APSCO
Student Small Satellite China Project

Beihang University
Harbin Institute of Technology
Shanghai-Tech University

China
Outline

1. Introduction
2. Mission Tasks
3. System and Subsystem Design
4. Project Experience
5. Cooperation and Training Program
6. Summing Up
Remarks

- Qualified Team, Design & Payloads
- Fully Open Platform
- At Least 3.5kg for Experiment Payload from All
- World Level Training for All Member State

**Payloads & Subsystem**

- GS Support for all Member State
- Share of Data and Application Future TT&C
- Mature S band High Speed Downlink
Purposes of Student Small Satellite project

- Demonstrate, verify new concepts and technologies
- Hand-on space engineering practice for students
- Low-cost university micro-satellite platform
- International academic exchange and cooperation
SSS Configuration

- 3-sat Constellation (APSCO)
- SSS-1
  - 30kg Micro-sat
  - 320*320*650mm³
- SSS-2A/B
  - 3.0kg Nano-sat
  - 3U CubeSat
APSCO SSS Purpose

- Satellite Constellation for Inter-sat Communication
- Remote Sensing/Video Imaging & Transmitting
- New Technology Space Flying Demonstration

APSCO Members Education
Outline

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Mission Task 1—Inter-Sat Communication

- **Space Node:**
  - SSS-1, SSS-2A/B

- **Inter-Sat Link:**
  - 33kbps @ 600km

- **Payload:**
  - Inter-sat Transceiver Based on Gamalink
Mission Task 2
Remote Sensing/Video Imaging & Transmitting

- **Resolution:**
  - 30m

- **Data Downlink:**
  - 1Mbps @ 600km
  - S-band
Mission Task 3
(a) Sat-based Air Traffic Management

- ADS-B is a new technology recommended by ICAO in 2002 for the global air traffic management.
- There are large blind areas in mountains, desert, ocean for the ground-based air traffic management.
- Sat-based ADS-B is to realize global air traffic management.

ADS-B System and the air management situation coverage in China
Mission Task 3
(b) New Component Space Test

- Performer:
  - SSS-1
  - SSS-2A/B

- New Component:
  - GPS/BD2 Receiver
Orbit Design

- **Orbit Type**: SSO
- **Latitude**: 600km (adjustable)
- **Inclination**: 97.8°
- **Local Time of Descending Node**: 10:30 A.M.
- **Launch Site**: Taiyuan
- **TC/TM Type**: USB, UHF/VHF
- **Launch Window**: Comply with primary satellite
## System and Subsystem Design
### Payload Configuration

<table>
<thead>
<tr>
<th>Tasks</th>
<th>Satellite</th>
<th>Payload</th>
</tr>
</thead>
<tbody>
<tr>
<td>Satellite constellation for Inter-sat Communication</td>
<td>1</td>
<td>Inter-Sat Transceiver</td>
</tr>
<tr>
<td></td>
<td>2A, 2B</td>
<td>Inter-Sat Transceiver</td>
</tr>
<tr>
<td>Remote Sensing/Video Imaging &amp; Transmitting</td>
<td>1</td>
<td>RS Camera S-band Transceiver</td>
</tr>
<tr>
<td>New Technology Demonstration</td>
<td>1</td>
<td>ADS-B Receiver GPS/BD2 Receiver</td>
</tr>
</tbody>
</table>
SSS-SAT Key Characteristic

**Mass:**
<30kg

**Size:**
320 × 320 × 650mm

**Configuration:**
- Rod-layer
- Main-sat/Sub-sat
- Coilable mast

**Lifetime:**
~6 months

**Design philosophy:**
- Modular, PnP, COTS

**Power:**
- Constant: >18W
- Peak: 60W
System and Subsystem Design

SSS-1: Configuration

- Main/Sub-sat, Coilable Mast
- GaAs Solar Array + Li-ion Bat
- ARM Processor with CAN Bus
- Passive + Active (MTQ, RW)
- Passive (MLI) + Active (Heater)
- S-band TRX + UHF/VHF TRX
- Inter-Sat Transceiver
- Remote Sensing Camera
- ADS-B Receiver
- GPS/BD Receiver
- Open for MS

Platform
- Structure
- EPS
- OBDH
- ADCS
- Thermal Control
- Communication

Payload
- Inter-Sat Transceiver
- RS Camera
- ADS-B Receiver
- GPS/BD Receiver
## System and Subsystem Design
### SSS-1: Structure Subsystem

<table>
<thead>
<tr>
<th>Layer</th>
<th>Height (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADS-B Layer</td>
<td>50</td>
</tr>
<tr>
<td>Battery Layer</td>
<td>70</td>
</tr>
<tr>
<td>PCU Layer</td>
<td>57</td>
</tr>
<tr>
<td>OBC Layer</td>
<td>29</td>
</tr>
<tr>
<td>S-band Layer</td>
<td>50</td>
</tr>
<tr>
<td>L&amp;R Layer</td>
<td>90</td>
</tr>
<tr>
<td>Sub-sat(L)</td>
<td>95</td>
</tr>
<tr>
<td>Sub-sat(H)</td>
<td>95</td>
</tr>
</tbody>
</table>
System and Subsystem Design

SSS-1: EPS Subsystem

- **Solar Array**
  - Body mounted
  - 3-junction GaAs: 28%
  - Lateral Panel Power: 35W

- **Battery**
  - Lithium-ion: 30%DOD
  - Capacity: 12Ah
  - Serial voltage: 9~12V

- **Power Control Unit**
  - Power management
  - 5.2V regulated 2nd bus voltage
System and Subsystem Design

SSS-1: OBDH Subsystem

- EPS
- OBDH
- Com.
- TCS
- Mast
- ADCS
- Payload

✓ Central Power Supply
✓ Redundant CAN Bus

EPS

Battery
PCU

Solar Array 1
Solar Array 2
Solar Array 3
Solar Array 4

OBDH

OBCA
OBCB
MOBC

Communication

UHF/VHF Antenna
UHF/VHF Transceiver
S-band Transceiver

TCS

Temp. Sensors
Heaters

ADCS

Reaction Wheel
Magnetorquer
Sun Sensor
Magnetometer
MEMS Gyro
Coilable Mast

Payloads

Remote Sensing Camera
Inter-Sat Transceiver
ADS-B Receiver
GPS/BD Receiver

Coilable Mast
L&R Unit
Measurement

Communication S-band Transceiver
UHF/VHF Antenna
UHF/VHF Transceiver
S-band Transceiver

TCS

Temp. Sensors
Heaters

ADCS

Reaction Wheel
Magnetorquer
Sun Sensor
Magnetometer
MEMS Gyro
Coilable Mast

Payloads

Remote Sensing Camera
Inter-Sat Transceiver
ADS-B Receiver
GPS/BD Receiver

Coilable Mast
L&R Unit
Measurement

Communication S-band Transceiver
UHF/VHF Antenna
UHF/VHF Transceiver
S-band Transceiver
System and Subsystem Design

SSS-1: ADCS Subsystem

Active Control
- Magnetorquer
- OBC
- Magnetometer, Gyros

Passive Control
- Coilable Mast
- Passive Damper

ADCS

Gravity gradient
Aerodynamic drag
Solar radiation pressure
Magnetic disturbance

Desired Attitude

OBC

Gravily gradient bar
Damper Magnetorquers

Attitude Determination

Magnetic Sensor
Rate Gyro
GPS&BDS Receiver

Satellite

Actual Attitude
System and Subsystem Design

SSS-1: Thermal Control Subsystem

PASSIVE + ACTIVE = −10～40℃

Multi-Layer Insulation (MLI)

Thermal Paint

Electronic Film Heater

MLI—For the Whole Satellite

For the Structure and Surface

For Key Component
## System and Subsystem Design

### SSS-1: Communication Subsystem

<table>
<thead>
<tr>
<th>BAND</th>
<th>USB</th>
<th>UHF/VHF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Consist</td>
<td>Transceiver、Omni Micro-strip Antenna</td>
<td>Transceiver、Omni Whip Antenna</td>
</tr>
<tr>
<td>Function</td>
<td>Distance/velocity measurement、download data package</td>
<td>Telemetry</td>
</tr>
<tr>
<td>Power/data rate</td>
<td>&lt;6W，1Mbps</td>
<td>&lt;2W，1200bps，AX.25</td>
</tr>
<tr>
<td>G.S. location</td>
<td>Xi’an、Beijing、Nanjing</td>
<td>Worldwide</td>
</tr>
<tr>
<td>Weight</td>
<td>1.5kg</td>
<td>150g</td>
</tr>
</tbody>
</table>
System and Subsystem Design

SSS-1: Coilable Mast Design

- Consist: Longitudinal Rod, Transverse Frame, Diagonal Wirerope
- Material: Amorphous Alloy
- Size: \( \Phi 190 \times 2200 \text{mm} \)
- Deployed: EED Release, Damp Deploy
Project Experience
Facilities

- UHF/VHF Ground Station
- Vacuum System
- Vibration Test Bed
- 3-axes Rotate Platform
- Thermal Sink System
- Radiation Test Bed
Project Experience

● Facilities
Project Experience
SSS Test Based Co-Research

- STR: FEM Analysis and Test
- MECH: Deployment Test
- EPS: Balance Analysis and Test
- Solar Array Illumination Test
- OBC: OBDH Function Test
- ADCS: ADCS Simulation and Test
- TT&C: Inside and Outside Test
- TCS: Thermal Analysis and Test
- GS: Ground Station Operation
Project Experience

- Research Activities (Launched)
  - Shiyan-1 Satellite
  - Shiyan-3 Satellite
  - Kuaizhou-1,2 Satellite
BX-1: Companion satellite for SZ-7

- Mission: companion flying experiment
- Mass: 40 kg (including 1.0 kg propellant)
- Dimension: 450 mm × 430 mm × 450 mm
- Launched in 2008.9.25
- Release from SZ-7 spaceship in 2008.9.27
- Designed lifetime: 3 months
- Life in-orbit: 13 months
Project Experience
QB50 Project

- International network of 50 Cube-Sats sponsored by Von Karman Institute for Fluid Dynamics (VKI)
- Demonstration in the Lower Thermosphere

BUSAT-1 (BUAA)  LilacSat-1 (HIT)
1. Introduction
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6. Summing Up
Sub-projects Implement by China
FEM Design and Analysis

FEM MODEL

1\textsuperscript{st} X-Direction
\omega = 48.847 \text{ Hz}

1\textsuperscript{st} Y-Direction
\omega = 48.74 \text{ Hz}

1\textsuperscript{st} Z-Direction
\omega = 139.99 \text{ Hz}
Sub-projects Implement by China Vibration Test
Sub-projects plan to Implement by China
ADS-B Payload Test

- ADS-B Chinese Research Status
- BUAA Aviation traffic management technology Key lab, Pursue on ADS-B research work
- BUAA solid foundation on the aviation traffic management research fields
Sub-projects Implement by China and Others

Key Electric Components Test

- SSS-1 provides the possibility to develop various key electric components, which should meet the requirements of the system platform such as mass, dimensions and power consumption.
Suggested Cooperation Sub-projects
EPS development and Test

- EPS Energy Balance Test
- Solar Array Illumination Test

Solar Array Panel
Power controller
Li-ion Battery
Suggested Cooperation Sub-projects
OBDH development and Test

- Flat-Satellite Test
- Energy Balance Test
- Camera Imaging Test
- Mast Deploy Test
Suggested Cooperation Sub-projects

ADCS design and Simulation
## Suggested Cooperation Sub-projects

**Ground Stations (BUAAGS)**

**Location:** BUAA

<table>
<thead>
<tr>
<th>Country</th>
<th>Satellite</th>
<th>Downlink Frequency (MHZ)</th>
</tr>
</thead>
<tbody>
<tr>
<td>China</td>
<td>Hope-1</td>
<td>435.79</td>
</tr>
<tr>
<td>Japan</td>
<td>CO-55</td>
<td>436.84</td>
</tr>
<tr>
<td>Japan</td>
<td>CO-57</td>
<td>436.85</td>
</tr>
<tr>
<td>Japan</td>
<td>CO-58</td>
<td>437.47</td>
</tr>
<tr>
<td>Japan</td>
<td>CO-65</td>
<td>437.39</td>
</tr>
<tr>
<td>Japan</td>
<td>CO-66</td>
<td>437.49</td>
</tr>
<tr>
<td>Japan</td>
<td>PRISM</td>
<td>437.25</td>
</tr>
<tr>
<td>Hungary</td>
<td>MASAT</td>
<td>437.35</td>
</tr>
<tr>
<td>Turkey</td>
<td>ITUPSAT</td>
<td>145.93</td>
</tr>
<tr>
<td>Spain</td>
<td>XATCOBEO</td>
<td>437.37</td>
</tr>
<tr>
<td>Netherland</td>
<td>DELFI-C3</td>
<td>145.87</td>
</tr>
<tr>
<td>India</td>
<td>HAMSAT</td>
<td>145.86</td>
</tr>
<tr>
<td>Swiss</td>
<td>SWISSCUBE</td>
<td>437.51</td>
</tr>
<tr>
<td>Japan</td>
<td>FO-29</td>
<td>435.80</td>
</tr>
<tr>
<td>Japan</td>
<td>KKS-1</td>
<td>437.39</td>
</tr>
<tr>
<td>Japan</td>
<td>STARS</td>
<td>437.30</td>
</tr>
</tbody>
</table>
The International Amateur Radio Union

Since 1925, the Federation of National Amateur Radio Societies
Representing the Interests of Two-Way Amateur Radio Communication

IARU Amateur Satellite Frequency Coordination

Back to List of Sats formally submitted

<table>
<thead>
<tr>
<th>CAMSAT_BUAA Sat-1</th>
<th>Updated: 19 Dec 2012</th>
<th>Responsible Operator</th>
<th>Alan Kung BA1DU</th>
</tr>
</thead>
</table>

Supporting Organisation: Chinese Amateur Satellite Group
Contact Person: camsat@vip.163.com.nospam

Headline Details: A 35kg microsat with 2 metre CW beacon at 20dBm, a 2 metre AX25 beacon at 27dBm and a U/V FM voice transponder at 27dBm. The spacecraft will have gravity gradient stabilisation. Planning a launch into a 800km sun synchronous orbit from Taiyuan in late 2014.**
The following downlinks have been coordinated- CW telemetry beacon 145,835 MHz - Digital telemetry beacon 145,950 MHz- FM Voice Repeater 145,875 MHz **

Application Date: 11 Sep 2012
Freq coordination completed on 15 Dec 2012

The IARU Amateur Satellite Frequency Coordination Status pages are hosted by AMSAT-UK as a service to the world wide Amateur Satellite Community
Suggested Cooperation Sub-projects

Communication Devices and Test

UHF/VHF Test
(Indoor and Outside)

USB Test
Suggested Cooperation Sub-projects

Integrated Demonstration System

Visual Simulation System

Virtual Ground Station 3-axis Rotate-Platform
Suggested Cooperation Sub-projects
Coilable Mast Analysis and Test
Suggested Cooperation Sub-projects
Thermal Simulation

Battery Test Results

Modified Thermal Model

Model Modification

Simulation

Battery Simulation Results

Compartment Temperature
(180°/ min spin)

<table>
<thead>
<tr>
<th>Component</th>
<th>Temp (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solar Array</td>
<td>-40~20</td>
</tr>
<tr>
<td>Battery pack</td>
<td>13~22</td>
</tr>
<tr>
<td>OBC</td>
<td>26~32</td>
</tr>
<tr>
<td>Camera</td>
<td>0~13</td>
</tr>
<tr>
<td>Sub-sat</td>
<td>-7~5</td>
</tr>
<tr>
<td>Coilable Mast (Stowed)</td>
<td>-12~2</td>
</tr>
</tbody>
</table>
Suggested Cooperation Sub-projects
Thermal Vacuum Test

- Test Facilities
  - Vacuum Chamber: $10^{-3}$ pa, Φ1.8×3m
  - Thermal Sink: liquid Nitrogen, low temp range: -170 ~ -196 °C
  - Sensor Measurement Accuracy: 0.5°C
  - Infrared Heating Cage

- Thermal Model Satellite
  - MLI
  - Temp Sensor Accuracy: 0.5°C
  - Simulate Inter-satellite Thermal Resource

- Test Procedure
  - Test Time Last: 8 Hour,
  - Thermal Recycle
  - Normal, Extreme Cold, extreme Heat
  - 3 Type Of Conditions
Training Program for APSCO

1. Objectives:

- Comprehensively train students to obtain space theory, techniques, engineering and skills
- Promote new space technique research and adoption
- Academic exchange for better collaborations on space technology
- Jointly small satellite design and implementation
2. Implementation:

- Provide a series of courses on space theory, satellite design and implementation
- Provide the necessary hands-on guidance on satellite development and transfers
- Open our satellite development environments, tools and platforms to APSCO countries
Training Program for APSCO

Courses provided by us (tentatively):

- Satellite System Design
- Structure and Mechanism System Design
- Satellite Control System Design and Simulation
- Satellite OBDH System Design and Test
- Satellite TT&C Technology
- Satellite Thermal Technology
- Satellite System Engineering Management
3. Hand-on Practice:

- **R&D Phases**
  - Course, Visiting, Hand-on practice, Proposal contest, Technology workshop

- **In-orbit Test Phase**
  - Visiting, Hand-on practice, Workshop

- **In-orbit Operation Phase**
  - Course, Hand-on practice, Workshop
Training Program for APSCO

- **APSCO** International Space Education Center

  - International education in space science and technology and to conduct the training programs

  - Over 100 international students have participated in the majors of Remote Sensing and Geographic Information Systems, Satellite Communication and Global Navigation Satellite System
Based on our empirical experience of successfully launching several university satellites, we will provide the following supports:

- **Satellite system design and simulation**
- **Satellite dynamics, guidance and control**
- **Miniature technologies of small satellites**
- **Micro-satellite missions and applications**
Training Program for APSCO

- Regional Centre for Space Science and Technology Education in Asia and the Pacific (RCSSTEAP)
  - Remote sensing & communication
  - Micro satellite technology
  - Space laws
Outline

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6. Summing Up
(1) China Team are Experienced in Micro/nano-Satellite System Design, Special payloads, Constellation & Formation flight, Space Communication, Deployable Mechanism, etc.

(2) More Innovation Concepts in Science and Applications are Welcomed, China will Help in mission design and Support.

(3) China will Provide Training Service
Thank You
for Your Attention!