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.

Tsinhgu-1 Microsatellite, which is developed by Tsinghua Space Center (TSC) and Surrey Space Center (SSC), is new generation 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.

Tsinhgu-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 Beijing when Tsinghua-1 was on its 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

Tsinhgu-1 Microsatellite
Tsinghua-1 Microsatellite is a new generation 3-axis stabilized Microsatellite in 50 Kg. It is used as technical demonstration of Microsatellite constellation for global disaster forecast network. 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 km ground swath requirement. Date Transmit experiments payload which is used to survey the radio Compartment. Two GPS antennas are frequencies interference and GPS receivers.

Configuration is shown in Tab.1. The Layout of Tsinghua-1 is shown in Fig.1. The spacecraft mass is approximately 50 kg measuring 350x350x640 mm (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 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 is accommodated on the space-facing facet.

<table>
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<th>Tab.1 Tsinghua-1 Configuration Table</th>
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<tr>
<td><strong>Physical Characteristics</strong></td>
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<td><strong>Envelope</strong></td>
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<td><strong>Mass</strong></td>
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<td><strong>Primary Platform Subsystems</strong></td>
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<tr>
<td><strong>Attitude Control</strong></td>
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<td><strong>Solar Panels</strong></td>
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<tr>
<td><strong>On-Board Data Network</strong></td>
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<tr>
<td><strong>Communications links</strong></td>
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</table>

### 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 1.0 Mbps. 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 CAN interface 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 data transfer rates of 32 kbps.

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

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

Fig. 2 Tsinghua-1 Microsatellite Block Diagram
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 multispectral 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.

Initial 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 following:

Conclussion

In this paper, the Tsinghua-1 Microsatellite is introduced. The initial mission control and analysis is described also. The further 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 “fountain 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.

<table>
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<th>Tab.2 The configuration of MEIS</th>
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<td><strong>Imaging sensor</strong></td>
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<td><strong>Optics</strong></td>
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<td><strong>Ground Sampling Distance</strong></td>
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<td><strong>Spectral bands (selectable)</strong></td>
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<td><strong>Radiometric resolution</strong></td>
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<td><strong>On-board data handling</strong></td>
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Finally the authors would like to thank SSTL Tsinghua-1 responsible engineers and Tsinghua team members for their great contributions for Tsinghua-1 Microsatellite.

6. References
