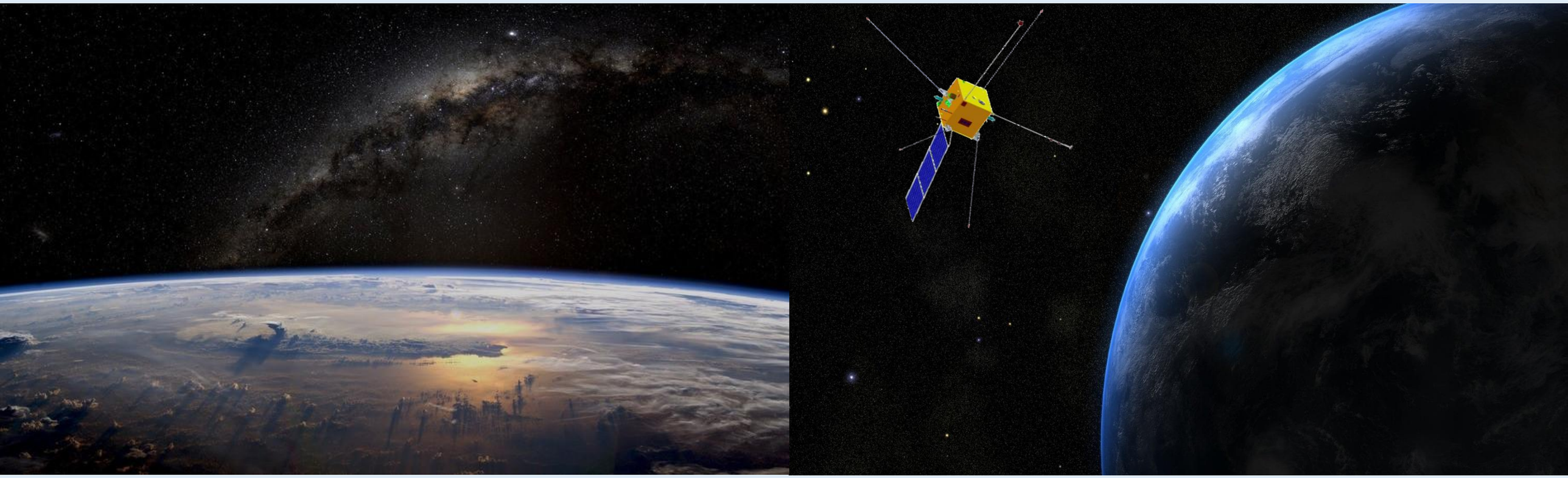
The Mission of the China Seismo-Electromagnetic Satellite



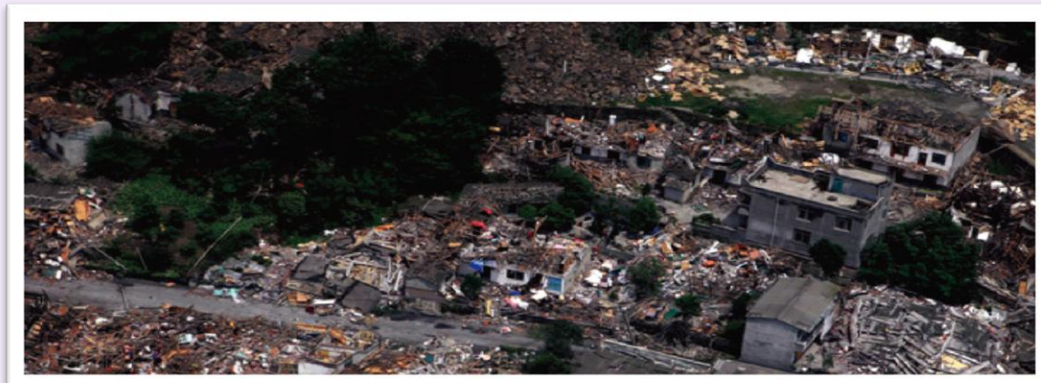
China National Space Administration (CNSA)

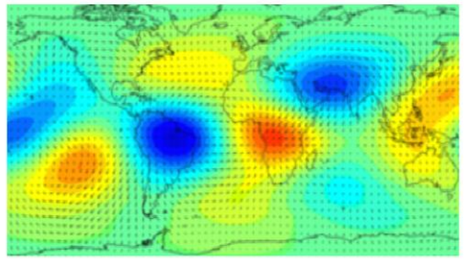
China Earthquake Administration (CEA)

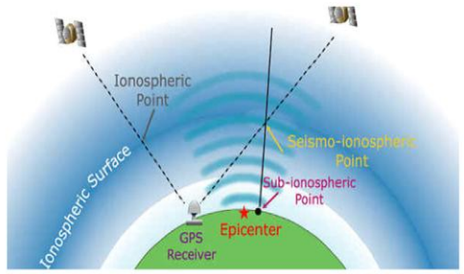
Italian Space Agency(ASI)

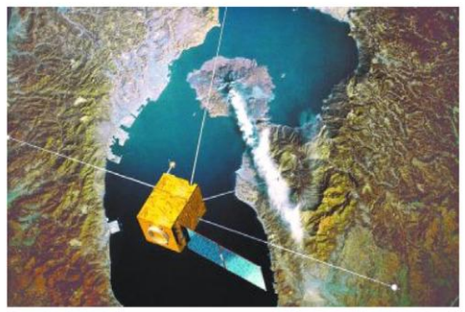
November 2014

CONTENTS：

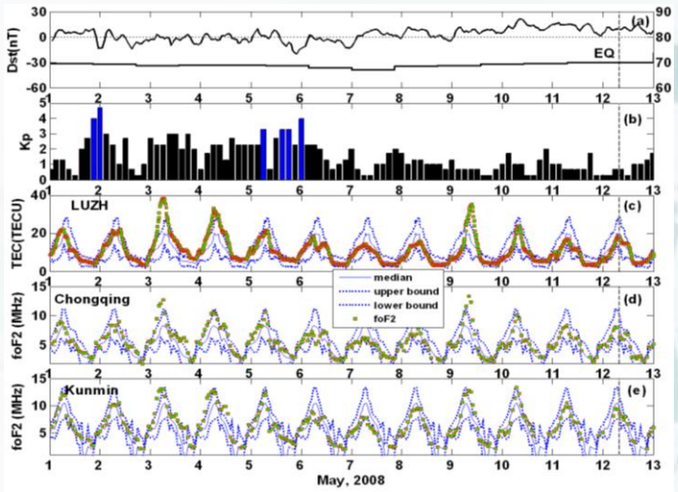






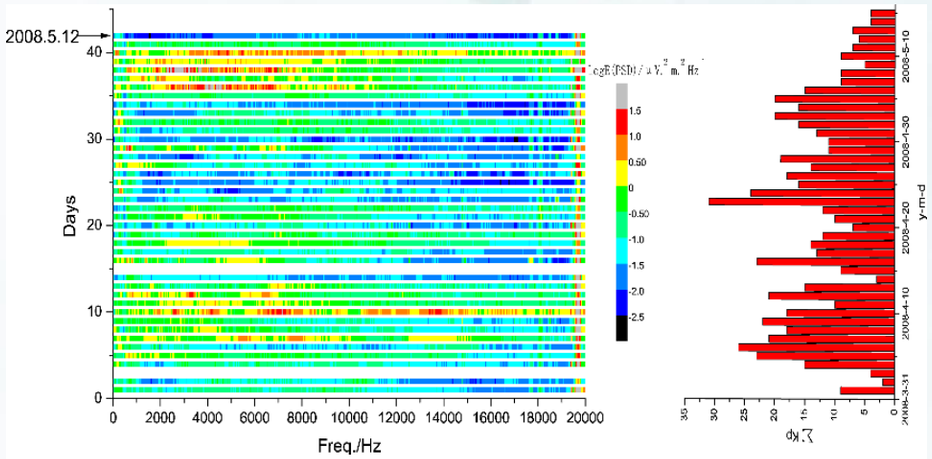


Earthquake is a very complex phenomenon with a long preparation process, however due to the low incidence of earthquake, especially the strong ones, so it is one of the most difficult challenges in the world. The positive aspect is that from several days to several hours before the shocks, some abnormal phenomena will occur, such as electromagnetic emissions in a wide frequency range, perturbations of ionospheric parameters, anomalies on the records of VLF transmitter signals and particle precipitation, which can be considered as earthquake precursors. Although we can not understand the mechanism completely, it is true that the electromagnetic emissions from the epicenter can propagate to the ground and up to the ionosphere, and can be observed by ground observation station and low-altitude satellites. So it is possible to detect all these abnormal phenomena by using satellite, and it is very helpful for us to understand the mechanism of earthquake and earthquake prediction.



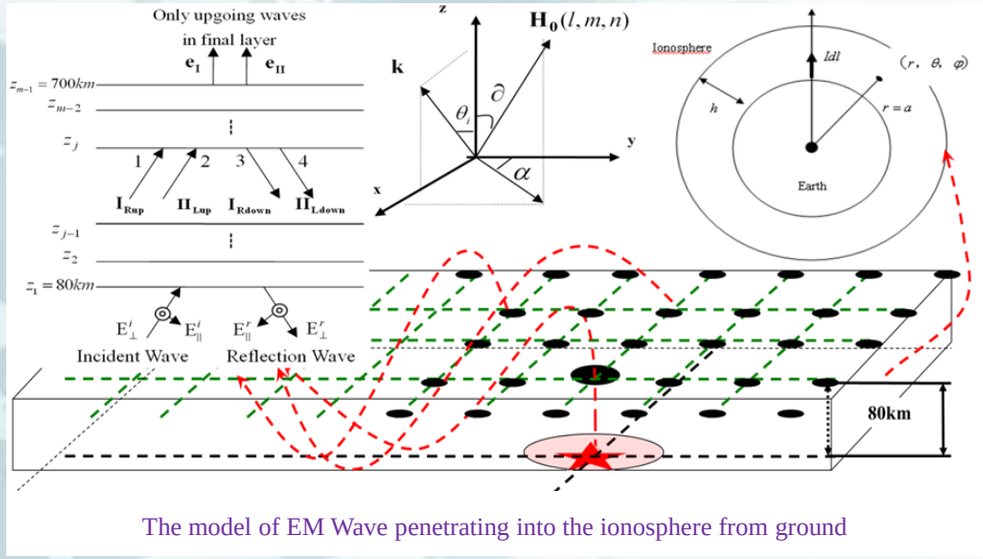
The abnormality on May 9 of local TEC and foF2 before the Wenchuan earthquake on May 12, 2008.

In the past ten years, many electromagnetic anomalies related to earthquakes have been observed by space based monitoring system. Combined with the ground based monitoring networks, it will improve the detecting abilities of abnormal information which is related to earthquakes.



The abnormality of electric field before the Wen-chuan earth-quake during May 6 and May 10, 2008

We are also developing some models and trying to find the mechanism of LAI, such as the model of EM Wave penetrating into the ionosphere from ground.



The model of EM Wave penetrating into the ionosphere from ground

China Seismo-Electromagnetic Satellite (CSES) is proposed to be the first experimental satellite for earthquake-related electromagnetic emission monitoring from ionosphere and make technical preparations for future operational satellite monitoring system in China. It is planned eight scientific payloads assembly, which will be used to monitor the electromagnetic field and its disturbance, the ionospheric environment, and to obtain the structure changing information of ionosphere below the satellite altitude. CSES Satellite will provide an approach on studying the electromagnetic disturbances related to earthquakes, recognizing the regularity and mechanism of ionosphere disturbance and studying the space physics and the interactions of atmosphere-ionosphere-lithosphere.

The 1st CSES is schedule to be launched before the end of 2016, with its life time of 5 years.

CSES is proposed to acquire the earthquake-related ionospheric disturbance. Its main scientific objectives can be described as following aspects.

Mission Objectives

- To obtain world-wide data of space environment of the electro-magnetic field, ionospheric plasma and energetic particles
- To monitor ionospheric perturbations in real-time when the satellite pass over the Chinese territory and the area close to the borders
- To study ionospheric perturbations which may be associated with earthquake activity, especially with those destructive ones
- To study the mechanism of Lithosphere-Atmosphere-Ionosphere coupling
- To support the research on geophysics, space sciences as well as electrical wave science and so on
- To provide the data sharing service for international cooperation and scientific community

Mission Specifications

Physical parameters to be detected

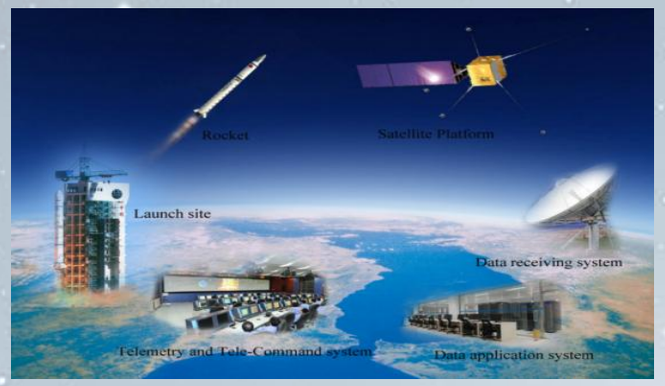
CSES detecting the magnetic field and electric field of the earth, the in-situ plasma and tomography in ionosphere and the energetic particles and so on. The main detection content and its specifications are shown in the table.

Detection Contents	Physical Parameters	Specifications
Electro-magnetic field	Electric field	DC～3.5MHz
	Magnetic field	DC～20kHz
Ionospheric plasma	TEC	—
	Ion density	$5\times10^2/cm^3$～$1\times10^7/cm^3$
	Ion temperature	500K～10000K
	Ion Components	O^+, H^+, He^+
	Electron Density	$5\times10^2/cm^3$～$1\times10^7/cm^3$
	Electron temperature	500K～10000K
Energetic particles	Proton Spectrum	3MeV～200MeV
	Electron Spectrum	200KeV～10MeV
	Pitch Angle	—

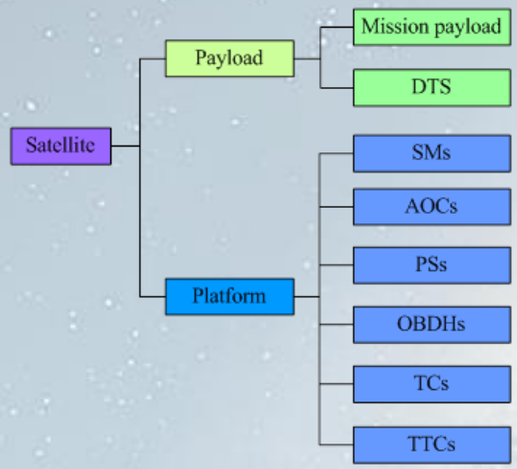
The Orbit Parameters

Style of orbit	**Sun synchronous orbit**
Attitude Control	**three-Axis Stabilized**
Altitude	**～500km**
Inclination	**～97.0°**
Local time of descending node	**14:00pm**
Revisiting period	**5 days**
Life Span	**≥5 years**

CSES mission consists Satellite system, Rocket system, Launch site system, Telemetry and Tele-Command system, Data receiving system and Data application system.



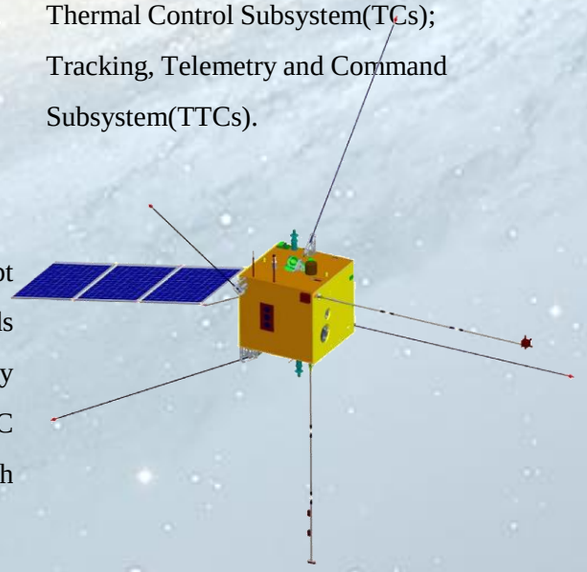
Satellite Platform



Satellite Platform subsystems include:

A. Structure and Mechanic Subsystem(SMs);
B. Attitude and Orbit Control Subsystem(AOCs);
C. Power Supply Subsystem(PSs);
D. On-board Data Handling Subsystem(ODBHs);
E. Thermal Control Subsystem(TCs);
F. Tracking, Telemetry and Command Subsystem(TTCs).

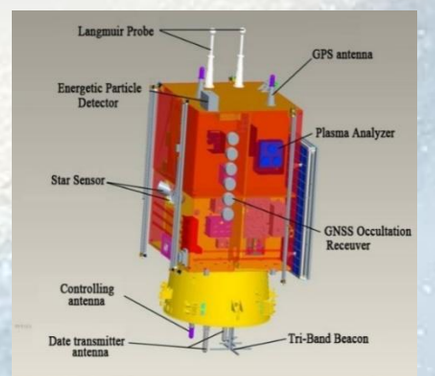
The preliminary design of CSES will adopt CAST-2000 platform with eight payloads onboard. In order to achieve high accuracy electromagnetic field detecting, a strict EMC is adopted to the satellite platform and each payload.

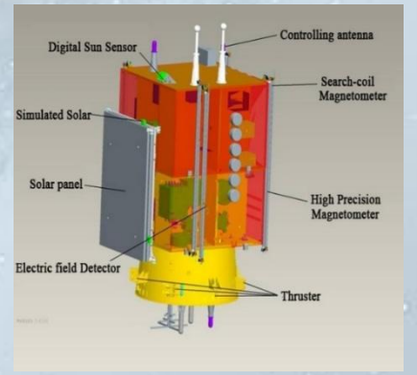


Satellite System

Payload Assembly

To achieve the observation objective in terms of electro-magnetic field, plasma and energetic particle, 8 different payloads are onboard， namely Electric field detector, Search-Coil Magnetometer, High Precision Magnetometer, GNSS Occultation Receiver, Tri-Band Beacon, Plasma Analyzer, Langmuir Probe, Energetic Particle Detector. The data transmission via X-band, which could accomplish coding, storage, modulation and transmission of payload information.





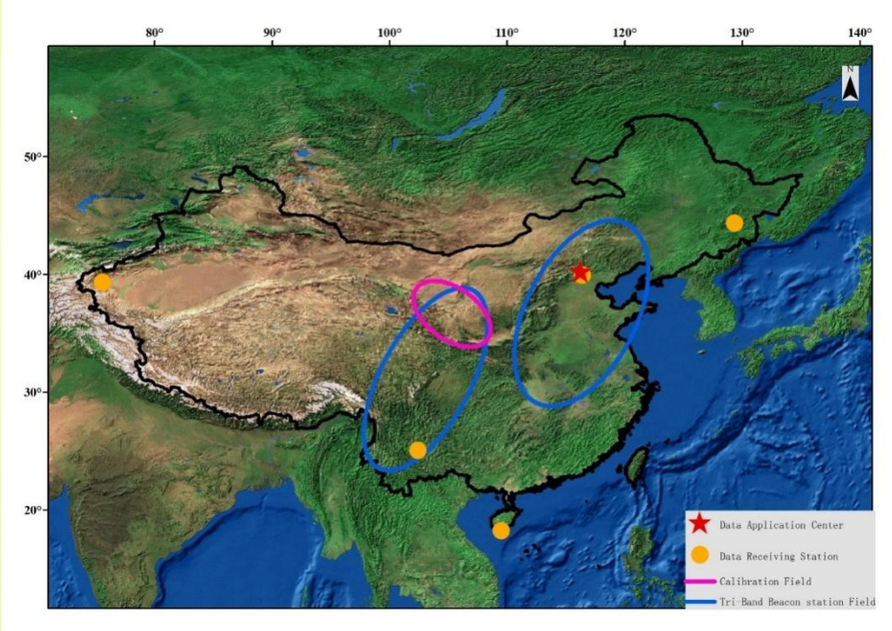
Detection Contents	Physical Parameters	Payload	Developing Institutions
Electro-magnetic field	Electric Field Intensity	Electric field detector	Lanzhou Institute of Physics, CAST
	Magnetic Field Intensity	Search-Coil Magnetometer	Beihang University
		High Precision Magnetometer	Center for Space Science and Application, CAS, together with Austria Space Institute
Plasma	Total Electron Content electron density profile	GNSS Occultation Receiver,	Space Star Technology Co., Ltd.
		Tri-Band Beacon	Institute of Electrical Wave Propagation of China
	Ion Density	Plasma Analyzer	Center for Space Science and Application Research, CAS
	Ion Temperature		
	Drifting Velocity		
	Ion Components		
	Electron Density	Langmuir Probe	Center for Space Science and Application Research, CAS
	Electron Temperature		
Energetic articles	Proton Energy Spectrum, flux	Energetic Particle Detector	Institute of High Energy Physics, CAS; Italian National Institute of Nuclear Physics
	Ion Energy Spectrum, flux		
	particle identification		
	Pitch Angle		
	X ray energy spectrum		

Ground Segment

Data Receiving System

The Data Receiving System was designed to fulfill the task of data receiving, data management, data preprocessing and data transferring to data application system.

The Data Receiving System includes 5 data receiving stations, namely Beijing, Mudanjiang, Kashi, Sanya and Kunming. It has the ability to receive, preprocess and manage the real-time and non-real-time monitoring data of the electromagnetic field and ionosphere all over the world.

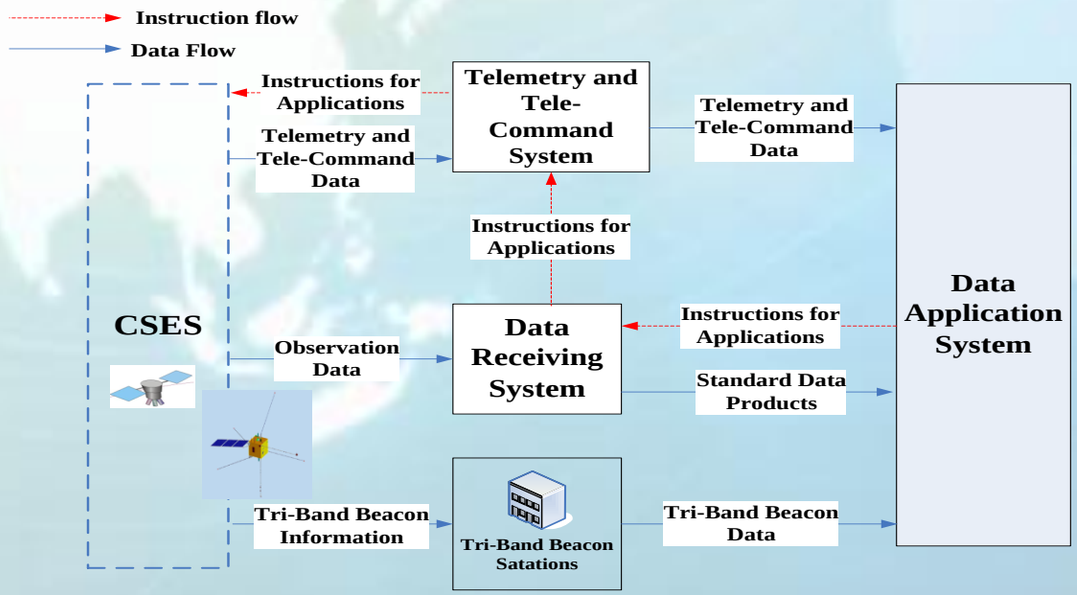


Ground segment of CSES

Data application System

Main Tasks

- To fulfill the operation and management requirements of CSES.
- To verify and evaluate the data from the satellite.
- To process the data and produce different level data according to the scientific data processing level.
- To extract the seismo-electromagnetic signals around earthquakes of Ms≥6 within Chinese territory and its neighboring area and Ms≥7 in globe. To test the possibility for short-term earthquake forecasting experimentally in terms of satellite observation.
- To study the LAI coupling mechanism by using CSES data.
- To provide data sharing for other scientific research, such as space weather, meteorology, aerospace, Navigation and communication.



Data Products

The data of CSES are classified into raw data, standard data and application data.

- Multi -band waveform and spectra of electric and magnetic field
- Vector and scalar geomagnetic field
- In-situ plasma parameters including electron and ion density, temperature in ionosphere
- Electron density profiles and tomography
- Energetic particle flux and energy spectra
- Data results applied to seismic monitoring and tracing
- Case study data of ionospheric perturbations associated with earthquakes which magnitude is larger than Ms6 in China and Ms7 around the world
- Geomagnetic field model, ionosphere model, as well as other related scientific research products

Data Distribution and Share Policy

- CSES Data Application Center is responsible for data distribution
- Level 2 scientific data shall be free for scientific and public affairs
- Accessing to the data shall be authorized