Space Application System aboard *Tiangong* 1 and *Shenzhou* 8

September and November of 2011 witnessed the launches of the space laboratory *Tiangong* 1 and the unmanned spaceship *Shenzhou* 8, respectively. The two spacecraft later perfectly accomplished their missions in space, including the eye-catching docking in orbit with surprising accuracy.

The CAS played an important role in this docking by providing a space application system (SAS), which on the one hand conducted some science experiments and applied research in space, taking both the *Tiangong* 1 and the *Shenzhou* 8 as supporting platforms; and on the other offered a safety guarantee for the orbiting spacecraft through a ground technological support system.

Application Tasks aboard *Tiangong* 1

On the space laboratory *Tiangong* 1, the SAS mainly performed tasks in three aspects, namely earth environment monitoring, space materials experiments and space environment detection.

To support the above-mentioned space experiments, a newly developed component, the information and energy managing system for the second generation of in-orbit technological support was put into operation, and the payload application center, a module subordinated to the ground technological support system of SAS, took charge of the in-orbit tests and operational management for this flight.

Sources say a total of 23 components, all newly developed, were installed in the payload, and made their maiden journey on board the *Tiangong* 1.

Hyperspectral imaging observations from *Tiangong* 1

The in-orbit tasks for earth environment monitoring were aimed at obtaining multi-dimensional information on change in global environment for further analyses and evaluation of factors influencing environmental change and their effects.

Using a hyperspectral imager, this multi-mode experimental earth observation from the orbiting *Tiangong* 1 was designed to obtain remote sensing data for subsequent processing and application. The experiments mainly focused on the environment within the territories of China itself, and analyses of the obtained data would help scientists appraise the effectiveness of the potential applications of such monitoring.

Capable of achieving wide-spectral band and multi-waveband spectral imaging of great accuracy, hyperspectral imaging is an attractive technology on the frontiers of aerospace remote sensing applications. Boasting a nano-scale spectral resolution within a spectrum of 0.4~2.5μm, it can detect and obtain fine images of objects on the ground to perform geological surveys, resources investigations, land desertification appraisal, hydrological monitoring, and environment pollutants/sources monitoring and analysis.

Its applications have a strategic bearing on the causal research of the vulnerable environment of China's western regions, scientific development planning of its central regions and pollution control of its coastal regions.

Composite colloidal crystal growth in space

The second part, the space materials experiments involved composite colloidal crystal growth, which was to provide data for research on condensed matter physics and applications.

Colloidal crystals refer to a kind of ordered arrays of sub-micrometer or nanometer colloidal particles analogous to standard crystals in structure. The growth experiments aboard the *Tiangong* 1 were intended for studying the phase transition process of three different types of colloidal crystals in a microgravity environment.

For the very first time in the world, the growth of colloidal crystals aboard the *Tiangong* 1 adopted the Kossel diffraction method to study the kinetics of the phase transition of three types of charged colloidal crystals in microgravity. Through long-term observations, this experiment could obtain a complete series of images for the kinetics of the crystallization, to understand the crystallization and dispersion processes subject to changing temperature and a changing electric field, with the objective to explore into the law governing the phase transition of crystals and the influence of gravity on the crystallization and the crystalline structure.

This marked the first attempt of China to directly obtain data of scientific experiments through remote imaging. It was also the first time in the world to use a remotely controlled Kossel imaging system to acquire the refraction images and morphology of the involved three types of colloidal crystals. The real-time recording could facilitate online analysis and research of higher accuracy, with less interference from the collecting process of data.

Tasks for space environment detection

Tasks in the aspect of space environment detection included experiments for detection of space environment and ionospheric disturbances, as an effort to meet the demand for long-term safety guarantee in space environment of future manned space projects.

The tasks were performed by three sets of detectors: one for the radiations from electriferous particles, one for the atmospheric environment on the orbit, and the other for ionospheric disturbances. The three detectors were able to work either independently or in a synchronized way. A component for space environment control was available to coordinate their operations in the latter case.

Application tasks aboard *Shenzhou* 8

At 5:58 am on November 1st of 2011, the *Shenzhou* 8 was blasted off from the Jiuquan Satellite Launch Center in western China and successfully entered the preset orbit. The SAS performed a series of Sino-German joint experiments on space life science using the re-entry capsule of the *Shenzhou* 8 as a lab. It was the very first case of international cooperation in the field of space scientific experiments for Chinese space projects. It provided an opportunity for Chinese scientists to do research together with internationally excellent experts in the field of fundamental biological research in space, to address S&T issues pertain to human life and health. It will also help build up valuable experience on organization and management for wider international cooperation in this field.

Space life science experiments

The space life science experiments performed aboard the *Shenzhou* 8, totaling 17, involved fundamental space biology, space biotechnology, and issues on fundamental biology and space radiation biology for advance life support system.

Among them the experiments in fundamental biology were aimed at deepening the current understanding of biological phenomena and life process, covering disciplines including protein genomics, cell biology, and metabolic biology.

Targeting human life, diagnosis of complex diseases, and development of new treatments or drugs, the part of space biotechnological experiments involved growth of biological macromolecules and protein crystals in the space.

As for the onboard biological research for advanced life support systems, the main goal was to provide theoretical and technical bases for the advanced and airtight "controlled ecological life support system" (CELSS). Under this framework the research on space

Image 1: General bio-incubator for the Sino-German experiments, developed by the EADS Astrium Space Transportation in Germany.
Image 2: Controlling appliance for the payload, developed by China.

radiation biology was to deepen the human understanding of the biological effects of space radiation and microgravity, which will form theoretical and technical bases for the design of the space life safety system.

Experiment devices

A series of experimental devices were developed for the onboard scientific experiments, including special components for different experiments, general bio-incubators, and controlling appliances for the payload. The general bio-incubator was developed for observing the biological responses of various subjects to the special conditions in the space. Designed in accordance with the standards set for the experimental modules aboard the International Space Laboratory, the incubator is highly flexible: with 40 containers independent to each other, it is capable of setting and maintaining suitable life support conditions like temperature and lighting for samples of different experiments simultaneously.

As an interface between the incubator and the *Shenzhou* 8 spaceship, two controlling appliances were developed by the China side to secure the compatibility between them.

Another important role played by the SAS was to offer a safety guarantee for the spacecraft in orbit. This task was performed by the ground technological support system.

Ground technological support system

The ground technological support system developed by CAS for the space mission consists of two centers, one for payload application and the other one for space environment forecast. The payload application center provided operational management of the payload when *Tiangong* 1 and *Shenzhou* 8 orbiting the Earth, including the following:

i) Effective operation planning and operation managerial control of the payload, arranging related tests and experiments in orbit, and necessary monitoring and management;

ii) Receiving, processing, storage and distribution of scientific data and engineering parameters of the payload;

iii) Online data services, literature searching and application for users;

iv) Ephemeris and orbit forecasts for the payload; and

v) Analysis and solution of possible malfunctions of the payload in orbit.

The center for space environment forecasts released long-, middle- and short- term forecasts during different stages of the project, including forecasts of solar activities, geomagnetism indices, space environment parameters and space environment effects. Particularly, this center would send warning and alert during the journey in response to abnormal environmental events, and suggest corresponding measurements. Whenever a malfunction occurred in the payload or the platform equipment, it would provide space environment parameters reflecting the current situation, analyze causes of the malfunction/failure, and appraise the environmental effect.

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