. In: Sensor, Systems, and Next -Generation Satellites? , Proceedings of SPIE, Barcelona, Volume 3498, pp409-417.