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The Experimental Satellite on Electromagnetism Monitoring

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ABSTRACT

The Experimental Satellite on Electromagnetism Monitoring (ESEM) was proposed in 2003 and proved in 2013 after 10-years' scientific demonstration. The ESEM mission was proposed to be the first satellite of space-based geophysical fields observation system in China with a lot of application prospects in earthquake science, geophysics, space sciences and so on. And coincide with the mission objectives, the satellite decides to use the Circular Sun Synchronous Orbit with an altitude of 507 km and descending node time at 14:00 LT. The payload assemble includes 8 instruments, Search-Coil Magnetometer, Electric Field Detector, High precision Magnetometer, GNSS occupation Receiver, Plasma Analyzer, Langmuir Probe, Energetic Particle Detector, and Three-frequency Transmitter. According to the planned schedule, the satellite is due to be launched in 2016–2017 and will be onboard operated for 5 years.

KEY WORDS

Experimental satellite, Electromagnetism monitoring, Ionospheric perturbation, Space segment, Ground segment

The Experimental Satellite on Electromagnetism Monitoring was proposed in 2003 and has been demonstrated during the last 10 years with funding from China National Space Administration (CNSA), the Ministry of Sciences and Technologies (MOST), the National Scientific Foundation of China (NSFC) and China Earthquake Administration (CEA). And according to "The National Earthquake Disaster Prevention and Mitigation Plan (2006–2020)", "The 12th Five-Year Plan on Civil Space Developing" and "The National Earthquake Science and Technology Developing Plan (2007–2020)", the Experimental Satellite on Electromagnetism Monitoring (ESEM) was officially approved by China National Space Administration and Ministry of Finance of the People's Republic of China in 2013 and is due to launch in 2016–2017.

1 Scientific Objectives and Mission Contents

1.1 Scientific Objectives

The ESEM mission was proposed to be the first satellite of space-based geophysical fields observation system in China with a lot of application prospects in earthquake science, geophysics, space sciences and so on. The objectives of the mission are described in the following.

- To obtain world-wide data of space environment of the electromagnetic field, ionospheric plasma and energetic particles, especially those ones of the real-time observation when the satellite pass over the Chinese territory.
- To monitor and study the ionospheric perturbations which may possibly associated with earthquake activity, especially with those destructive ones.
- To monitor and research the Earth's near-Earth space environment, as well as to explore the impact of human activity on that.
- To analyze the features of seismo-ionospheric perturbations, in order to test the possibility for short-term earthquake forecasting experimentally in terms of satellite observation. To explore the new approaches for short-term and imminent prediction.
- To support the research on geophysics, space science as well as electrical wave science and so on.
- To provide the data sharing service for international cooperation and scientific community.

1.2 Mission Contents

According to the scientific objectives, the ESEM mission concerns various physical parameters including electromagnetic field, electromagnetic waves, ionospheric plasma in-situ parameters and structure disturbance, and high energy particle disturbance, *etc*. The detail parameters are as following.

(1) Measurements of background magnetic field in the space

- 3-component of magnetic field with frequency band from DC to15 Hz.

(2) Measurement of signals from electromagnetic emission

- 3-component magnetic field with frequency band of 10–20 kHz.
- 3-component electric field with frequency band of 0–3.5 MHz.

(3) Measurement of plasma in-situ parameters and profile structure

- Electron and ion temperature.
- Electron and ion density.
- Measurement of TEC and Plasma Profile.

(4) Measurement of energetic particle precipation

- Energetic particle spectrum from 200keV–200 MeV.
- Pitch angle.

1.3 Main Physical Parameters to Detect

Based on the characters of seismo-ionospheric perturbations and current level of technology, physical parameters to be detected are listed in Table 1.

Tab. 1 Detecting physical parameters of CSES

Detecting content	Physical parameters	Frequency and scope
Electromagnetic field	Magnetic field	DC–20 kHz
	Electric field	DC–3.5 MHz
Plasma parameters	Total electron content	–
	Electron density	–
	Ion density	$5\times10^2-1\times10^7$ cm^{-3}
	Ion temperature	500–10000 K
	Ion component	O^+, H^+, He^+
	Electron density	$5\times10^2-1\times10^7$ cm^{-3}
	Electron temperature	500–10000 K
Energetic particle	Proton energy spectrum	3–200 MeV
	Electron energy spectrum	200 keV–10MeV
	Pitch angle	–

2 Space Segment of the Mission

2.1 Orbit Parameters

The main orbit parameters of ESEM are as following (Table 2).

Tab. 2 Main orbit parameters of the ESEM

Parameter	Design value
Orbit type	Circular Sun synchronous orbit
Orbit altitude	507 km
Inclination angle	97.4°
Local time at descending node	14:00
Recursive period	5 days

2.2 Design of the Platform

The platform of ESEM was redesigned upon the CAST2000. CAST2000 offered a standard multi-mission platform

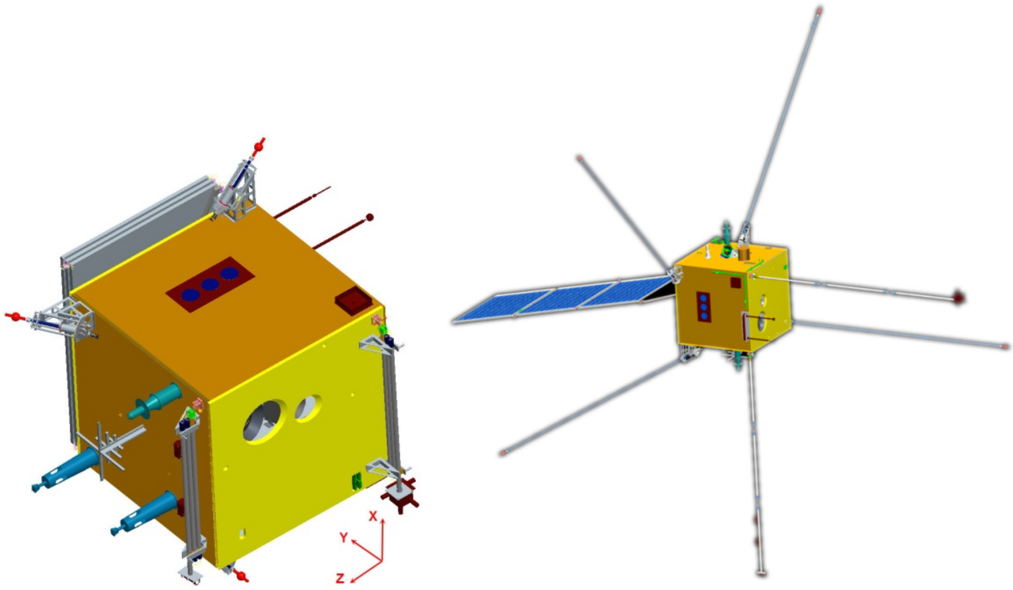

Fig.1 Launch (left panel) and flight (right panel) states of ESEM

for a very attractive cost. Technically, the platform architecture is generic, and adaptations are limited to relatively minor changes in a few electrical interfaces and software modules.

The platform includes 8 units, Data Transmission subsystem (DTs), Structure and Mechanism subsystem (SMs), Thermal Control subsystem (TCs), Attitude and Orbital Control subsystem (AOCs), Power Supply subsystem (PSs), Telemetry and Tele-Command subsystem (TTCs), onboard Data Handling subsystem (OBDHs) and scientific payloads.

Tab. 3 List of seismo-electromagnetism satellite operations and support for capacity

Parameters	Specifications
Measurement precision of orbit	Real-time orbit determination: better than 100m; Non-real-time orbit determination: better than 50cm
Attitude control	Pointing accuracy: ± 0.5°; tri-axis stabilized
Storage capacity of satellite	120 Gbits
Data transfer capacity	X-band data downloading
Life time	More than 5 years

2.3 Payloads Assemble

The scientific payloads have been selected as Search-Coil Magnetometer, Electric Field Detector, High precision Magnetometer, GNSS occultation Receiver, Plasma Analyzer, Langmuir Probe, Energetic Particle Detector, and Three-frequency Transmitter. Table 4 list their main parameters.

3 Ground Segment

The ground segment of CSES consists of scientific mission and application center, satellite ground networks, field verification bases and comparison system for satellite-ground measurement.

The scientific mission and application center, which will be on the duty of mission operation and control, data management and service, as well as earthquake science application, will be constructed in China Earthquake Administration.

The ground station of ESEM is comprised of two main parts: domestic and international stations. In China, the existed civil ground stations will be used to receive the ESEM data in real time or near-real time within the Chinese territory and in its surrounding area. The establishment of overseas ground stations should meet the needs of international cooperation and data sharing.

4 Mission Status and Planned Schedule

As mentioned above, the ESEM mission was proved in the middle of 2013 and now is in its Phase C for Primary model. Now the team is working hard to make the satellite pass the Electrical Model test in June, 2014, and turn into Phase D for Flight Model in 2015. According to the planned schedule, the Satellite is due to be launched in 2016–2017.

Tab. 4 List of payloads of seismo-electromagnetism satellite

Payloads	Physical parameter	Frequency or range
Search coiling magnetometer	3 components of magnetic field	10–20 kHz
Electric field detector	3 components of electric field	DC–3.5 MHz
High precision magnetometer	3 components of basic magnetic field	DC–15 Hz
GNSS occultation receiver	Ionospheric TEC; Electron density Ne and plasma tomography	
plasma Analyzer	Ion density	10^2–10^7 cm^{-3}
	Ion temperature	500–10000 K
	Ion components	
	Ion velocity	
Langmuir probe	Electron density	10^2–10^7 cm^{-3}
	Electron temperature	500–10000 K
	Satellite design voltage	
Energetic particle detector	Proton flux	1.5–200 MeV
	Electron flux	≥ 100 keV
Three frequency transmitter	The profiling of electron content	150, 450, 1066 MHz

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