Initial Mission Status Analysis of 3-axis stable Tsinghua-1 Microsatellite

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Abstract

The 50kg 3-axis stable Tsinghua-1 microsatellite, the first Chinese university Microsatellite will be launched in Russia by COSMOS rocket before June of 2000. This paper is planning to report the initial mission status of Tsinghua-1 microsatellite.

Tsinghua-1 Microsatellite, which is developed by Tsinghua Space Center (TSC) and Surrey Space Center (SSC), is new generational 3-axis stable Microsatellite in 50 Kg region. It is used as technical demonstration of Microsatellite constellation for globe disaster forecast net. The main Payloads include Multi-Spectral Earth Image System (MEIS) which have a 40 meters ground resolution and the cameras will be mounted 19 degrees off Z-axis of the satellite to meet the 400 kilometre ground swath requirement, Date Transmit Experiment payload which is used to survey the radio frequencies interference and GPS receiver for orbit determining .

This paper will describe the Tsinghua-1's design in detail,. Specially for the 3-axis stable controlling technology , the image payload and it's targeting technology . After it be launched, the Initial Mission Status, such as initial attitude capture, 3-axis precision control of the satellite platform and the initial images form image payloads will be published in this paper firstly.

Tsinghua-1 Microsatellite Launched

Right on schedule, at 14:37 Moscow Summer Time Wednesday 28 June, a Russian COSMOS rocket launched Tsinghua-1 into a perfect 650km sun-synchronous orbit, in the Plesetsk Cosmodrome.

Following the launch and a 1-hour ,successful separation of the Russian satellite composite from the rocket was announced. About 2-hour later , Tsinghua-1 had successfully separated from the Nadezhda main satellite and were flying free in orbit.

At 1:37 Beijing Time Tuesday 29 June, Tsinghua-1 microsatellite was contacted with Tsinghua Ground Station which is located in Tsinghua University in Bejing when Tsinghua-1 was on it's first pass over the Beijing.

This was a significant launch in many ways:

* 400th launch of a COSMOS rocket
* first ever launch from Plesetsk into a sun-synchronous orbit
* first Chinese satellite ever launched by Russia
* Tsinghua's first microsatellite

Tsinghua-1 Microsatellite

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Configuration is shown in Tab.1. The Layout of Tsinghua-1 is shown in Fig.1. The spacecraft mass is approximately 50kg measuring 350x350x640mm (excluding flexible antennas). Module trays carry the standard platform modules, and payloads and experiments. Three payload modules include the GPS, Transputer, and DSP/DTE. The cameras and wheels are accommodated in the Earth Observation

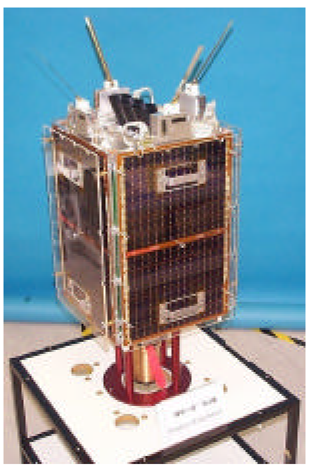


Fig.1 Tsinghua-1 Microsatellite Flight Model

2.1 Tsinghua-1 platform

2.1.1 Spacecraft configuration

The spacecraft configuration has been developed and is illustrated below. Tsinghua-1 accommodated on the space facing facet.

Tab.1 Tsinghua-1 Configuration Table

Physical Characteristics		
Envelope	330 mm X 330 mm X 640 mm (approx.)	
Mass	50 kg (approx.)	
Primary Platform Subsystems		
Attitude Control	3 axis stable control with 3 Reaction wheels and 3 Magnetorquer Gravity gradient is used as back up	≈ ±0.3° roll/pitch nadir pointing ≈ ±0.3° yaw pointing accuracy ≈ ±19° roll nadir off-pointing
Solar Panels	GaAs ≈35 W per panel (BoL)	4 fixed body-mounted panels
Batteries	7 Ah NiCd	SSTL qualified
On-Board Computing	80C186 + 16 Mbytes 80C386 + 128 Mbytes	Primary OBC Secondary OBC
	2×T805 Transputer +32Mbytes	
On-Board Data Network	9.6 kbps serial bus High speed CAN bus Ethernet bus	Single network Dual network
Communications links	9.6 kbps VHF uplink	3 single channel receivers, 2 synthesised receivers
	9.6 – 76.8 kbps UHF downlink	2 synthesised transmitters

2.1.2 **Spacecraft system block diagram**

The spacecraft system block diagram is shown in Fig.2 .The Controller Area Network (CAN) is a standard widely adopted in the automotive and process-control industries for distributed telemetry and telecommand and medium-rate data transfer with a data rate of 1.0Mbps. The

CAN provides a standard physical and data-link layer interface, above which SSTL has defined application protocols for spacecraft data transfer. Any payload with a CANinterface and on-board software implementing the SSTL application protocol can be connected directly into the Microsatellite CAN bus. In Tsinghua-1 there are two CAN bus as the primary and the secondary.

On board the spacecraft telemetry and telecommand, bootloading and file transfer protocols are implemented, with typical net dat transfer rates of 32kbps.

The imaging system includes 20Mbps links to transfer data from the cameras to the transputer. A 10Mbps Ethernet link exists between the OBC386 and transputers for bulk data transfer, supporting net data transfer rates up to 8Mbps. Experiments such as the imaging system and DSP/DTE require higher rates, dedicate d point-to-point links are employed.

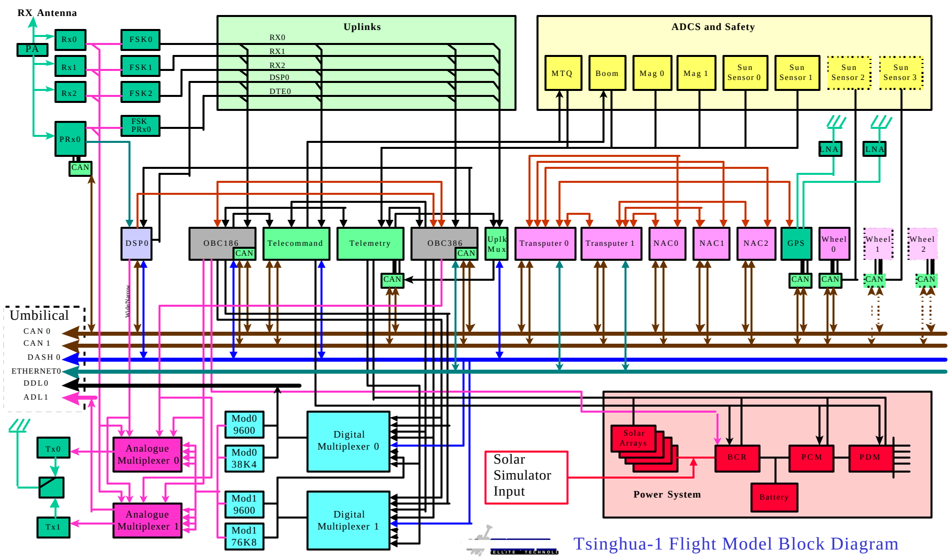


Fig.2 Tsinghua-1 Microsatellite Block Diagram

2.1.3 **Attitude Control and Determination**

The attitude control system is designed in order to provide nadir pointing for the Earth Observation Platform (EOP). This is achieved via a gravity gradient boom, magnetorquers and magnetometers.

The Tsinghua-1 is also to carry sun sensors, wheels and additional software. In order to meet the desire to image targets point accuracy ±0.3 degrees, the full three-axis control to be used , tested and validated with a safe fallback mode.

The primary operational attitude modes envisaged are

- 3-axis control with GG boom stowed
- 3-axis control with GG boom deployed
- Yaw control with GG boom deployed
- Yaw spun with GG boom deployed

In the three axis modes, the satellite is to be controlled to perform fast slew maneuvers within +/-15 degrees about the roll-axis or +/-180 degrees about the yaw-axis, and then to keep an accurate off-nadir pointing for a required period of up to half an orbit. This can be performed at lower risk with the gravity gradient boom deployed.

The imaging mode will be gravity gradient with yaw control. The cameras are mounted at 15 degrees from nadir, so that the yaw angle can be

selected to offer the required off-pointing angle (±19°) from nadir.
The nominal mode will be gravity gradient control with yaw spin, in order to maintain the optimum thermal environment for the mission.

2.2 Tsinghua-1 payloads

In tsinghua-1, the Payloads include :

- 50m Multispectral imaging system
- Wide band range DSP/DTE
- GPS
- 3-axis stable experiment

Now the main payload---Multi-Spectral Earth Imaging System is test and got perfect result.
In 650 km low Earth orbit, the MSEIS provides high quality 40-metre ground sampling multi-spectral images in 3 spectral bands using 1024x1024 pixel 2-dimensional CCD array detectors digitized to 8 bits radiometric resolution (256 levels). The image swath width is 80km and each imager can collect 4 images contiguously along the flight path. The MSEIS carries out on-board autonomous histogram analysis to ensure optimum image quality and dynamic range. After this images are processed and can be compressed using advanced scene-dependent software compression techniques using the T805 Transputers and then stored on-board the Microsatellite OBCs and RAMDISKs for later transmission to ground via digital packet error-controlled links at UHF. The OBCs can also be employed to carry out autonomous on-board cloud editing & high-compression "thumb-nail" image previews. The configuration of MEIS is shown in Tab.2.

Tab.2 The configuration of MEIS

Imaging sensor	1024x1024 pixel Eastman-Kodak KAI-1001 non-interlaced scientific sensor
Optics	colour-corrected Nikon lenses 150mm
Ground Sampling Distance	50x50 metres
Swath width	50 km, contiguous frames
Spectral bands (selectable)	0.81-0.89μm NIR, 0.61-0.69 μm red, 0.5-0.59 μm; green
Exposure control	electronic integration time & gain (1000:1)
Radiometric resolution	8-bit (256 levels) - video digitization is synchronized with pixel stream producing 8-bit quantisation (9-bit linearity)
Signal-to-noise	better that 35dB at 100% (~2000:1)
Image raw data size	1 Mbyte per spectral band per frame
Image compression	scene-dependent compression 3:1 to 5:1 (using Transputer software adaptive moment preserving block truncation coding techniques)
On-board processing	2xT805 20MHz Transputers + 32Mbytes SRAM
On-board storage	150 compressed multi-spectral images
On-board data handling	dual CAN-bus (ISO 11898 & ISO 11519-1) 20 Mbps INMOS serial point-to-point link 9600 bps asynchronous duplex (UART)

nitial Mission Status of Tsinghua-1

When the Tsinghua-1 was contacted, Following control and test program and queue have been performed .

Fig.3 Tsinghua-1 Initial Mission control queue

Some images from Tsinghua-1 Microsatellite have been achieved as foolowing:

Conculsion

In this paper, the Tsinguha-1 Microsatellite is introduced. The initial mission control and analysis is described also. The futher operation will be concentrated on precision attitude control to demonstrate the stereo-image technology and we want to demonstrate the concept of "software Satellite" and "fountion restructure" technology through the operation of Tsinghua-1 Microsatellite. We hope we can achieve much more experience which can be used in Tsinghua nanosatellite and Tsinghua-2 Microsatellite.

Finally the authors would like to thank SSTL Tsinghua-1 responsible engineers and Tsinghua team members for their great contributions for Tsinghua-1 Microsatellite.

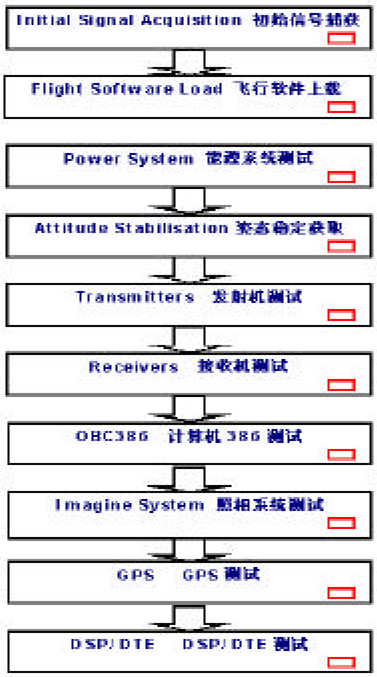
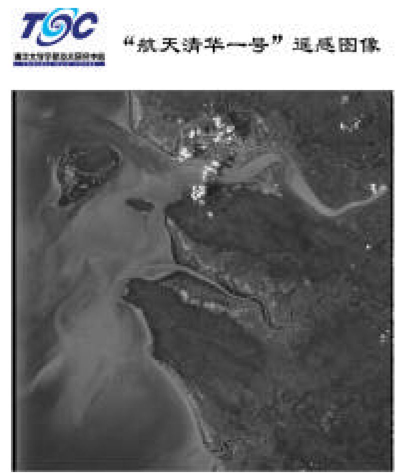
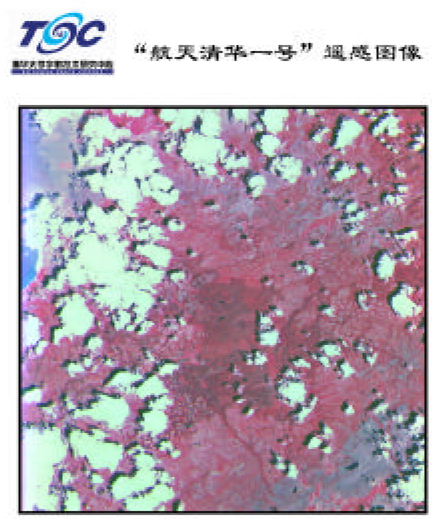
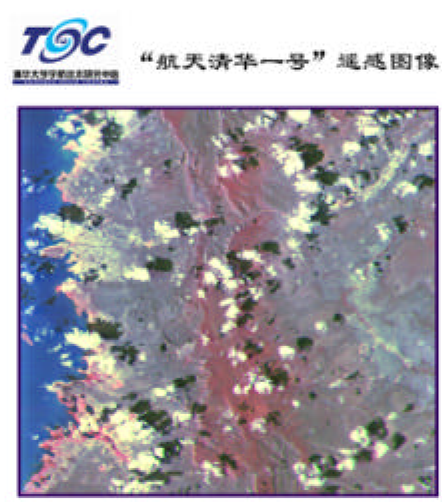


Fig.4 The first image from Tsinghua-1







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