APSCO SSS Project

A Model of University Cooperation in Asian and Pacific
The Idea – APSCO Small Student Satellite (SSS) project was put forward during the Third Council Meeting of APSCO in September 2010.

This project try to provide the students of universities in APSCO Member States the opportunity to study aerospace technologies through hand on practice.
APSCO Small Student Satellite (SSS) Project

➢ The project finally was approved by APSCO in Oct. 2015
➢ Project Budget: 3.2 million dollars
➢ Launching service will be provided by CNSA

1 micro-satellite SSS-1
30 Kg, 350*350*650mm³

2 Cube-Sats SSS-2A, 2B
4.0 kg for each,
3U Cube-Sat
Eight Member States, including China, Turkey, Iran, Pakistan, Peru, Mongolia, Bangladesh and Thailand

➢ Beihang University was identified as the Leading University

APSCO's note to CNSA
This program aims to:

- Train students and faculties from Member States (MS) for satellite engineering through a satellite project;
- Build their own capability to develop satellites as well as payload/subsystem integrated on the satellite(s);
- Build their own capability to operate satellites and/or process image/data.
APSCO SSS Project kick-off meeting was held in Beijing (December 2016)  
(BUAA prepared most of materials for this successful meeting)
Contract signing

Contracts for SSS-1 Project
  – Beihang University

Contract for SSS-2A/B Project
  --Shanghai Jiaotong University
  Mid-east Technical University
Mission Task 1
(a) Satellite Constellation Configuration

- Performers:
  - SSS-1 (passive)
  - SSS-2A/B (maneuverable)

- Relative Distance:
  - 2.5-500 km

- Orbit Maneuver:
  - Multi-low impulse
Mission Task 1
(b) 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

- Performer: SSS-1
- Resolution: 50~100 m
- Data Downlink: 1Mbps @ 600km, S-band
Mission Task 3
(a) Sat-based Air Traffic Management

◆ ADS-B is a new technology recommend 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) Study ionosphere with radiation dosimeter

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

- Radiation dosimeter
Mission Task 3
(c) Mechanism Deploying test

- **Performer:**
  - SSS-1

- **Coilable mast & release mechanism**
System and Design

Orbit Design

- Orbit type: SSO
- Altitude: 500~700km (adjustable)

Ground station coverage for one week (5°)
System Design

SSS-1: Key Characteristics

- **Mass:**
  - ~30kg

- **Configuration:**
  - Main-sat/Sub-sat
  - Coilable Mast

- **Power:**
  - ~2018W

- **Attitude:**
  - 5°, 1° (3σ),
  - 0.1°/s, 0.01°/s,
System 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

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

Payload
- Inter-Sat Transceiver
- Remote Sensing Camera
- ADS-B Receiver
- Radiation Dosimeter

Inter-Sat Transceiver
- RS Camera
- ADS-B Receiver
- Radiation Dosimeter
## System Design

### SSS-1: Key Characteristics (Mass Budget)

<table>
<thead>
<tr>
<th>Subsystem</th>
<th>Mass (kg)</th>
<th>Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Structure Subsystem</td>
<td>8.4</td>
<td>28</td>
</tr>
<tr>
<td>TCS Subsystem</td>
<td>0.6</td>
<td>2</td>
</tr>
<tr>
<td>EPS Subsystem</td>
<td>7.5</td>
<td>25</td>
</tr>
<tr>
<td>OBDH Subsystem (harness included)</td>
<td>1.8</td>
<td>6</td>
</tr>
<tr>
<td>TTC Subsystem</td>
<td>1.5</td>
<td>5</td>
</tr>
<tr>
<td>ADCS Subsystem</td>
<td>4.5</td>
<td>15</td>
</tr>
<tr>
<td>Payload Subsystem</td>
<td>4.5</td>
<td>15</td>
</tr>
<tr>
<td>Margin</td>
<td>1.2</td>
<td>4</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>30</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

*Note: each subsystem MASS includes its own margin.*
## SSS-1: Key Characteristics (Power Budget)

<table>
<thead>
<tr>
<th>Subsystem</th>
<th>Component</th>
<th>Number of Units On</th>
<th>Power Consumption/W</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>TCS</strong></td>
<td>Battery Heater</td>
<td>2 (1 backup)</td>
<td>3.00</td>
</tr>
<tr>
<td><strong>EPS</strong></td>
<td>Power Control Unit</td>
<td>1</td>
<td>1.50</td>
</tr>
<tr>
<td><strong>OBDH</strong></td>
<td>OBCA/B</td>
<td>2 (1 backup)</td>
<td>3.20</td>
</tr>
<tr>
<td></td>
<td>MOBC</td>
<td>1</td>
<td>0.80</td>
</tr>
<tr>
<td></td>
<td>Magnetometer</td>
<td>1</td>
<td>0.50</td>
</tr>
<tr>
<td></td>
<td>GPS/BD2</td>
<td>1</td>
<td>0.30</td>
</tr>
<tr>
<td></td>
<td>Gyroscope</td>
<td>1</td>
<td>0.50</td>
</tr>
<tr>
<td></td>
<td>Magnetorquer</td>
<td>1 pack</td>
<td>3.60                5.00</td>
</tr>
<tr>
<td><strong>ADCS</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Communication</strong></td>
<td>S-band Segment</td>
<td>1</td>
<td>2.80                5.00</td>
</tr>
<tr>
<td></td>
<td>UV-band Segment</td>
<td>1</td>
<td>3.32                4.8</td>
</tr>
<tr>
<td><strong>Payload</strong></td>
<td>Camera Control Unit</td>
<td>1</td>
<td>5.00</td>
</tr>
<tr>
<td></td>
<td>Remote Sensing Camera</td>
<td>1</td>
<td>2.50</td>
</tr>
<tr>
<td></td>
<td>EED(Coilable Mast)</td>
<td>1</td>
<td>50.0</td>
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<tr>
<td></td>
<td>Encoder(Coilable Mast)</td>
<td>1</td>
<td>0.90</td>
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<td></td>
<td>Heat Knife(Coilable Mast)</td>
<td>1</td>
<td>20.0</td>
</tr>
<tr>
<td></td>
<td>ADS-B receiver</td>
<td>1</td>
<td>1.80                1.80</td>
</tr>
<tr>
<td></td>
<td>Inter-satellite linker</td>
<td>1</td>
<td>TBD                 TBD</td>
</tr>
<tr>
<td></td>
<td>Radiation Dosimeter</td>
<td>1</td>
<td>TBD                 TBD</td>
</tr>
</tbody>
</table>
## 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>
## Subsystem Design

**SSS-1: Structure Subsystem**

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<td>PCU Layer</td>
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<tr>
<td>OBC Layer</td>
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<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>
Subsystem Design

SSS-1: Thermal Control Subsystem

PASSIVE + ACTIVE = −10~40°C

Multi-Layer Insulation (MLI)
Thermal Paint
Electronic Film Heater

MLI—For the Whole Satellite
For the Structure and Surface
For Key Component
Subsystem Design
SSS-1: EPS Subsystem

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

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

- **Power Control Unit**
  - Power management
  - 5.2V regulated 2nd bus voltage
Subsystem Design
SSS-1: OBDH Subsystem

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

Central Power Supply
Redundant CAN Bus

- Battery
- PCU
- Solar Array 1
- Solar Array 2
- Solar Array 3
- Solar Array 4

- OBCA
- MOBC
- OBCB

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

- Temp. Sensors
- Heaters

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

- Sun Sensor
- Magnetometer
- MEMS Gyro
- Magnetorquer
- Reaction Wheel
- ADCS

- L&R Unit
- Measure-
- Coilable Mast

Payloads
Communication
TCS
EPS
OBDH
Com.
TCS
Mast
ADCS
Payload

Central Power Supply
Redundant CAN Bus
Subsystem Design
SSS-1: ADCS Subsystem

ADCS

Active Control
- Magnetorquer
- OBC
- Magnetometer, Gyros

Passive Control
- Coilable Mast
- Passive Damper

Gravity gradient
Aerodynamic drag
Solar radiation pressure
Magnetic disturbance

Gravity gradient bar
Damper Magnetorquers

Attitude Determination

Magnetic Sensor
Rate Gyro
GPS&BDS Receiver

Desired Attitude → OBC → Actual Attitude
Subsystem Design

SSS-1: ADCS Subsystem (Hardware Configuration)
Subsystem Design: SSS-1: Coilable Mast Design
System Design

SSS-2A/B: Key Characteristics

- CubeSat: 3U Mass:
  - ~4.0 kg
- Power:
  - ~7.5W
- Attitude:
  - 2°(3σ), 0.1°/s
- ΔV Capability:
  - 10m/s
System and Subsystem Design

SSS-2A/B: Key Components

- Body mounting solar panel, 3-axis attitude stabilization and control based on fine Sun sensor, Star tracker, reaction wheels, and micro-propulsion. UHF TT&C, and S-band transmitter.
System and Subsystem Design

SSS-2A/B: Configuration
## System and Subsystem Design Project Time Schedule

<table>
<thead>
<tr>
<th>Phase</th>
<th>Content</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Kick-off</td>
<td>T0</td>
</tr>
<tr>
<td>A</td>
<td>Preliminary Requirement Phase</td>
<td>T0+4 months</td>
</tr>
<tr>
<td>B</td>
<td>Preliminary Design Phase</td>
<td>T0+10 months</td>
</tr>
<tr>
<td>C</td>
<td>Critical Design Phase</td>
<td>T0+22 months</td>
</tr>
<tr>
<td>D</td>
<td>Flight Model Development and Joint Test Phase</td>
<td>T0+33 months</td>
</tr>
<tr>
<td>E</td>
<td>Launch and On-orbit Assessment Phase</td>
<td>T0+36 months</td>
</tr>
<tr>
<td></td>
<td><strong>Total Project R&amp;D Period</strong></td>
<td><strong>36 months</strong></td>
</tr>
</tbody>
</table>
Most special aspect of the project — **Training/education**

(1) **long-term trainings**

Master programs for small satellite technologies at Beihang University.

The students from APSCO MSs who join the program will conduct the hand-on small satellite design and development works under professors of Beihang as well as experts of China aerospace industry.

(2) **Short-term trainings**

3 times of Summer Camps in the 3 summers of year 2017, 2018 and 2019.
On the Base of APSCO Education & Training Center, Regional Centre for Space Science and Technology Education in Asia and the Pacific (RCSSTEAP), established in the later of 2014.

4 Directions of the Center

- Remote Sensing & Communication
- Global Navigation Satellite System
- Micro Satellite Technology (New)
- Space laws (New)

Doctoral Program: Space Technology Application (DOCSTA)
1st Summer Camp of APSCO SSS Project
Hosted by Beihang University
Co-organized by China Academy of Space Technology (CAST), China Academy of Launch Vehicle Technology (CALT), DFH Satellite Co., Ltd., APSCO Education and Training Center in China
1st Summer Camp of APSCO SSS Project
2nd Summer Camp of APSCO SSS Project
Hosted by Middle East Technical University
Co-organized by Space Technology and Research Institution of the Scientific and Technological Research Council of Turkey (TUBİTAK-UZAY)
Turkish Atomic Energy Authority (TAEK)
Asia-Pacific Space Cooperation Organization (APSCO)
Education/Training Activities