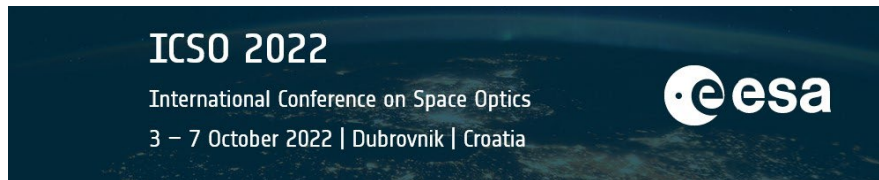


# International Conference on Space Optics—ICSO 2022

Dubrovnik, Croatia

3–7 October 2022

*Edited by Kyriaki Minoglou, Nikos Karafolas, and Bruno Cugny,*



## *Optics in China's Space Program*



ICSO 2022

International Conference on Space Optics  
3 – 7 October 2022 | Dubrovnik | Croatia



# Optics in China’s Space Program

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October 4, 2022

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- High-resolution earth observation system
- Space Infrastructure Mission
- Deep Space Exploration Mission
- Commercial Remote Sensing Satellite
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- International Cooperation Mission
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## INTRODUCTION

### Space Activities in 2021

Country	Launch vehicle launches					Spacecraft Development and Launch						
	LEO	MEO	Non-Earth orbit	launches	loads	Manned spacecraft	Space probes	Navigation satellites	Communication satellites	Remote sensing satellites	Scientific and experimental satellites	Total
America	43	6	2	51	1335	8	3	1	1356	86	88	1542
China	41	14	-	55	115	5	-	-	17	34	34	117
Russia	21	4	-	25	340	8	-	-	2	5	3	18

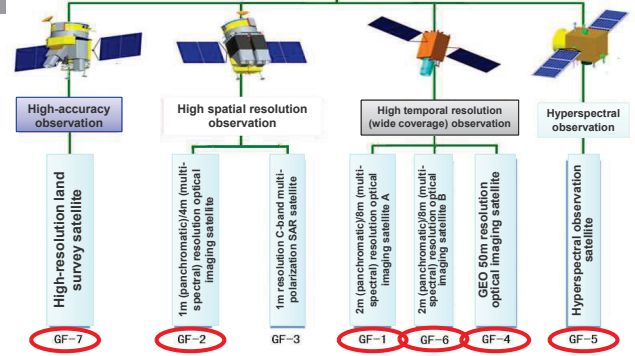
Until Now, **37 launches** in 2022. Planned **more than 50 launches** in 2022.

## INTRODUCTION

- In Jan. 2022, the recent and future development goals of China Aerospace were publicly introduced in the **White Paper** entitled “China’s Space Program: A 2021 Perspective”.
- Since 2016, China’s space industry has made rapid and innovative progress
  - **space infrastructure**
  - **high-resolution earth observation system**
  - **lunar exploration program**
  - **exploration of Mars**
- In the next five years, China will integrate space science, technology and applications while pursuing the new development philosophy, building a new development model and meeting the requirements for high-quality development.

## HIGH-RESOLUTION EARTH OBSERVATION SYSTEM

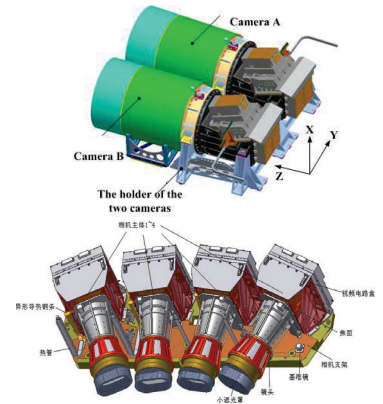
- High Resolution Earth-Observing System is approved in May, 2010.



## HIGH-RESOLUTION EARTH OBSERVATION SYSTEM

- GF-1: China's first launched satellite of the HREOS. It is a mid and high resolution MS camera with the widest swath around the world, Launched on April 26, 2013.

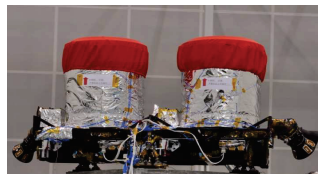
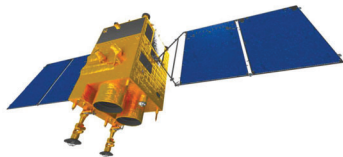
Payload	Specification	Value
Panchromatic and Multi-spectral CCD Camera(PMS)	Spectral range	0.45~0.90μm 0.45~0.52μm 0.52~0.59μm 0.63~0.69μm 0.77~0.89μm
	GSD	2m/8m
	Swath	70km
		coaxial three-mirror optical system with long focal length
Wide field of view camera(WFV)	Spectral range	0.45~0.52μm 0.52~0.59μm 0.63~0.69μm 0.77~0.89μm
	GSD	16m
	Swath	800km
		Refractive optical system



## HIGH-RESOLUTION EARTH OBSERVATION SYSTEM

- GF-2: China's first submeter high-resolution Earth observation satellite, Launched August 19, 2014.

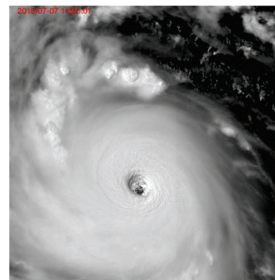
Payload	Specification	Value
1m/4m camera	Spectral range	0.45μm~0.90μm 0.45μm~0.52μm 0.52μm~0.59μm 0.63μm~0.69μm 0.77μm~0.89μm
	GSD	0.81/3.24m
	Swath	45km



## HIGH-RESOLUTION EARTH OBSERVATION SYSTEM

- GF-4: China's first high-resolution Earth observation satellite in geosynchronous orbit, Launched in December 29, 2015

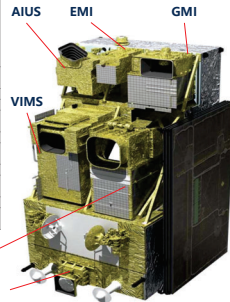
Payload	Specification	Value
GF-4 imager	Spectral range	0.45-0.9um
		3.5-4.1um
	GSD	40m/400m
	Swath	400*400km



# HIGH-RESOLUTION EARTH OBSERVATION SYSTEM

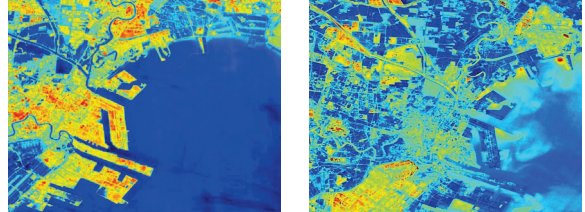
◆ GF-5: high-spectral satellite, Launched in May 9, 2018

Payload	Specification	Value	Payload	Specification	Value
The Environmental Trace Gases Monitoring Instrument (EMI)	Spectral range	240-315nm 311-403nm 401-550nm 545-710nm	Visual and Infrared Multispectral Sensor (VIMS)	Spectral band	450nm~520nm 520nm~600nm 620nm~680nm 760nm~860nm 1.56μm~1.76μm 2.08μm~2.35μm 3.50μm~3.90μm 4.85μm~5.05μm 8.01μm~8.39μm 8.42μm~8.83μm 10.3μm~11.3μm 11.4μm~12.5μm
	Spectral resolution	0.3~0.5nm		GSD	VNIR/SWIR: 20m MIR/LWIR: 40m
	Swath	2600km		swath	60km
Greenhouse Gases Monitoring Instrument (GMI)	Central wavelength	0.756μm 1.575μm 1.65μm 2.05μm	Advanced Hyperspectral Imager (AHSI)	Spectral range	0.4~2.5μm
	Spectral range	0.758~0.769μm 1.565~1.583μm 1.642~1.658μm 2.043~2.058μm		Spectral resolution	VNIR: 5nm SWIR: 10nm
	Spectral resolution	0.027nm 0.067nm 0.113nm 0.133nm		GSD	30m
Directional Polarization Camera (DPC)	FOV coverage	±31°	Atmospheric Infrared Ultraspectral (AIUS)	Spectral range	750~4100 cm <sup>-1</sup>
	Spectral range	433nm~453nm 480nm~500nm (P) 555nm~575nm 660nm~680nm (P) 768nm~768nm 745nm~785nm 845nm~885nm 900nm~920nm		Spectral resolution	0.03 cm <sup>-1</sup>
	Polarization Analysis	Linear polarization: 0° 90° 120°		FOV	1.25mrad
	FOV	±60° ~ ±150°		FOV coverage	±10°
	Multi-angular Measurements	9 angles along track			
	GSD	3.5 km			



# HIGH-RESOLUTION EARTH OBSERVATION SYSTEM

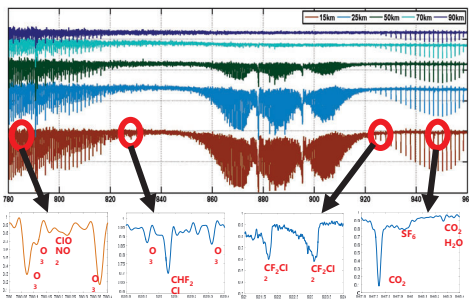
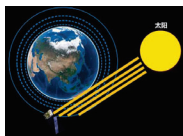
## Nocturnal thermal pollution monitoring



Contrast between the temperature brightness of a port during day and night  
The above pictures of a power plant nearby a port give us a clear view of the slight temperature differences and the diffusion scope.

Image by Visual and Infrared Multispectral Sensor (VIMS)

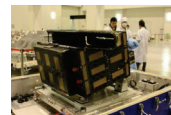
# HIGH-RESOLUTION EARTH OBSERVATION SYSTEM



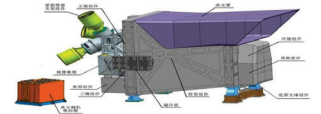
Spectral line by Atmospheric Infrared Ultraspectral (AIUS)

# HIGH-RESOLUTION EARTH OBSERVATION SYSTEM

◆ GF-6: similar as GF-1, New technology used, Launched in June 2, 2018

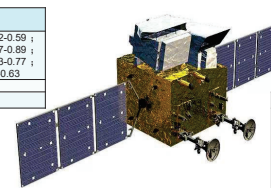


Feature: Freeform mirror



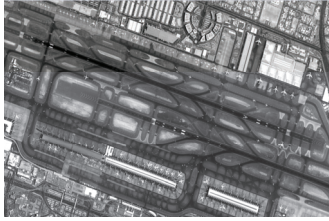
Feature: Wide field of Triple Reflective Off-Axis Optical System

Payload	Specification	Value
Wide field of view imagery (WFV)	Spectral range	0.45~0.52 ; 0.52~0.59 ; 0.63~0.69 ; 0.77~0.89 ; 0.69~0.73 ; 0.73~0.77 ; 0.40~0.46 ; 0.57~0.63
	GSD	16m
	Swath	850km



Payload	Specification	Value
Panchromatic and Multi-spectral CCD Camera (PMS)	Spectral range	0.45μm~0.90μm 0.45μm~0.52μm 0.52μm~0.59μm 0.63μm~0.69μm 0.77μm~0.89μm
	GSD	2m/8m
	Swath	95km

## HIGH-RESOLUTION EARTH OBSERVATION SYSTEM



PMS

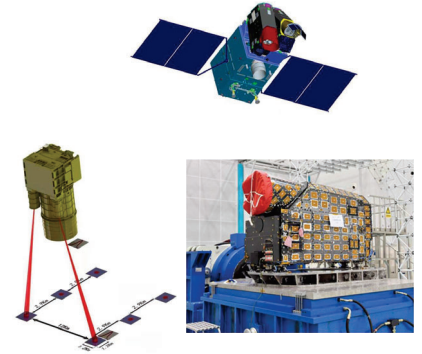


WFV

## HIGH-RESOLUTION EARTH OBSERVATION SYSTEM

- ◆ GF-7: Next generation of map satellite, Launched in November 3, 2019  
1: 1 0000-scale topographic mapping

Payload	Specification	Value
two-line array camera	Panchromatic band range	450~900nm
	Multi-spectral band range	450~520nm
		520~600nm
		620~680nm
		760~890nm
	Front view camera GSD	0.79m
	Rear view camera GSD	0.64m
Multi-spectral band GSD	2.56m	
laser altimeter	Front view camera	+26°
	Rear view camera	-5°
	swath	20km
	Number of laser beams	2
	Laser divergence angle	40μrad
laser altimeter	Laser repetition frequency	3Hz
	Laser wavelength	1064nm
	Energy	180mJ
	Ranging accuracy	0.3m



## HIGH-RESOLUTION EARTH OBSERVATION SYSTEM

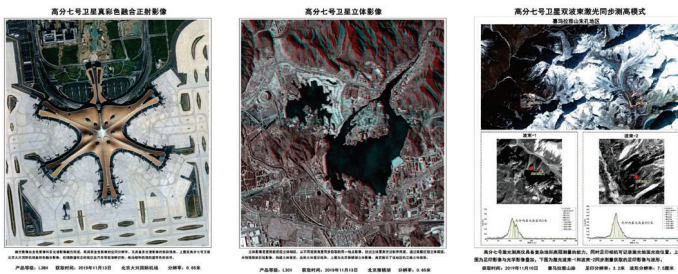


Image by two-line array camera

Waveform by laser altimeter

## HIGH-RESOLUTION EARTH OBSERVATION SYSTEM

Space Optics in China made great progress by HREOS, such as system design, mirror manufacture, detector development, alignment and test.

Some payloads are top up to now.

GF-4 imager: the highest GSD in GEO.

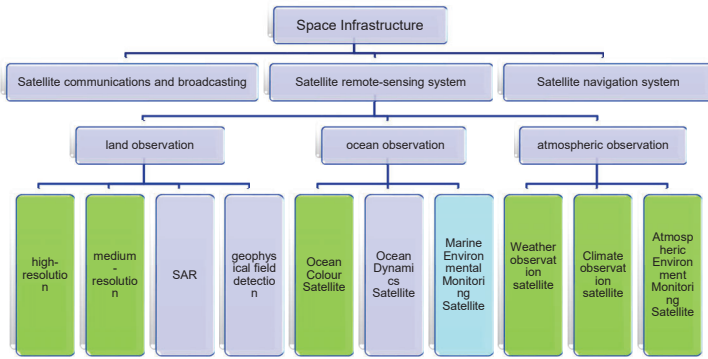
GF-5 Advanced Hyperspectral Imager (AHSI): the widest swath of spectrometer  
Atmospheric Infrared Ultraspectral Sounder (AIUS): the highest spectral resolution

GF-6 Wide field of view imagery(WFV): the widest swath of 16m GSD

Panchromatic and Multi-spectral CCD Camera(PMS): the widest swath of 2m GSD

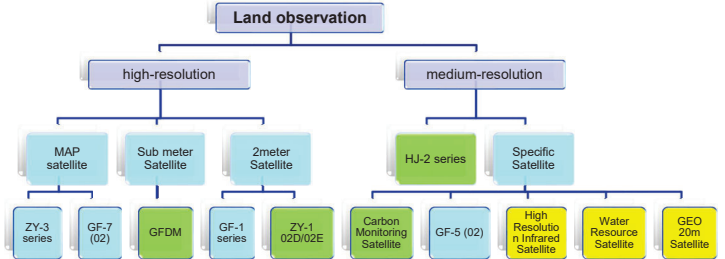
GF-7 the highest mapping accuracy

# SPACE INFRASTRUCTURE



# SPACE INFRASTRUCTURE

## land observation



# SPACE INFRASTRUCTURE

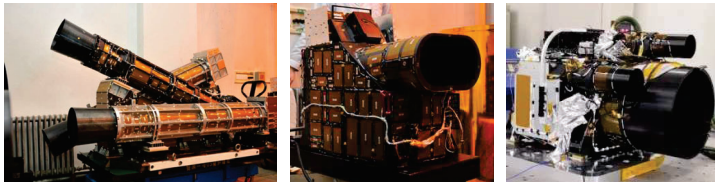
## Mapping Series

### ZY-3 Satellite

It is the first generation of high resolution 3D mapping satellite in China. Map ratio is 1:50000 The main payloads are three-line array camera and MS camera.

- The First Satellite was launched in January 2012.
- The Second Satellite was launched in May, 2016. The satellite is loaded with a new payload -- China's first Laser altimeter.
- The Third Satellite was launched in July, 2020.

Payload	Specification	Value
three-line array camera	Panchromatic band range	500~800nm
	Front/Rear GSD	3.5m(01) 2.7m(02/03)
	Middle view camera GSD	2.1m
	swath	51km
Multi-spectral Camera	band range	450 ~ 520nm 520~600nm 620~680nm 760~890nm
	GSD	4.5m
	swath	51km
	laser altimeter	Number of laser beams
Laser divergence angle		150urad(02), 90urad (03)
Laser repetition frequency		2Hz
Laser wavelength		1064nm
Energy		200mJ(02), 150mJ (03)
Ranging accuracy	1m(02), 0.3m(03)	

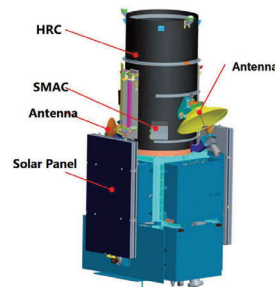


# SPACE INFRASTRUCTURE

## Sub meter Satellite

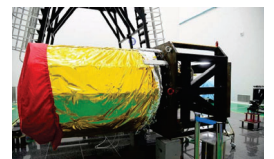
### GFDM- 1

An agile optical remote sensing satellite has many technical characteristics such as agile imaging, agile mobility, positioning accuracy assurance and micro vibration. GFDM- 1 satellite was launched in July, 2020.



High-Resolution Camera (HRC)

Payload	Specification	Value
High-Resolution Camera (HRC)	Spectral range	0.45~0.90µm
		0.40~0.45µm
		0.45~0.52µm
		0.52~0.59µm
		0.59~0.625µm
		0.63~0.69µm
GSD	Swath	0.705~0.745µm
		0.77~0.89µm
		0.86~1.04µm
		0.46m/1.84m
Synchrotron Monitoring Atmospheric Corrector (SMAC)	Spectral range	15km
		490nm(P)
		550nm
		670nm(P)
		870nm(P)
		910nm
GSD	Swath	1380nm
		1610nm(P)
		2250nm(P)
8km	15km	



# SPACE INFRASTRUCTURE

Imaging sequence

Pitch angle

Side-swing angle

Agile ability Excellent!

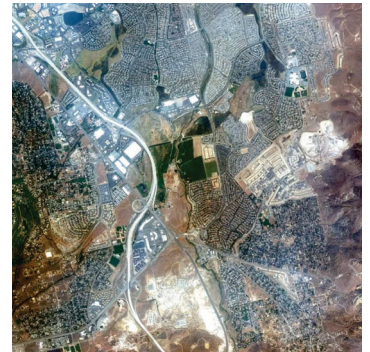
1pass, 11angles!



# SPACE INFRASTRUCTURE



Original image



With Atmospheric correction

# SPACE INFRASTRUCTURE

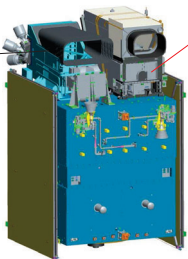
## ZY-1 02D/02E

ZY-1 02D satellite is the promotion and continue satellite of ZY-1-02C satellite. A new Visible and Near-Infrared Camera was developed. Advanced Hyperspectral Imager (AHSI) first aborbed on GF-5 was installed. 02D was launched in September, 2019.

ZY-1 02E satellite is similar as 02D. An Infrared Camera was aborbed. 02E was launched in December, 2021.

Visible and Near-Infrared Camera	Spectral range	0.45~0.90μm
		0.40~0.45μm
		0.45~0.52μm
		0.52~0.59μm
		0.59~0.625μm
		0.63~0.69μm
	0.705~0.745μm	
	0.77~0.89μm	
	0.86~1.04μm	
	GSD	2.5m/10m
	swath	115km
Advanced Hyperspectral Imager (AHSI)	Spectral range	0.4-2.5um
	Spectral resolution	Vnir:10nm Swir:20nm
	GSD	30m
	swath	60km
Infrared Camera (Only 02E)	Spectral range	7.7~10.5um
	GSD	10m
	swath	115km
	NEDT	0.1K

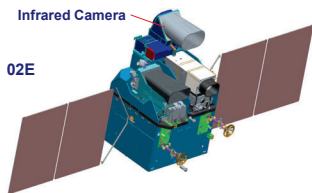
Visible and Near-Infrared Camera



ZY-1 02D

Advanced Hyperspectral Imager (AHSI)

Infrared Camera



ZY-1 02E

# SPACE IN

5米光学02星真彩色融合影像图



Visible and Near-Infrared Image

Date: 27<sup>th</sup> Dec, 2021

Site: Shanghai, China

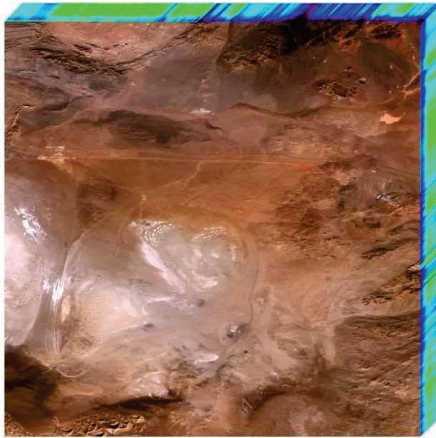
分辨率: 2.5米  
获取时间: 2021年12月27日 10:42  
数据来源: 5米光学02星

上海市滴水湖

自然资源部国土卫星遥感应用中心  
中国空间技术研究院  
中国资源卫星应用中心  
中国科学院空天信息创新研究院

## SPACE INFRAS

5米光学02星高光谱真彩色影像图



分辨率: 30米  
 获取时间: 2022年1月25日 12:14  
 数据来源: 5米光学02星高光谱载荷

自然资源部国土卫星遥感应用中心  
 中国科学院空天信息创新研究院  
 中国科学院空天信息创新研究院

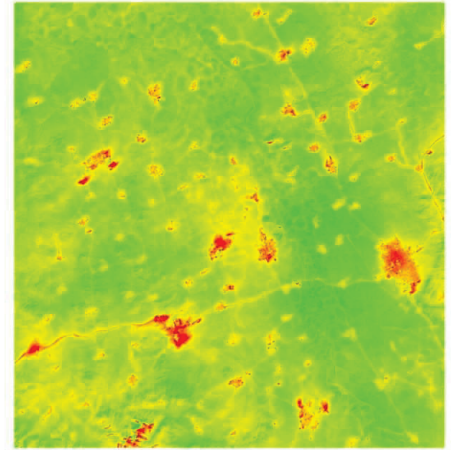
Advanced Hyperspectral Imager (AHSI) Image

Date: 25<sup>th</sup> Jan, 2022

Site: Inner Mongolia Autonomous Region, China

## SPACE INFRAS

5米光学02星热红外影像渲染图



分辨率: 16米  
 获取时间: 2022年1月25日 10:33  
 数据来源: 5米光学02星热红外载荷

黑龙江省哈尔滨市  
 自然资源部国土卫星遥感应用中心  
 中国科学院空天信息创新研究院

Infrared Camera Image

Date: 25<sup>th</sup> Jan, 2022

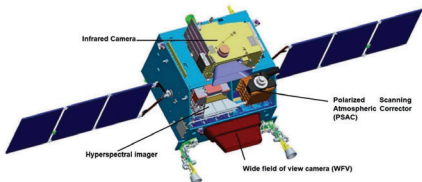
Site: Heilongjiang Province, China

## SPACE INFRASTRUCTURE

### □ HJ-2 series

A small constellation for environmental and disaster monitoring and forecasting.

HJ-2 A/B satellites are equipped with four optical payloads. The two satellites adopt the CAST2000 public platform, and operate in an on-orbit network, which can realize the full coverage observation of the global area within 80° north and south latitude within 2 days.



Payload	Specification	Value
Wide field of view camera (WFOV)	Spectral range	0.45~0.52µm 0.52~0.59µm 0.63~0.69µm 0.69~0.73µm 0.77~0.89µm
	GSD	16m
	Swath	800km
Infrared Camera	Spectral range	0.63~0.69µm 0.73~0.77µm 0.78~0.90µm 1.19~1.29µm 1.55~1.66µm 2.08~2.35µm 3.50~4.80µm 10.5~11.4µm 11.5~12.5µm
	GSD	48m/96m
	Swath	720km
	Spectral range	0.45~0.92µm 0.90~2.50µm
	GSD	16m
	Swath	96km
Polarized Scanning Atmospheric Corrector (PSAC)	Spectral range	410nm, 443nm 555nm, 670nm 865nm, 910nm 1380nm, 1610nm 2250nm
	GSD	6km
Wide field of view camera (WFOV)	GSD	16m
	Swath	800km

## SPACE INFRASTRUCTURE

### □ Carbon Monitoring Satellite (CM-1)

Terra Ecosystem Carbon Inventory Satellite (TECIS) is the world's first joint active-passive observation remote sensing satellite for forest carbon sinks. It was launched in August, 2022.

#### Feature:

Combination of active and passive remote sensing;  
 Combination of "point data" and "plane data";  
 Combination of vertical data and horizontal data.

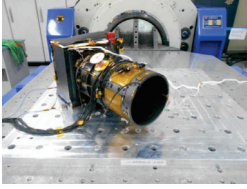


TARGET	ACTIVE POINT DATA VERTICAL DATA	PASSIVE PLANE DATA HORIZONTAL DATA
Forest Biomass	Multi-Beam LIDAR	Directional Multi-Spectral Camera (DMSC)
Aerosols Distribution	Multi-Beam LIDAR	Directional Polarization Camera (DPC)
Photosynthetic Fluorescence	/	The Solar-Induced Chlorophyll Fluorescence Imaging Spectrometer (SIFIS)

Payload	Specification	Value
Multi-Beam LIDAR (Tree height measuring)	Number of laser beams	5
	Laser repetition frequency	35Hz
	Laser wavelength	1064nm
Multi-Beam LIDAR (Aerosols detecting)	Energy	70mJ
	Vertical resolution	0.15m
	Ranging accuracy	0.3m
Multi-Beam LIDAR (Nadir Camera)	Number of laser beams	1
	Laser repetition frequency	20Hz
	Laser wavelength	1064nm & 532 nm
Multi-Beam LIDAR	Vertical resolution	30m
	band range	450 ~ 520nm 520 ~ 600nm
Multi-Beam LIDAR	GSD	620 ~ 680nm 760 ~ 890nm
	swath	2m
Multi-Beam LIDAR	GSD	2m
	swath	20km

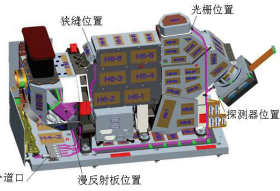


# SPACE INFRASTRUCTURE

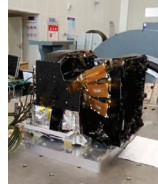


One of DMPC

Payload	Specification	Value	
Directional Multi-Spectral Camera(DMPC)	band range	500~760nm (Front1&Rear1) 450~520nm 520~600nm 620~680nm 760~890nm 690~730nm(Front2&Rear2)	
	Front/Rear GSD	6m/12m	
	swath	20km	
Solar-Induced Fluorescence Spectrometer (SIFIS)	Chlorophyll Imaging	Spectral band 670~780nm Spectral resolution 0.3nm GSD 0.8km swath 34km	
	Directional Polarization Camera (DPC)	band range	433~453 nm 480~500 nm (P) 555~575 nm 660~680 nm (P) 758~768 nm 745~785 nm 845~885 nm (P) 900~920 nm
		GSD	3.5km
swath		800km	



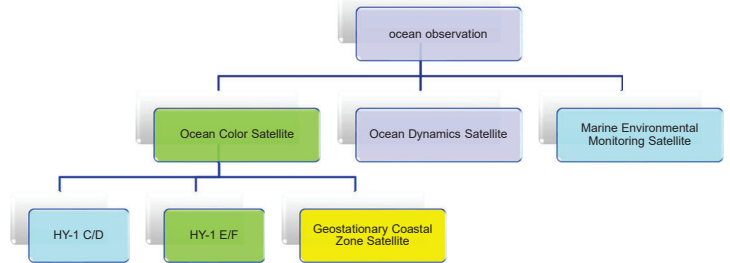
SIFIS



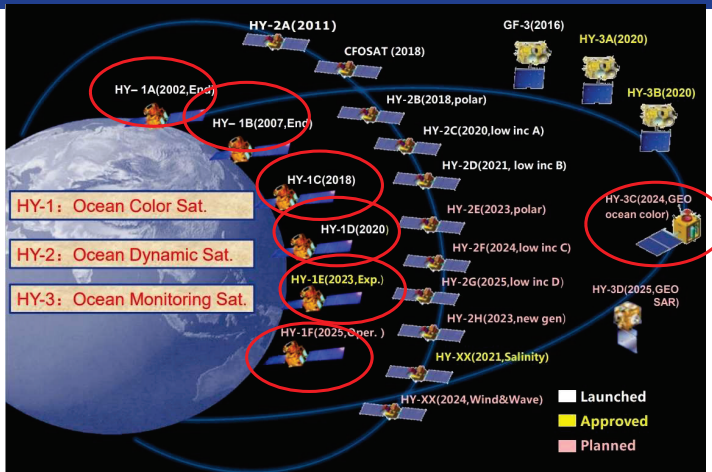
DPC

# SPACE INFRASTRUCTURE

## Ocea observation



# SPACE INFRASTRUCTURE

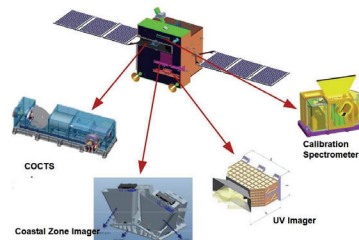


# SPACE INFRASTRUCTURE

## HY-1 C/D

China's second generation of ocean water colour remote sensing special Satellite. C satellite was launched in Sept, 2018. D satellite was launched in June, 2020.

It is the first time cross calibration CZI and COCTS with Calibration Spectrometer.

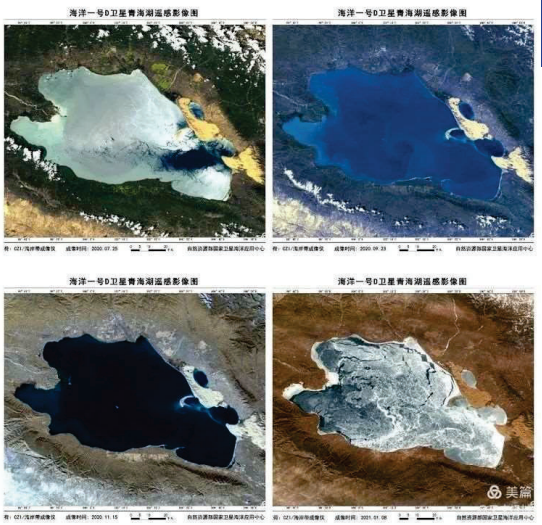


Payload	Specification	Value
Coastal Zone Imager (CZI)	band range	420~500nm 520~600nm 610~690nm 760~890nm
	GSD	50m
	swath	950km
Chinese ocean color and temperature scanner (COCTS)	Spectral band	0.402~12.5µm
	Number of Band	10
	GSD	1.1km
UV Imager (UVI)	band range	345~365nm 375~395 nm
	GSD	650m
	swath	3000km
Calibration Spectrometer	Spectral band	400~900nm
	Spectral resolution	5.2nm
	GSD	1.1km
	swath	11km

## SPACE IM

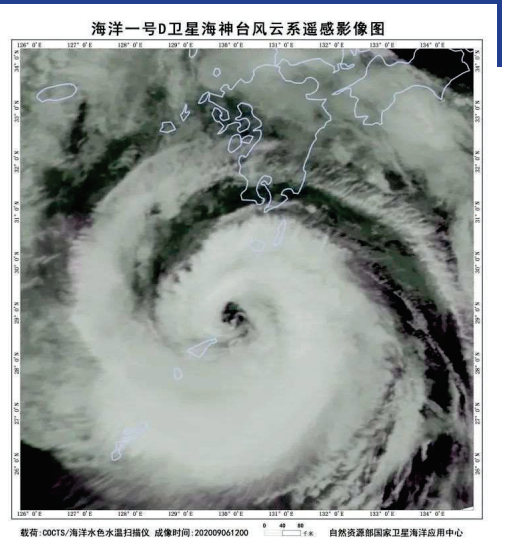
Coastal Zone Imager (CZI)

Site: Qinghai Lake, China



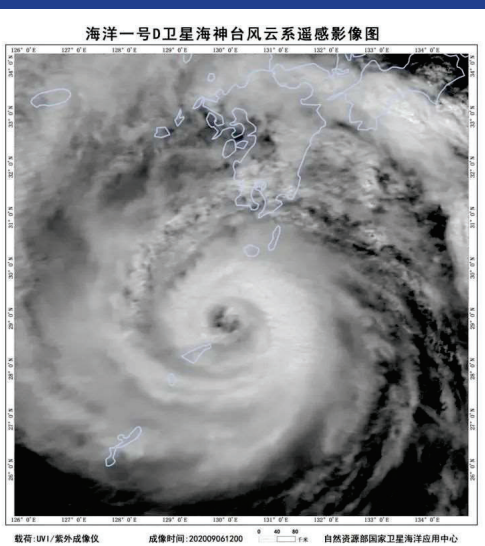
## SPACE INFR

Chinese ocean color and temperature scanner (COCTS) image



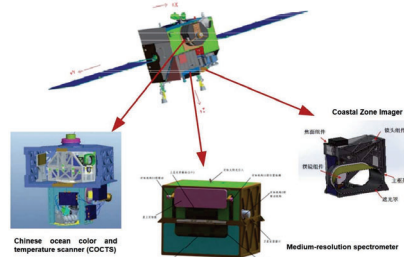
## SPACE INFR

UV Imager (UVI) Image



## SPACE INFRASTRUCTURE

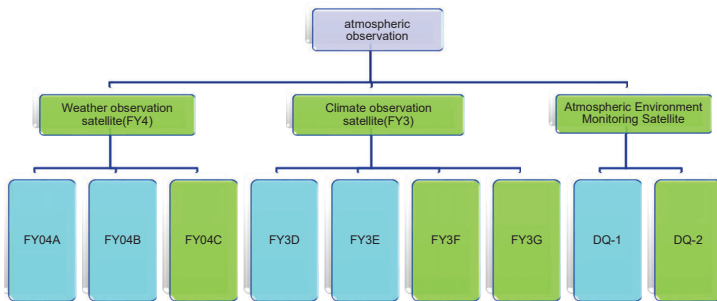
- HY-1 E/F  
China's third generation of ocean water colour remote sensing special Satellite. E satellite will be launched in 2023. F satellite was launched in June, 2025.  
CZI and COCTS are greatly updated. Medium-resolution spectrometer is added.



Payload	Specification	Value
Coastal Zone Imager (CZI)	band range	0.40~1.04 $\mu$ m
	Number of Band	1(pan)
		8(multiband)
	GSD	5m/20m
	swath	60km
	Sight	950km
Chinese ocean color and temperature scanner (COCTS)	Spectral band	0.35~12.5 $\mu$ m
	Number of Band	18
	GSD	500m
	swath	3000km
Medium-resolution spectrometer	Spectral band	0.35~2.5 $\mu$ m
	Number of Band	15(vis)
		4(swir)
	GSD	100m
	swath	950km

## SPACE INFRASTRUCTURE

atmospheric observation



## SPACE INFRASTRUCTURE

□ FY-04A

**Spacecraft:**

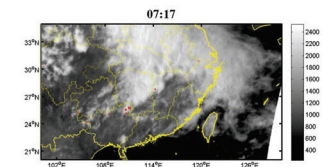
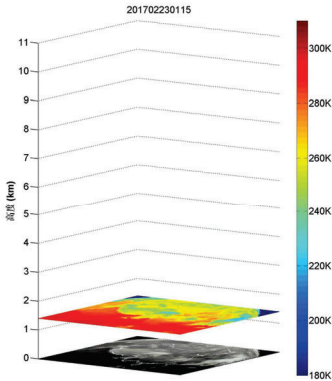
1. Launch Weight: approx. 5300kg
2. Stabilization: Three-axis
3. Attitude accuracy: 3"
4. Bus: 1553B+Spacewire
5. Raw data transmission: X band
6. Output power: >= 3200W
7. Design life: over 7 years

**Main instrument**

- 1) GIIRS: Geo. Interferometric Infrared Sounder
- 2) AGRI: Advanced Geosynchronous Radiation Imager
- 3) LMI: Lightning Mapping Imager
- 4) SEP: Space Environment Package

## SPACE INFRASTRUCTURE

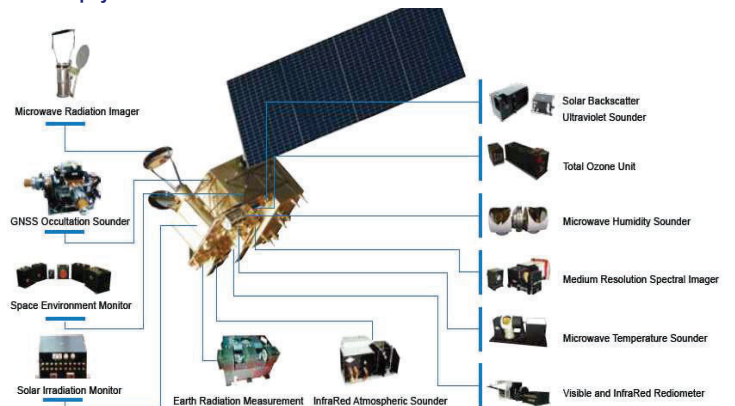
GIIRS: BT animation of different layers in troposphere for China area



LMI lightning events about 3 hours, is displayed over the LMI background image in June 5, 2017. Red color indicates lightning events. The brightest storm system is located over in the south of the Yangtze River.

## SPACE INFRASTRUCTURE

□ FY-03D  
12 payloads.



## SPACE INFRASTRUCTURE

### FY-3D GAS

- > Interferometer (FTS) is used to obtain high spectral resolution for CO<sub>2</sub> and CH<sub>4</sub> column density.
- > The maximum optical path difference of 2.5cm provides a spectral resolution of 0.2 cm<sup>-1</sup>

Bands	1	2	3	4
Objects	O <sub>2</sub>	CO <sub>2</sub> , CH <sub>4</sub>	CO <sub>2</sub> , H <sub>2</sub> O	CO, CH <sub>4</sub>
Center wave	0.76μm	1.6μm	2.00μm	2.3μm
SpCoverage	0.75-0.77μm	1.56-1.72μm	1.92-2.08μm	2.20-2.38μm
Spectral res	0.6cm <sup>-1</sup>	0.27cm <sup>-1</sup>	0.27cm <sup>-1</sup>	0.27cm <sup>-1</sup>
SNR	320	260-300	160-300	140-300
Spatial res	13.2 km			



### Next Generation GAS

Band	O <sub>2</sub> A-band	Weak CO <sub>2</sub>	Strong CO <sub>2</sub>	CO <sub>2</sub> , CH <sub>4</sub> , N <sub>2</sub> O
Center wavel.	0.76 μm	1.61 μm	2.06 μm	2.3 μm
Wavel. Range	>15 nm	>30 nm	>40 nm	>50 nm
Spectral resolution	0.04 nm	0.07 nm	0.09 nm	0.1 nm
Sample num. /FWHM	≥3			
Coverage	> 100 km			
Spatial resolution	< 3 km			

- > FY-3G will be launched in 2023.
- > High spectral and spatial resolution
- > High signal to noise ratio
- > Coverage > 100 km

## SPACE INFRASTRUCTURE

### □ DQ-1/2

DQ-1 is first active Laser radar sounder to detect CO<sub>2</sub>. It was launched in 2022. XCO<sub>2</sub> is 1ppm.

DQ-2 is a passive and active green house gas sounder and will be launched in June, 2023.



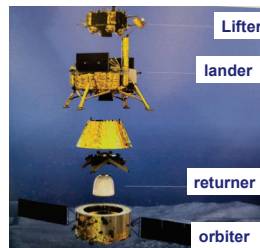
Payload	Specification	Value
The Environmental Trace Monitoring Instrument (EMI)	Spectral range	240-315nm 311-403nm 401-550nm 545-710nm
	Spectral resolution	0.3-0.5nm
	GSD	7km
	Swath	2500km
Greenhouse Gases Monitoring Instrument (Only DQ-2)	Central wavelength	0.76μm 1.61μm 2.06μm 2.33μm
	Spectral resolution	0.04nm 0.07nm 0.09nm 0.10nm
	GSD	3km
	Swath	100km
IPDA LIDAR	Number of laser beams	1
	repetition frequency	20Hz
	Laser wavelength	1572nm, 1064nm, 532nm
	energy	150mJ@532nm 110mJ@1064nm 75mJ@1572nm
	Diameter of mirror	1m
Advanced Hyperspectral Imager (AHSI) (Only DQ-1)	Spectral range	0.4-2.5um
	Spectral resolution	Var: 5nm Star: 10nm
	GSD	30m
	swath	60km

## DEEP SPACE EXPLORATION MISSION

In China, Lunar Exploration(CE) and TianWen(TW) series mission.

### □ Lunar Exploration

lunar exploration phase	Task	Satellite	Launch Schedule
1	orbiting	CE-1/2	2007/2010
2	landing	CE-3/4	2013/2018
3	returning	CE-5	2020
4	Surveying	CE-7	2025
	Checking	CE-6	2026
	Station	CE-8	2028



CE-5

### □ TianWen series mission

TW	Task	Target	Launch Schedule
1	Orbiting, landing, roving	Mars	2020
2	Sample and return	2016HO3, 311P	2025
3	Sample and return	Mars	2028
4	interplanetary exploration	Jupiter & its moons	2030

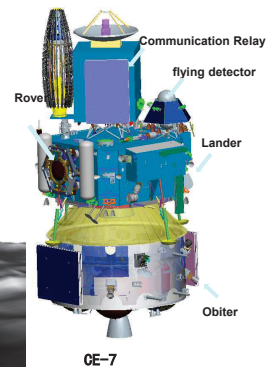
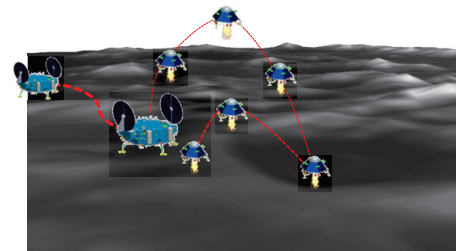


## DEEP SPACE EXPLORATION MISSION

### □ CE-7

CE-7 perform environmental and resource surveys of the lunar polar region, investigate the distribution of water the permanently shadowed area.

It includes: a telecommunication relay, an orbiter, a lander, a rover and a flying detector. 17payloads onboard.

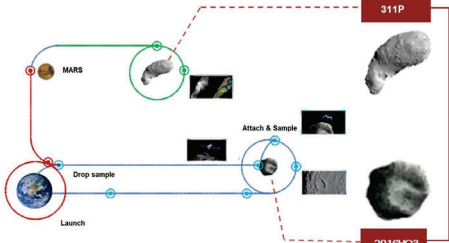
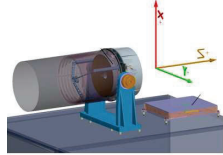


CE-7

## DEEP SPACE EXPLORATION MISSION

### □ TW-2

A near-Earth asteroid named 2016H03 will be detected and returned with samples, and a main belt comet named 311P will be orbited.



Payload	Specification
Color camera with intermediate field of view	Band range: 0.45 $\mu$ m–0.76 $\mu$ m Color: multispectral GSD: 1m@10km Width: 4km × 4km@10km MTF: $\geq 0.2$
Thermal emission spectrometer	Spectral range: 5.0–50.0 $\mu$ m Spectral resolution: 10cm <sup>-1</sup> SNR: $\geq 320$ GSD: 10m@5km
Visible and IR imaging spectrometer	Spectral range: 0.45–4.50 $\mu$ m Spectral resolution: 8nm (0.5–1.0 $\mu$ m) 15nm (1.0–2.5 $\mu$ m) 25nm (2.5–4.5 $\mu$ m) GSD: 0.5m@5km SNR: $\geq 40$ dB MTF: $\geq 0.2$
Multispectral camera	Spectral range: 480nm–1000nm; Field of view: 16° × 16° SNR: $\geq 40$ dB MTF: $\geq 0.2$
Detection radar	
Magnetometer	
Charged and neutral particle analyzer	
Dust analyzer	

## COMMERCIAL REMOTE SENSING SATELLITE

In recent years, China's national policies have facilitated the development and deployment of commercial remote sensing satellites. These policies stimulated investment from private commercial cater rises, attracted talent, and spurred technological innovation in this sector.

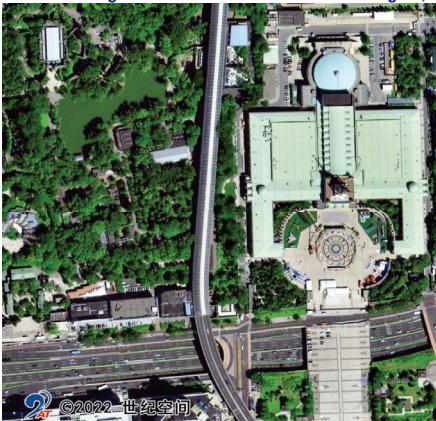
In China, there are many commercial companies, such as: China Siwei Surveying and Mapping Technology(Superview Satellite), Twenty First Century Technology(Beijing series Satellite), Chang Guang Satellite Technology (Jilin Satellite).

Year	launches	satellites
2019	11	22
2020	6	17
2021	10	28

## COMMERCIAL REMOTE SENSING SATELLITE

### □ Beijing-3B

The highest GSD in China. Launched in August, 2022.

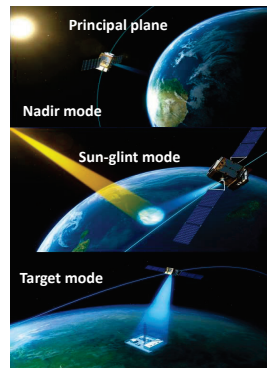


Payload	Specification	Value
Tianshu Camera	Spectral range	0.45–0.90 $\mu$ m 0.45–0.52 $\mu$ m 0.52–0.59 $\mu$ m 0.63–0.69 $\mu$ m 0.77–0.89 $\mu$ m
	GSD	< 0.5m
	Swath	11km



## SCIENTIFIC AND EXPERIMENTAL MISSION

National High Technology Research & Development Programs by Ministry of Science and Technology of China (MOST) (2011-2017)  
TanSat mission kicked-off at 2011, launched at 2016.



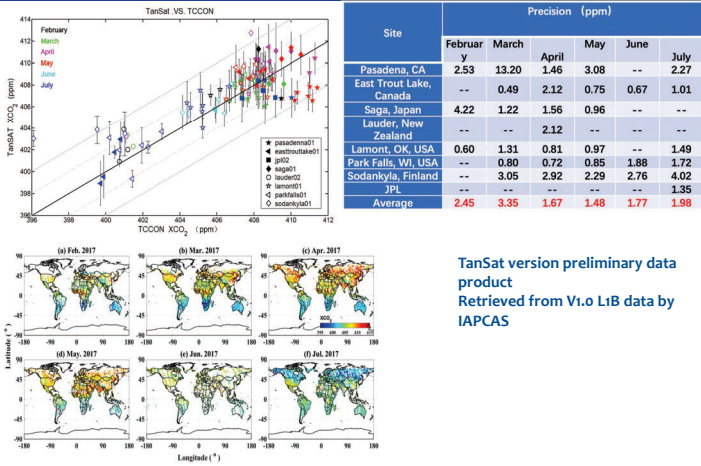
Atmospheric Carbon-dioxide Grating Spectrometer  
ACGS

Band	O <sub>2</sub> -A	Weak CO <sub>2</sub>	Strong CO <sub>2</sub>
Spectral Coverage (nm)	758-778	1594-1624	2042-2082
Spectral Resolution (nm)	0.044	0.12	0.16
SNR@mW m <sup>-2</sup> sr <sup>-1</sup> nm <sup>-1</sup>	360@15.2	250@2.6	180@1.1
Spatial Resolution	2 km × 2 km		
Swath	20 km		

Cloud and Aerosol Polarization Imager  
CAPI

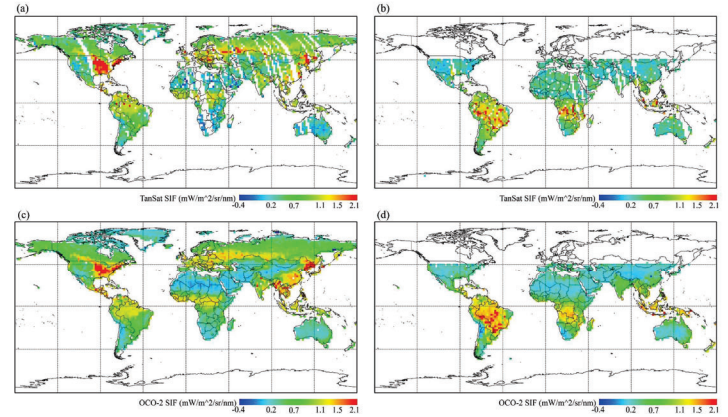
Band	Spectral coverage (nm)	FOV	No of pixels
1	365-408	400 km x 0.5 km	1600
2	660-685(P)		1600
3	862-877		1600
4	1360-1390		800
5	1628-1654(P)		800

## SCIENTIFIC AND EXPERIMENTAL MISSION



## SCIENTIFIC AND EXPERIMENTAL MISSION

### TanSat-SIF



## SCIENTIFIC AND EXPERIMENTAL MISSION

Strategy Priority Research Program by Chinese Academy of Sciences

In January 2011, the first phase of the Strategic Priority Program on Space Science (hereafter referred to as SPP 1) officially kicked off as the first batch of the Strategic Priority Program initiated by the Chinese Academy of Sciences (CAS), which marks the beginning of systematic funding support to space science in China.

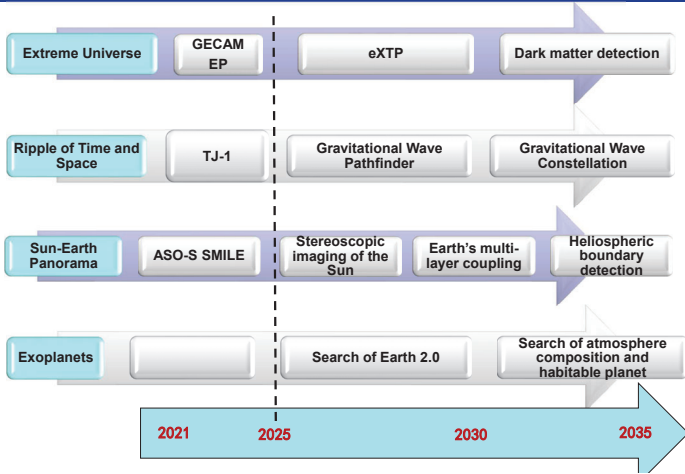
Satellite	launch	Achievements
Dark Matter Particle Explorer (DAMPE, or Wukong)	Dec., 2015	The observation data in the last three years have provided precise measurements of the cosmic ray proton spectrums from 40 GeV to 100 TeV.
Shijian-10 (SJ-10)	Apr., 2016	The Shijian-10 mission has made several new scientific and technological achievements with high impact
Quantum Experiments at Space Scale (QUESS, or Micius)	Aug, 2016	the satellite-ground and ground-satellite quantum entanglement distribution, satellite-ground quantum key distribution, and satellite-ground quantum teleportation over the scale of 1000 km.
Hard X-ray Modulation Telescope (HXMT, or Insight)	June, 2017	Regarding the X-ray observations in the first gravitational wave event caused by binary neutron star merging. The X-ray pulsar navigation experiment has been successfully carried out

## SCIENTIFIC AND EXPERIMENTAL MISSION

On 31 May 2018, CAS officially kicked off the second phase of the Strategic Priority Program on Space Science (SPP II)

Satellite	launch	Goal
Taiji-1	August, 2019	The program adopts the space laser interferometry in the middle and low frequency band (0.1Hz-1.0 Hz). It is China's first experimental space gravitational wave detection satellite.
Gravitational Wave High-energy Electromagnetic Counterpart All-sky Monitor (GECAM)	Oct., 2022	Aims to detect as many gravitational wave gamma-ray bursts and new electromagnetic counterparts as possible to unveil the mystery of the violent merger of dense celestial bodies in the universe.
Advanced Space-based Solar Observatory (ASO-S)	Oct., 2022	Aims to study the relationship between solar magnetic field, solar flare, and Coronal Mass Ejection (CME), observe the responses of different layers of solar atmosphere to solar eruption, and study the transmission mechanism and dynamic characteristics of solar eruption energy.
Einstein Probe (EP)	2023	Aiming to systematically detect high-energy transients and variable cosmic X-ray sources, and explore their natures and physical processes
Solar Wind Magnetosphere Ionosphere Link Explorer (SMILE)	2024	Observing the solar wind-magnetosphere coupling via simultaneous X-ray imaging of the magnetosheath and polar cusps, UV imaging of global auroral distributions and in situ solar wind / magnetosheath measurements.

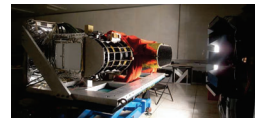
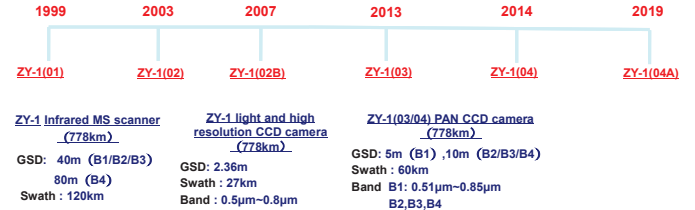
## SCIENTIFIC AND EXPERIMENTAL MISSION



## INTERNATIONAL COOPERATION MISSION

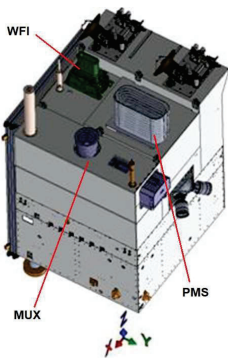
### CBERS Series

China-Brazil Earth Resource Satellite (CBERS) was approved by the joint protocol of Chinese and Brazilian governments. CBERS is invested and developed jointly by China and Brazil. Each country has 50% control.



## INTERNATIONAL COOPERATION MISSION

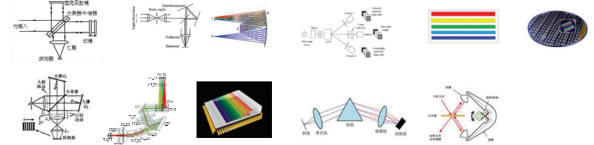
ZY-1 (04A)



Panchromatic and Multispectral camera (PMS) China	Spectral range	0.45~0.52μm 0.52~0.59μm 0.63~0.69μm 0.77~0.89μm
	GSD	2m/8m
Mux Brazil	Spectral range	0.45~0.52μm 0.52~0.59μm 0.63~0.69μm 0.77~0.89μm
	GSD	17m
	swath	90km
WFI Brazil	Spectral range	0.45~0.52μm 0.52~0.59μm 0.63~0.69μm 0.77~0.89μm
	GSD	60m
	swath	653km



## SUMMARY



China has developed almost all types of optical payloads, such as Camera, Spectrometer, Infrared camera, laser.

China has developed optical payloads for almost all technology lines, such as Coaxial, Off-axis, FTS, grating, Prism, pushbroom, scanner, Free-form.

The data quality and accuracy improve quickly, The user is on the shift from "can use" to "good use" and then to "love to use".

There are many chances to cooperate with China, especially in Climate Change field and deep space exploration.

Thanks!

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