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

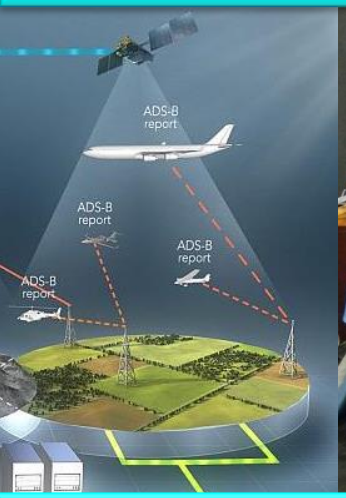
Remarks

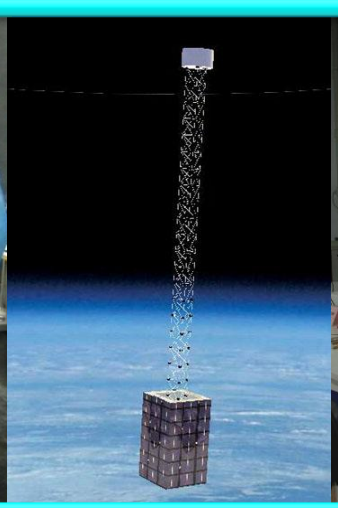
- Qualified Team, Design & Payloads
- Fully Open Platform
- At Least 3.5kg for Experiment Payload from All
- World Level Training for All Member State

  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

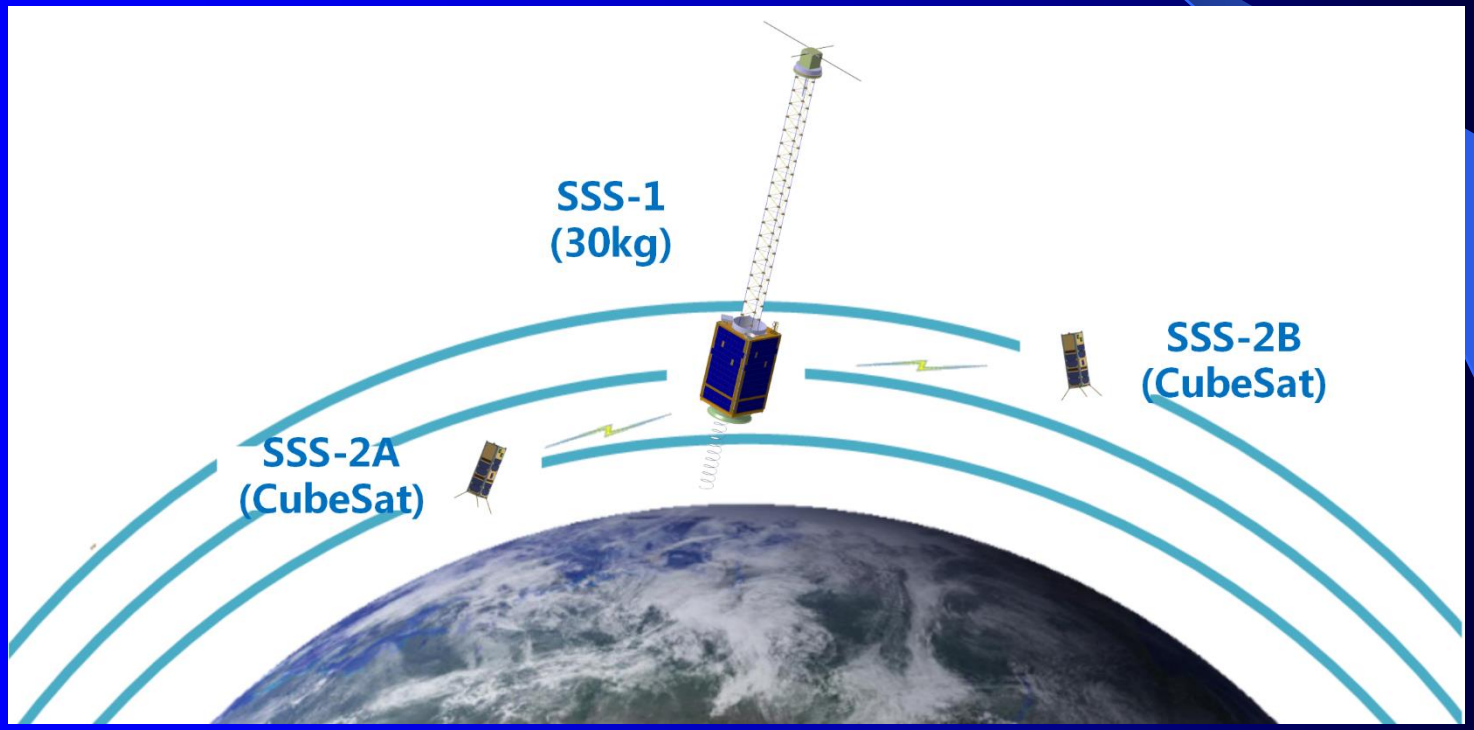
- Demonstrate, verify new concepts and technologies
- Hand-on space engineering practice for students
- Low-cost university micro-satellite platform
- International academic exchange and cooperation




SSS Configuration

- 3-sat Constellation
  (APSCO)
- SSS-1
  - 30kg Micro-sat
  - 320*320*650mm^3
- 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

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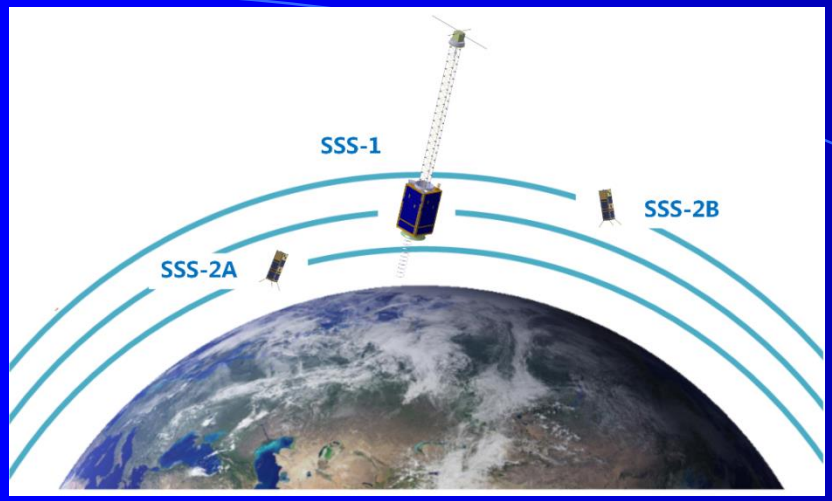
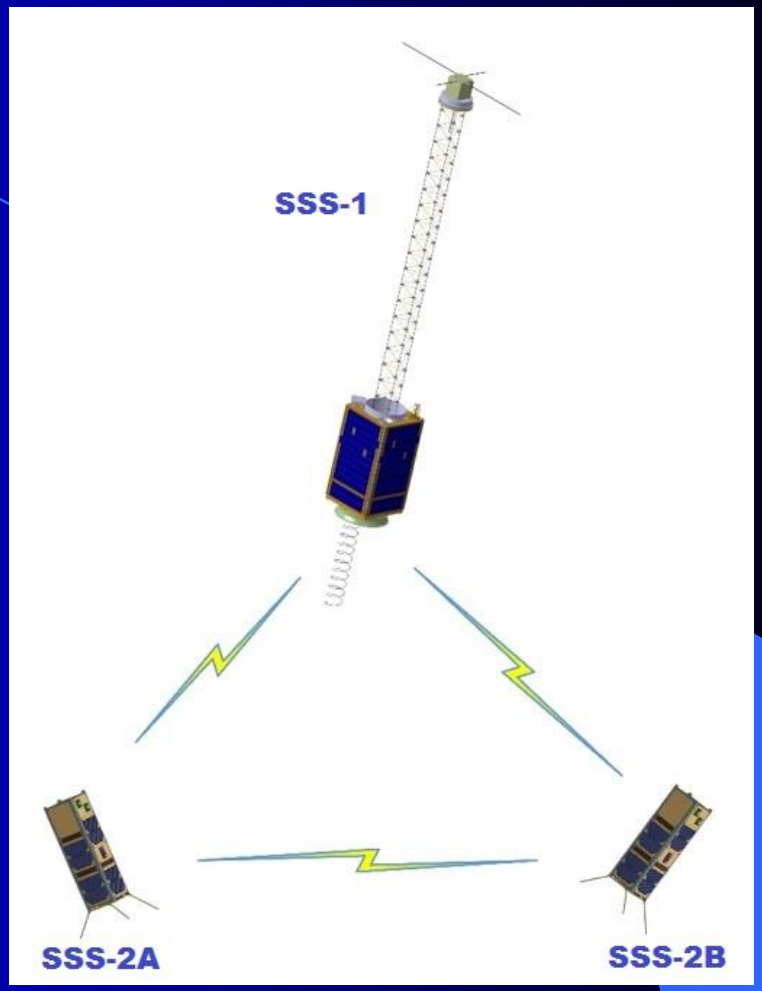
Mission Task1——Inter-Sat Communication





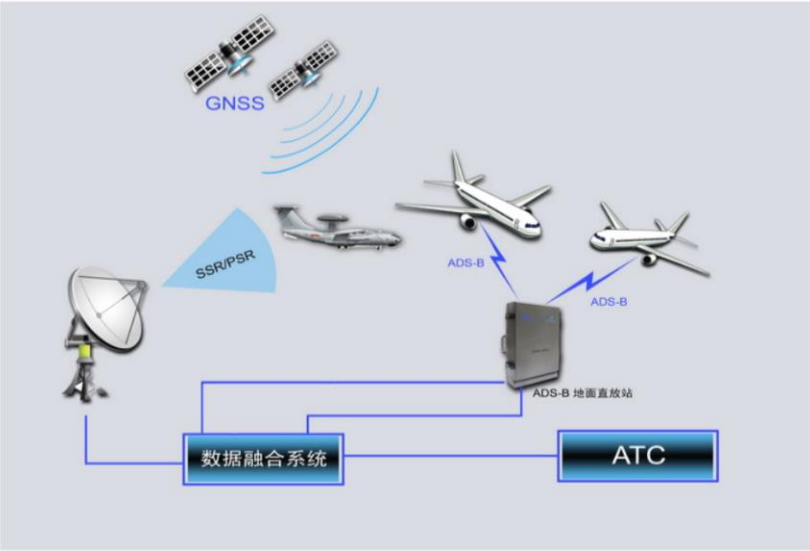
- Space Node:
  - SSS-1， SSS-2A/B
- Inter-Sat Link:
  - 33kbps @ 600km
- Payload:
  - Inter-sat Transceiver Based on Gamalink

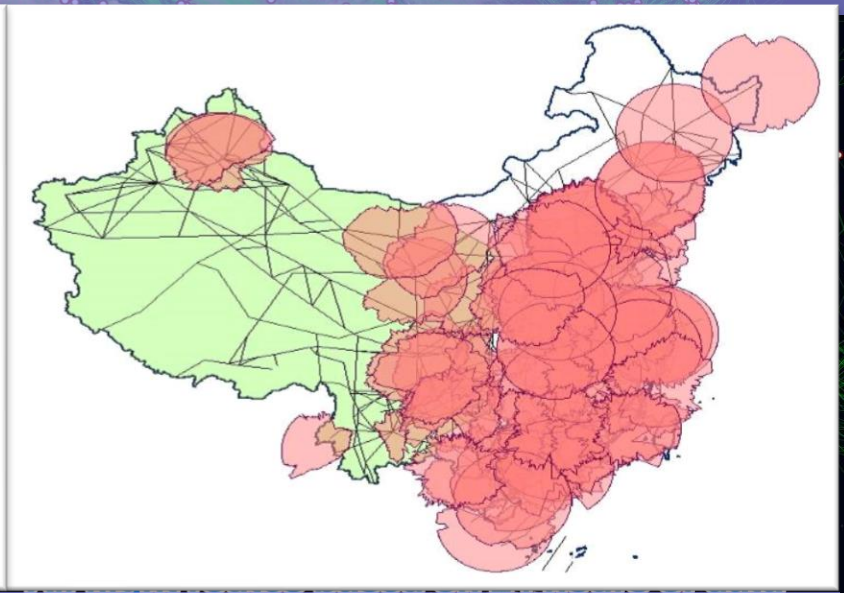
Mission Task2
Remote Sensing/Video Imaging & Transmitting

- **Resolution:**
  - 30m
- **Data Downlink:**
  - 1Mbps @ 600km
  - S-band

Mission Task3
(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

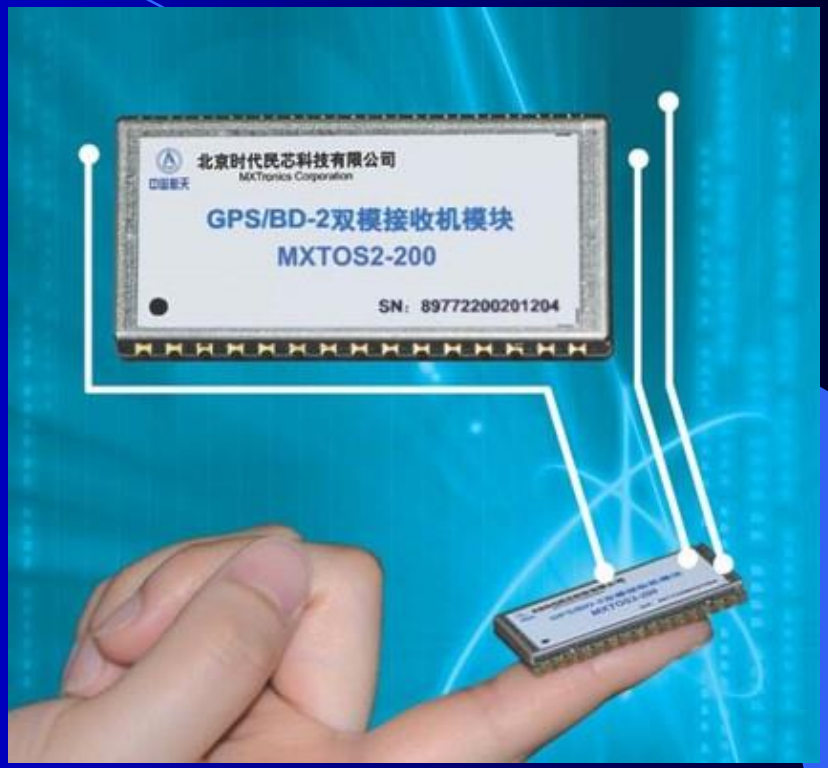




ADS-B System and the air management situation coverage in China

Mission Task3
(b) New Component Space Test

- Performer:
  - SSS-1
  - SSS-2A/B
- New Component:
  - GPS/BD2 Receiver



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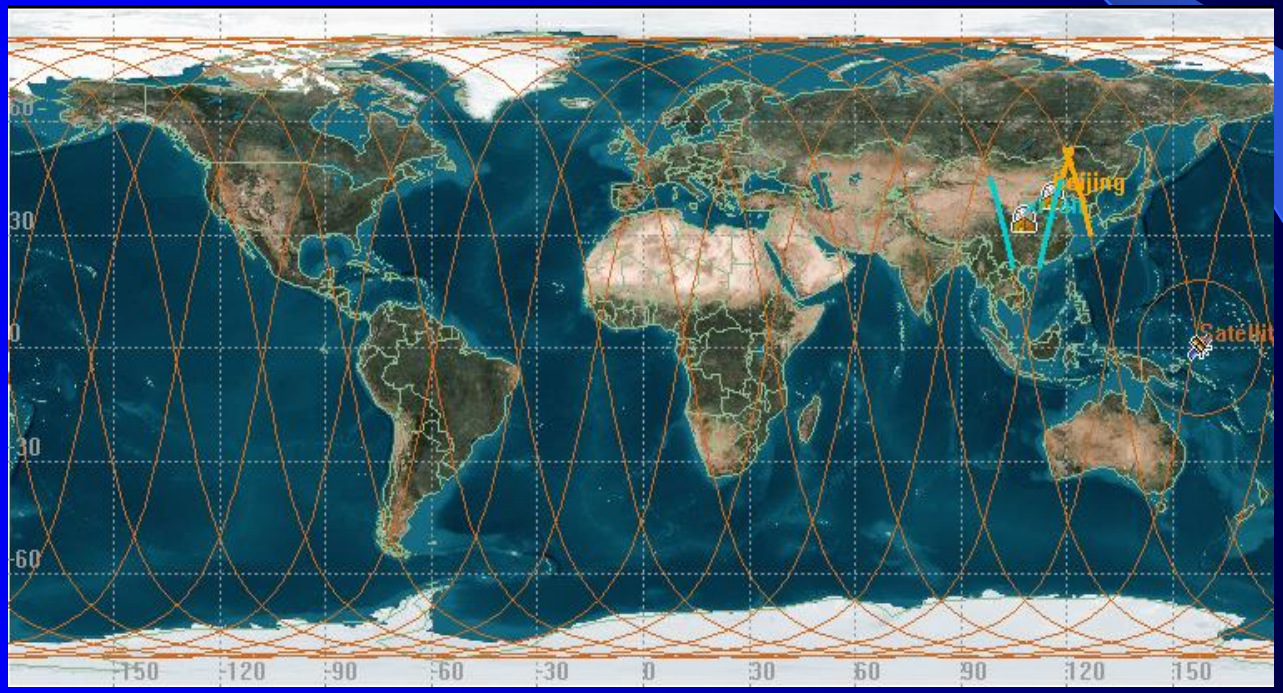
Orbit Design

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

Tasks	Satellite	Payload
Satellite constellation for Inter-sat Communication	1	Inter-Sat Transceiver
	2A, 2B	Inter-Sat Transceiver
Remote Sensing/ Video Imaging & Transmitting	1	RS Camera S-band Transceiver
New Technology Demonstration	1 ADS-B Receiver GPS/BD2 Receiver	

SSS-SAT Key Characteristic

Mass:

<30kg

Size:

320×320×650mm

Configuration:

Rod-layer
Main-sat/Sub-sat
Coilable mast

Lifetime:

~6 months

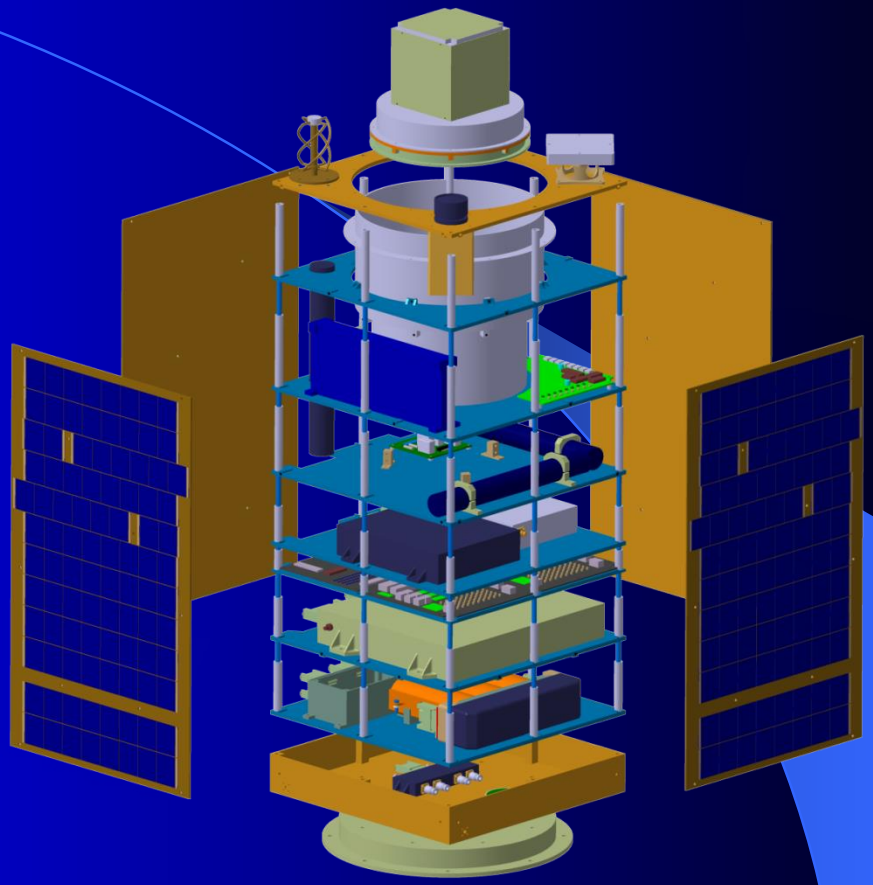
Design philosophy:

Modular, PnP, COTS

Power:

Constant: >18W

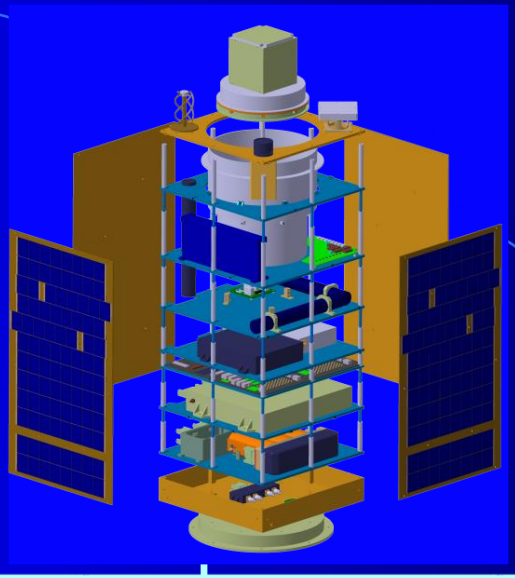
Peak: 60W



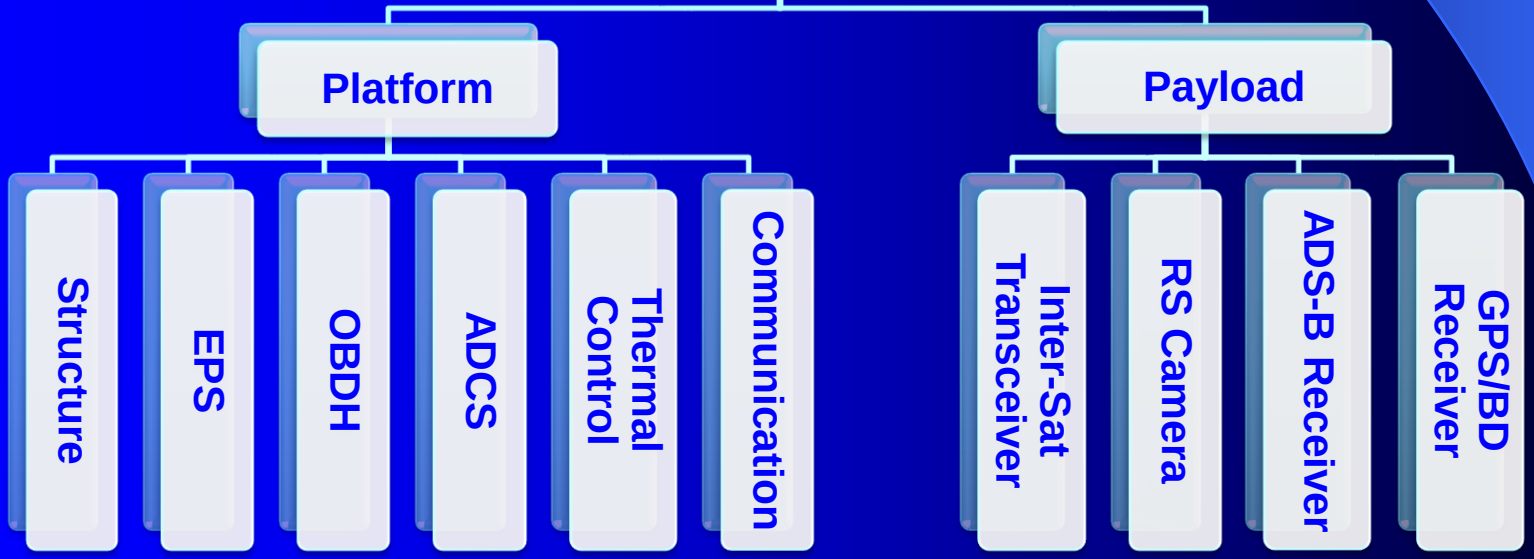
System and Subsystem Design

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



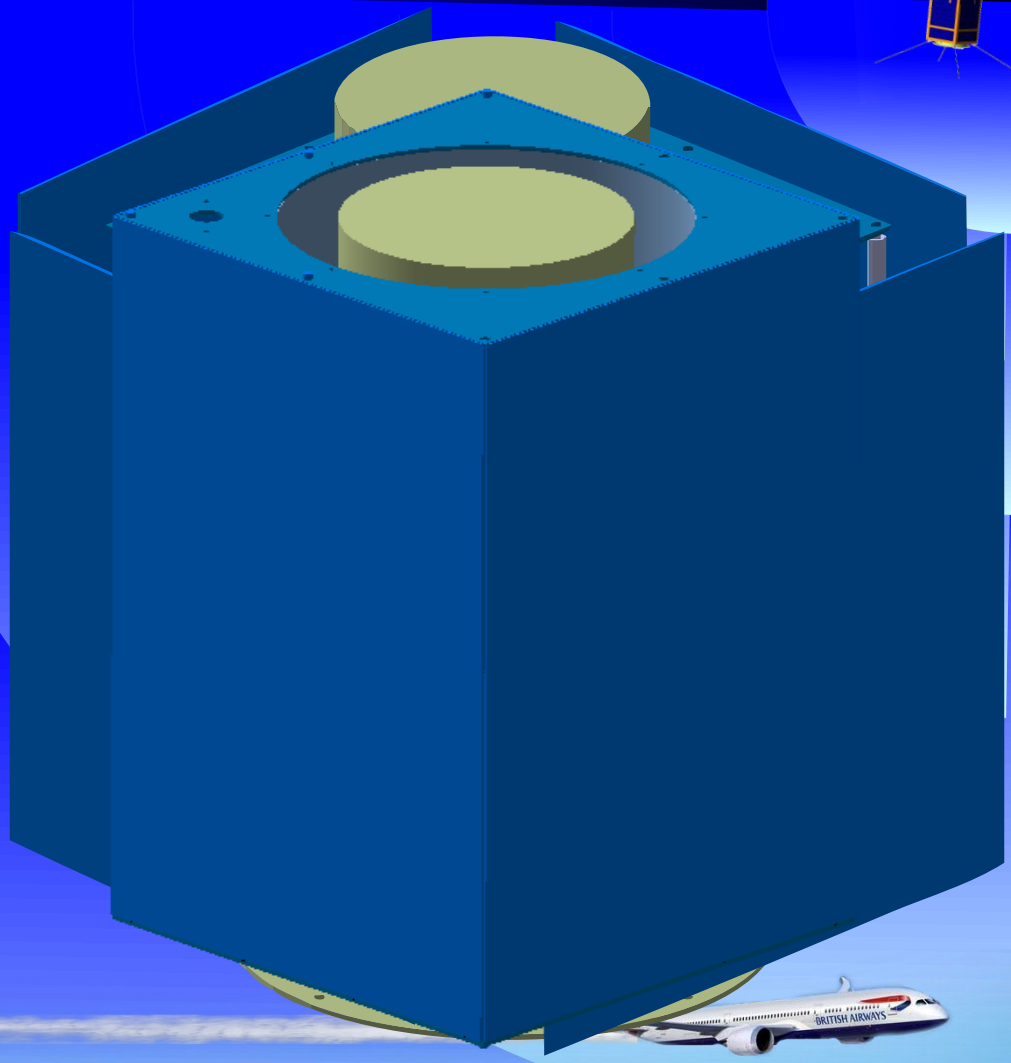
- Inter-Sat Transceiver
- Remote Sensing Camera
- ADS-B Receiver
- GPS/BD Receiver
- Open for MS



System and Subsystem Design

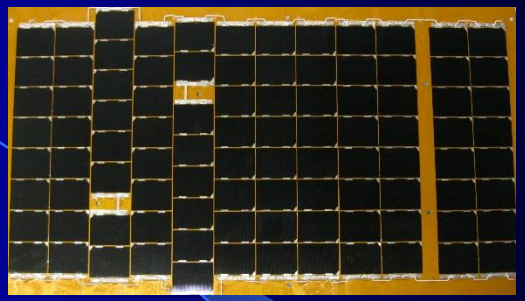
SSS-1: Structure Subsystem

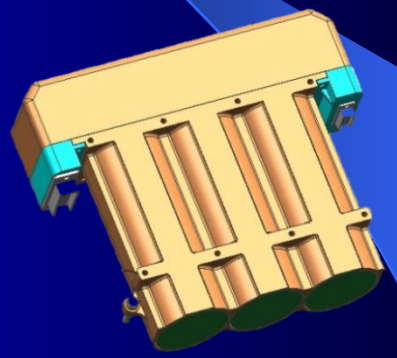
Layer	Height(mm)
ADS-B Layer	50
Battery Layer	70
PCU Layer	57
OBC Layer	29
S-band Layer	50
L&R Layer	90
Sub-sat(L)	95
Sub-sat(H)	95

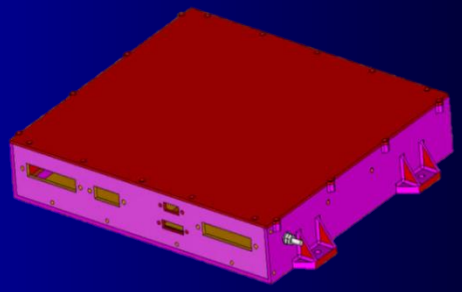


System and Subsystem Design
SSS-1: EPS Subsystem

- **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





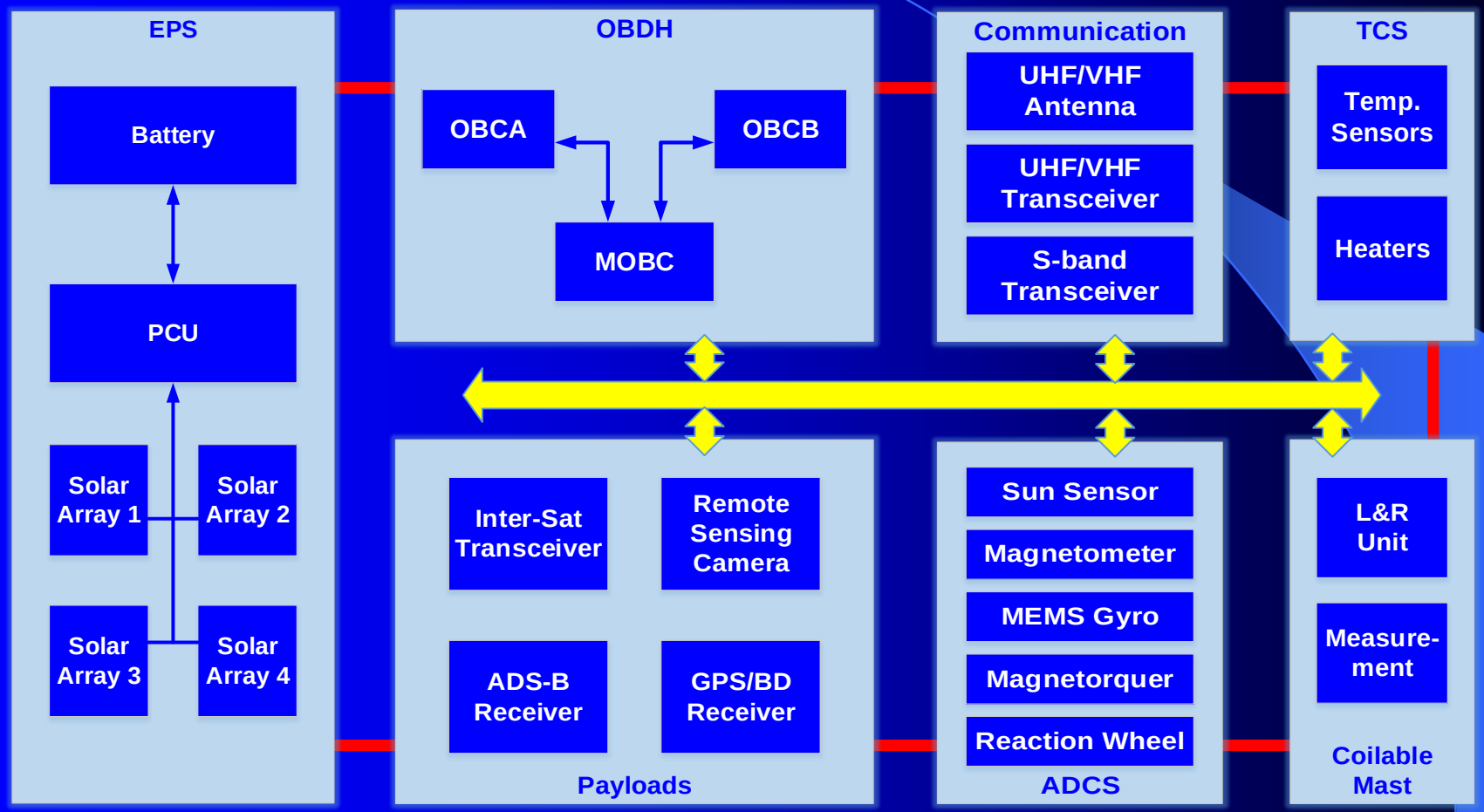


System and Subsystem Design

SSS-1: OBDH Subsystem

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

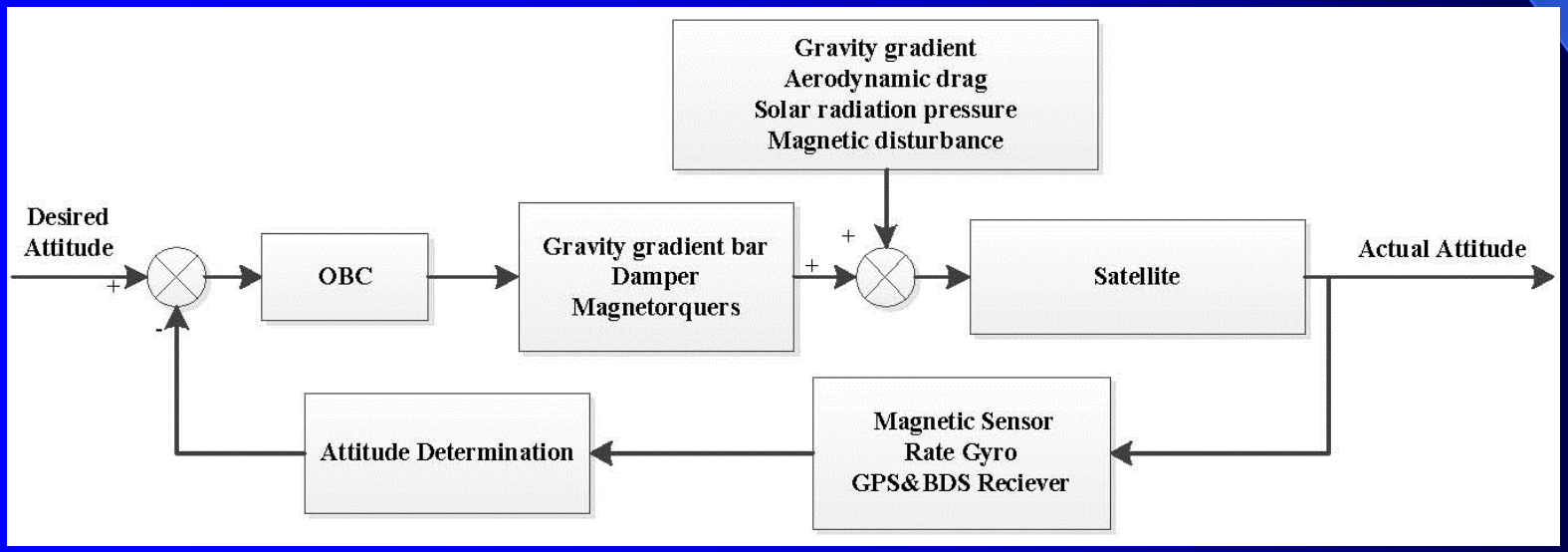
✓ Central Power Supply ✓ Redundant CAN Bus

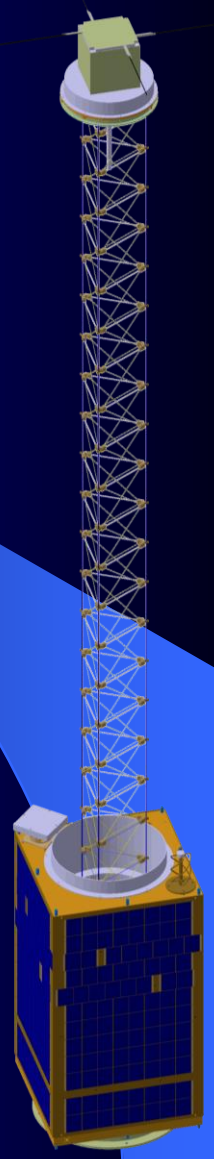


System and Subsystem Design

SSS-1: ADCS Subsystem

- **ADCS**
  - **Active Control**
    - Magnetorquer
    - OBC
    - Magnetometer、Gyros
  - **Passive Control**
    - Coilable Mast
    - Passive Damper



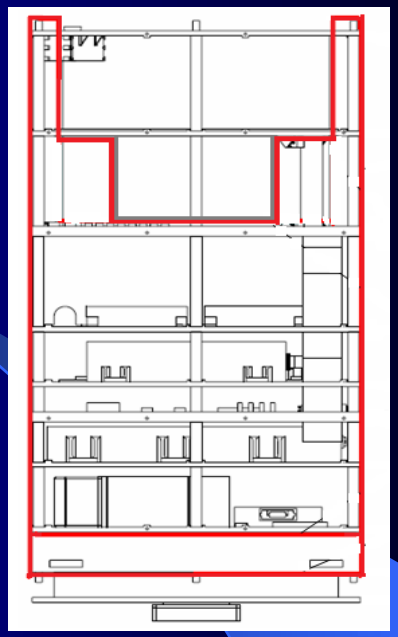


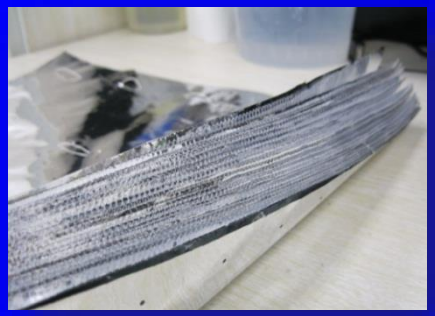
System and Subsystem Design

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

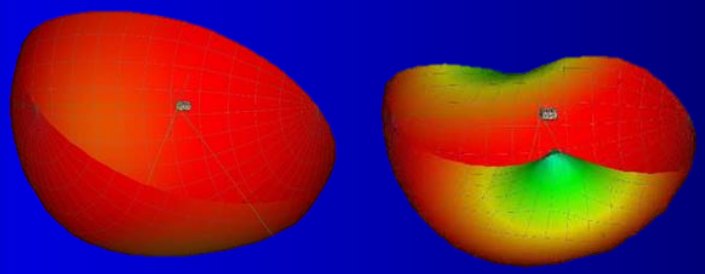
For Key Component

System and Subsystem Design

SSS-1: Communication Subsystem

BAND	USB	UHF/VHF
Consist	Transceiver、Omni Micro-strip Antenna	Transceiver、Omni Whip Antenna
Function	Distance/velocity measurement、download data package	Telemetry
Power/data rate	<6W，1Mbps	<2W，1200bps，AX.25
G.S. location	Xi'an、Beijing、Nanjing	Worldwide
Weight	1.5kg	150g

U/V Transceiver



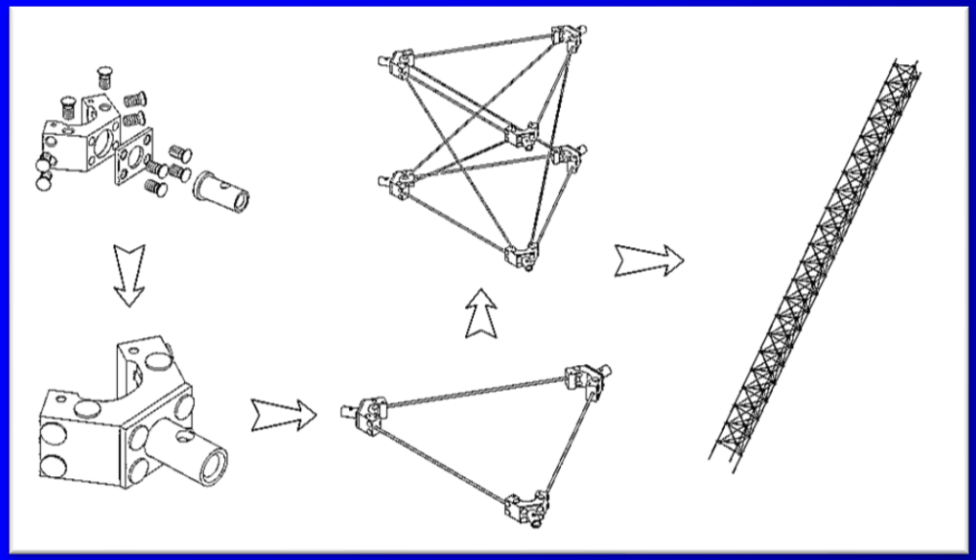
Antenna Pattern

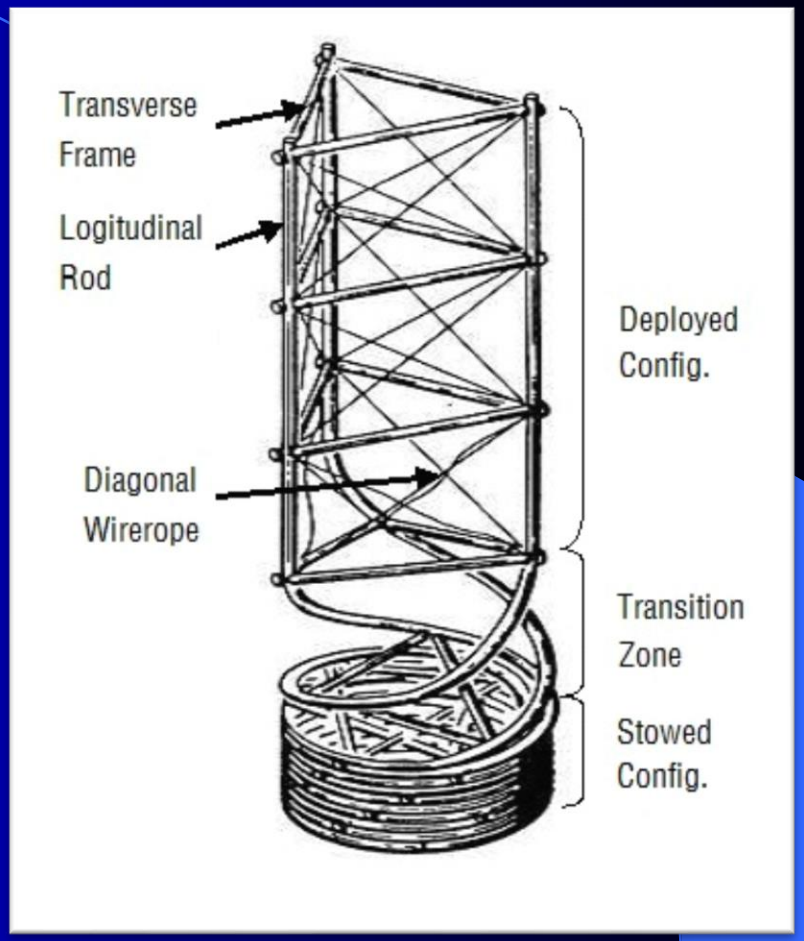
G.S. Architecture

System and Subsystem Design

SSS-1: Coilable Mast Design

- Consist: Longitudinal Rod, Transverse Frame , Diagonal Wirerope
- Material: Amorphous Alloy
- Size: Φ190×2200mm
- Deployed: EED Release、Damp Deploy





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Project Experience
Facilities

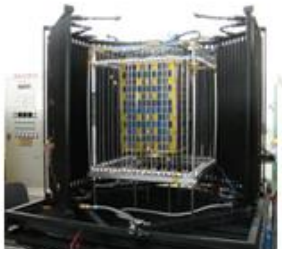
UHF/VHF Ground Station

Vibration Test Bed

Vacuum System

BUAA facilities

3-axes Rotate Platform



Thermal Sink System

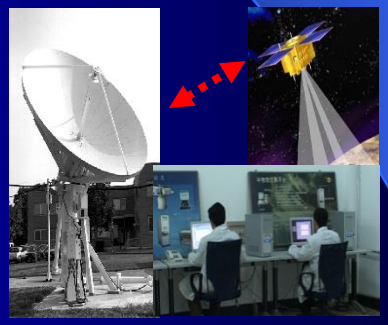
Radiation Test Bed

Project Experience

- Facilities



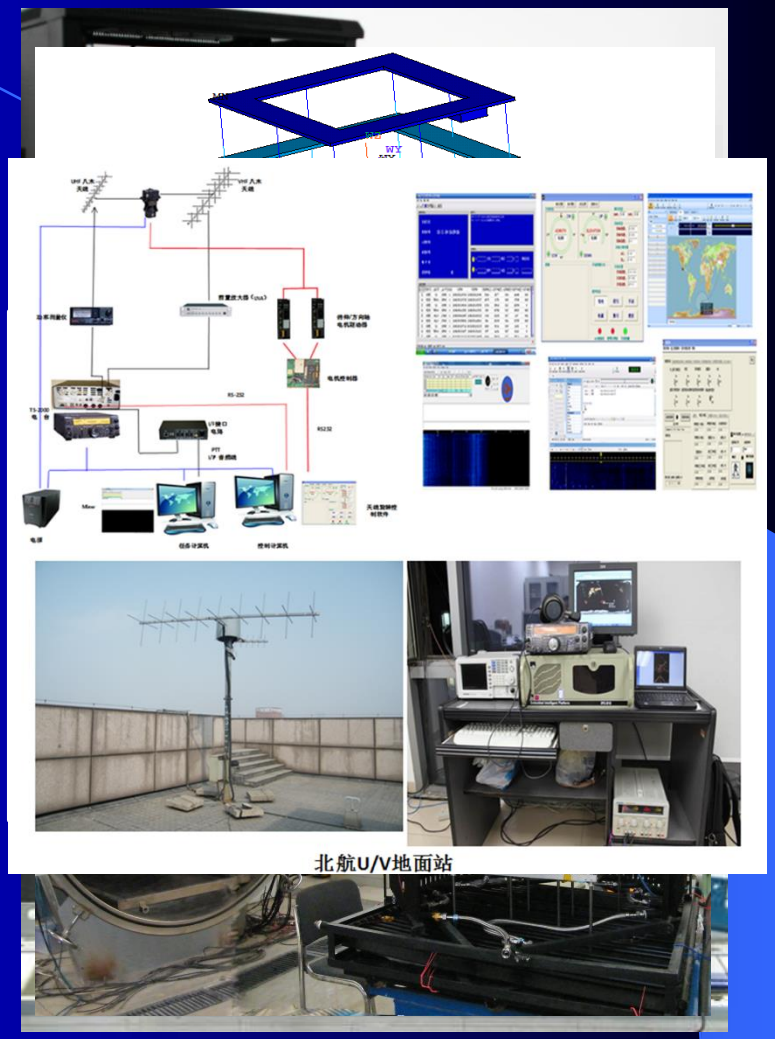



Project Experience

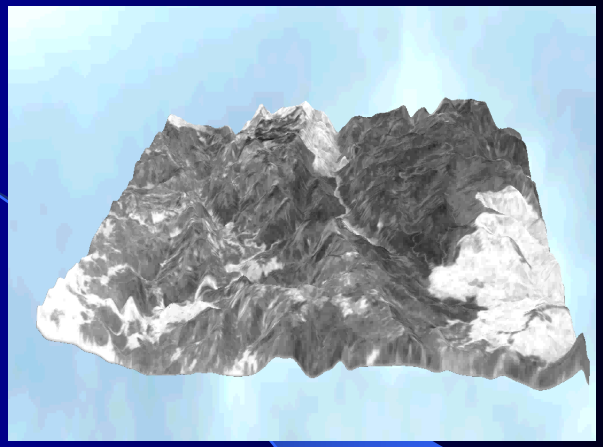
SSS Test Based Co-Research

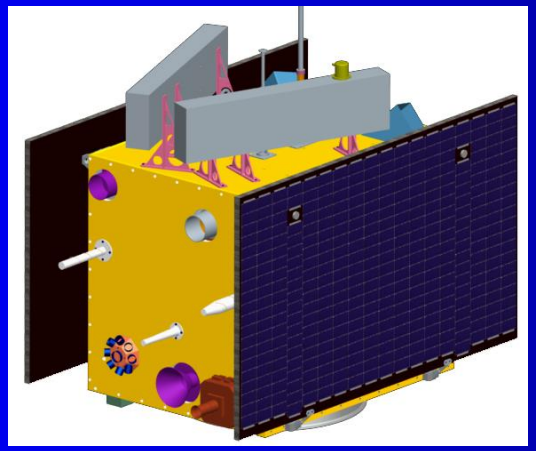
- SSS
  - STR — FEM Analysis and Test
  - MECH — Deployment Test
  - EPS
    - Balance Analysis and Test
    - Solar Array Illumination Test
  - OBC — OBDH Function Test
  - ADCS — ADCS Simulation and Test
  - TT&C — Inside and Outside Test
  - TCS — Thermal Analysis and Test
  - GS — Ground Station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



Project Experience

- Research Activities(Launched)
  - ◆Shiyan-1 Satellite
  - ◆Shiyan-3 Satellite
  - ◆Kuaizhou-1,2 Satellite



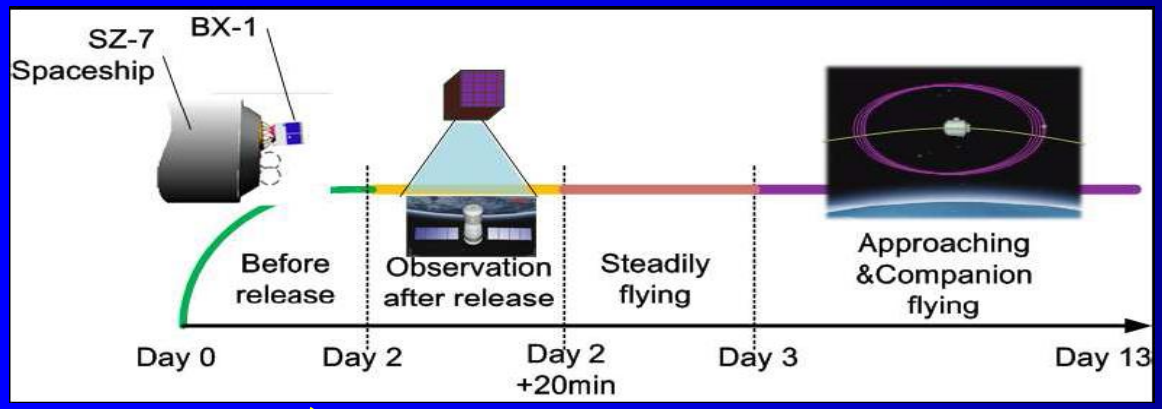


Shiyan-1 Satellite Shiyan-3 Satellite Kuaizhou-1,2 Satellite

Project Experience

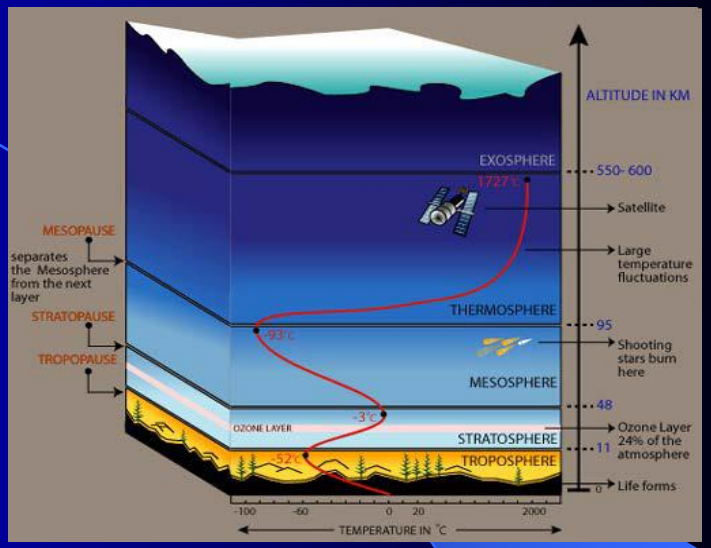
BX-1: Companion satellite for SZ-7

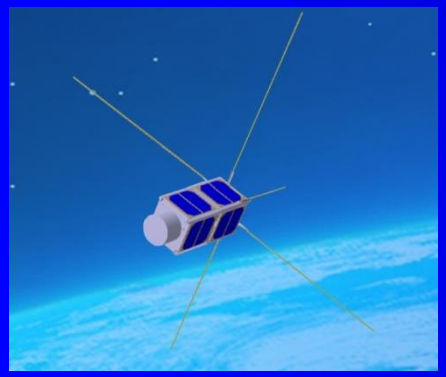
- Mission: companion flying experiment
- Mass: 40 kg (including 1.0kg propellant)
- Dimension: 450mm ×430mm × 450mm
- Launched in 2008.9.25
- Release from SZ-7 spaceship in 2008.9.27
- Designed lifetime: 3 months
- life in-orbit : 13 months



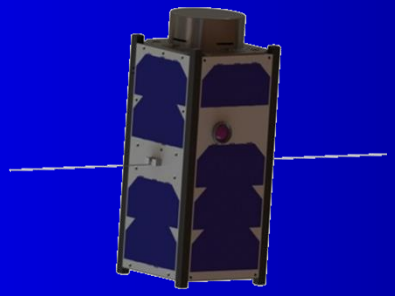
Project Experience
QB50 Project

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

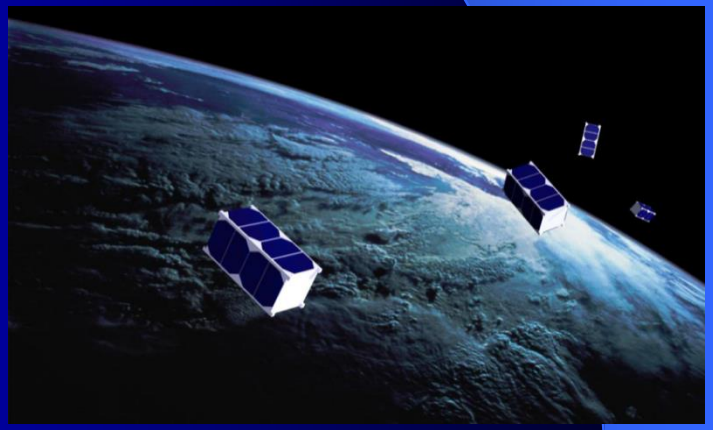




BUSAT-1(BUAA)



LilacSat-1(HIT)



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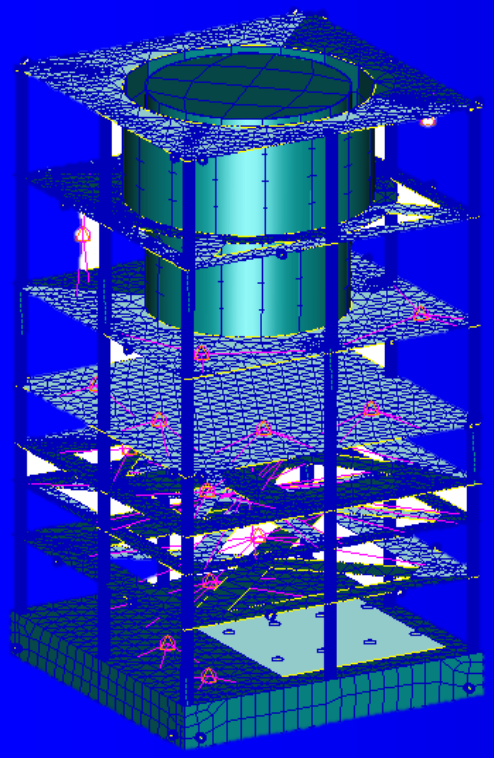
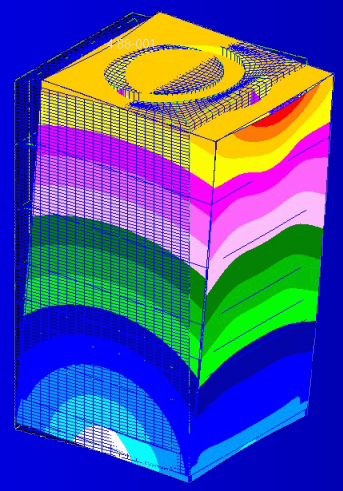
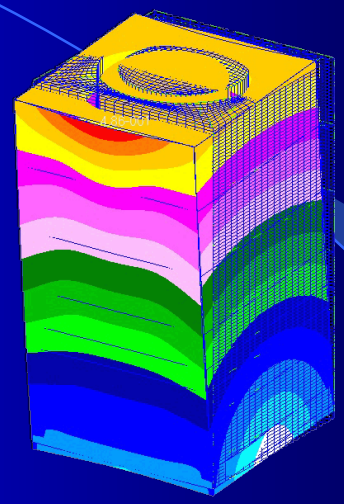
Sub-projects Implement by China FEM Design and Analysis



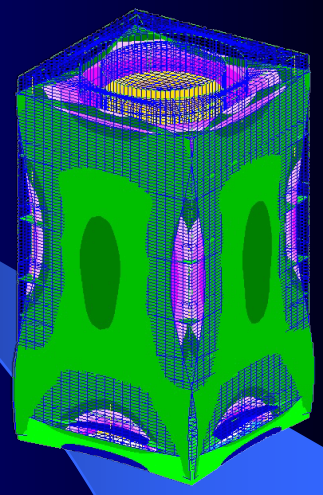
FEM MODEL



1st X-Direction
ω=48.847 Hz



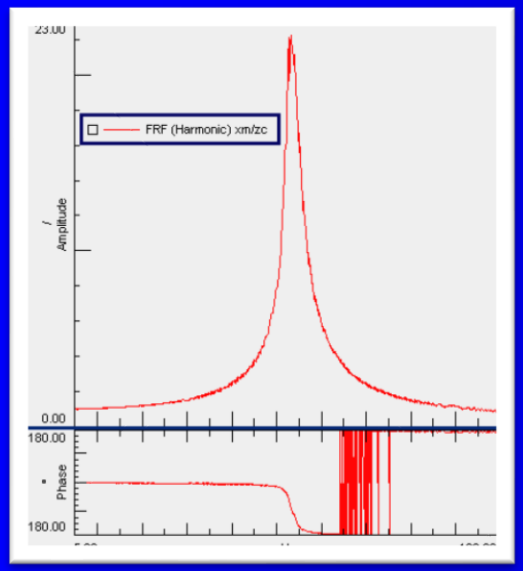
1st Y-Direction
ω=48.74 Hz



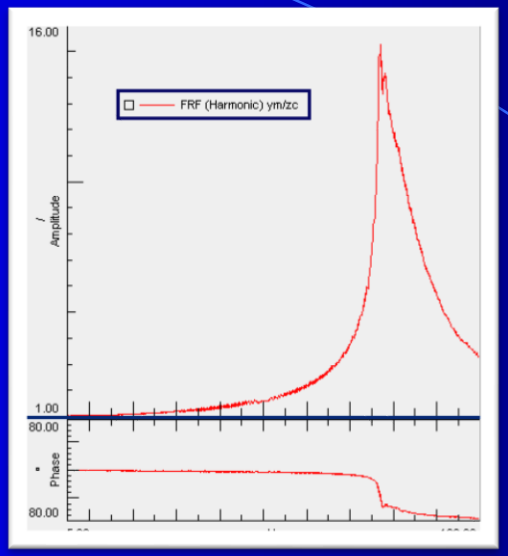
1st Z-Direction
ω=139.99 Hz

Sub-projects Implement by China Vibration Test

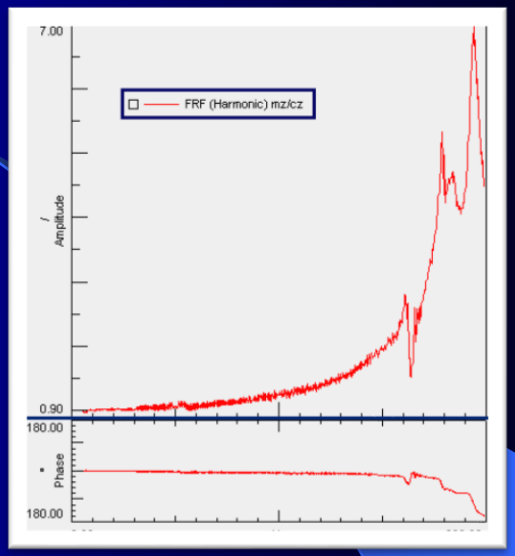
X

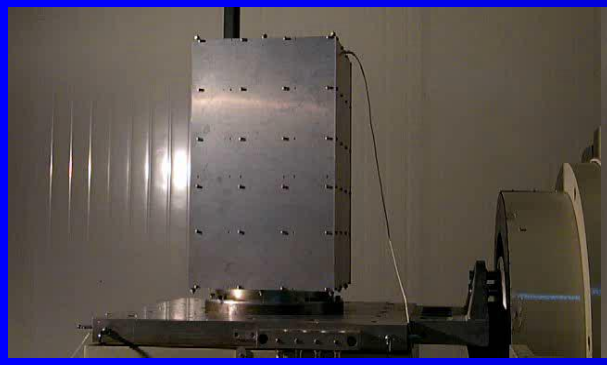


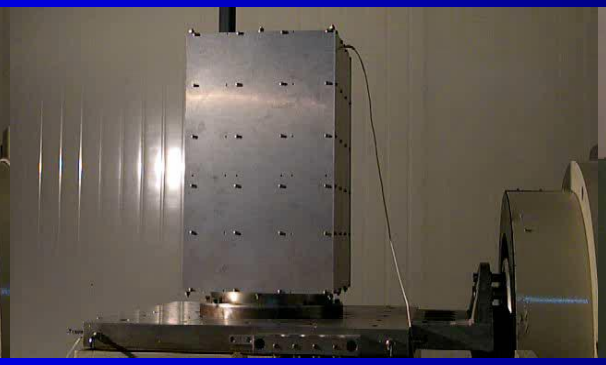
Y



Z

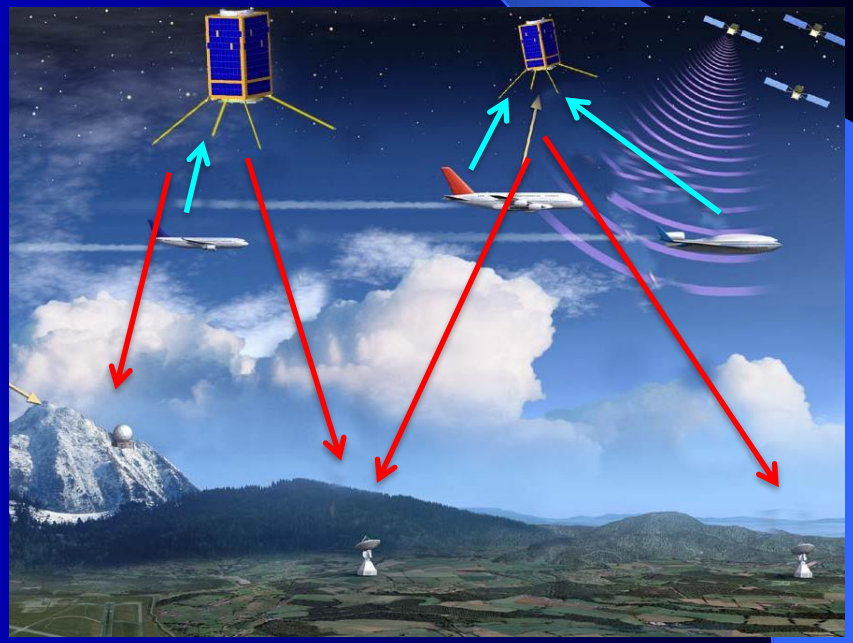






Sub-projects plan to Implement by China
ADS-B Payload Test

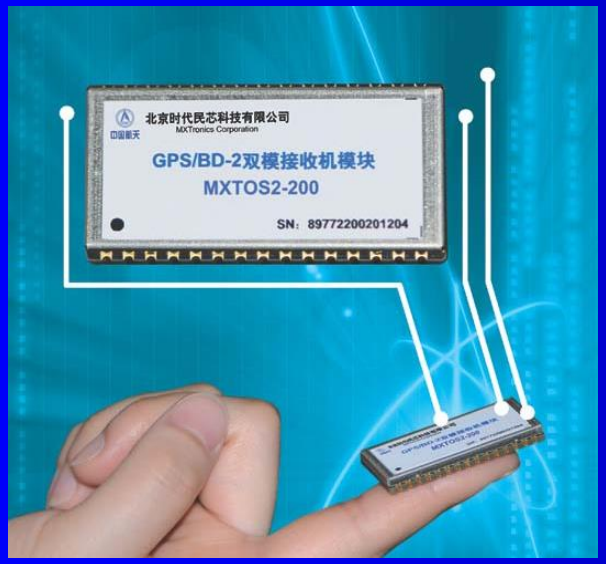
- ADS-B Chinese Research Status
  - BUAA Aviation traffic management technology Key lab , Pursue on ADS-B research work
  - BUAA solid foundation on the aviation trafic management research fields

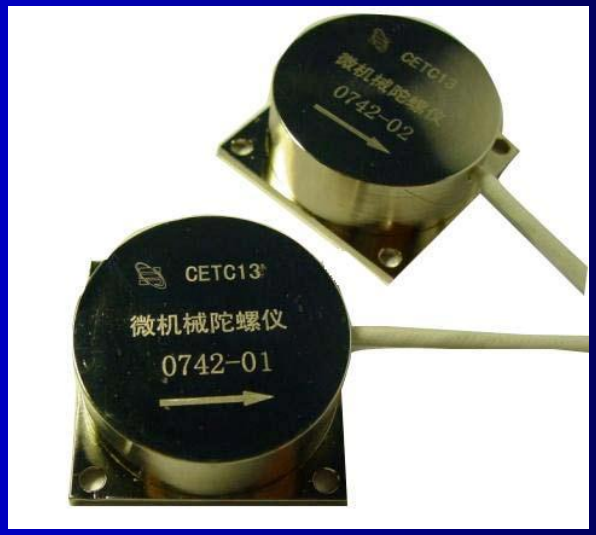


Sub-projects Implement by China and Others

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.

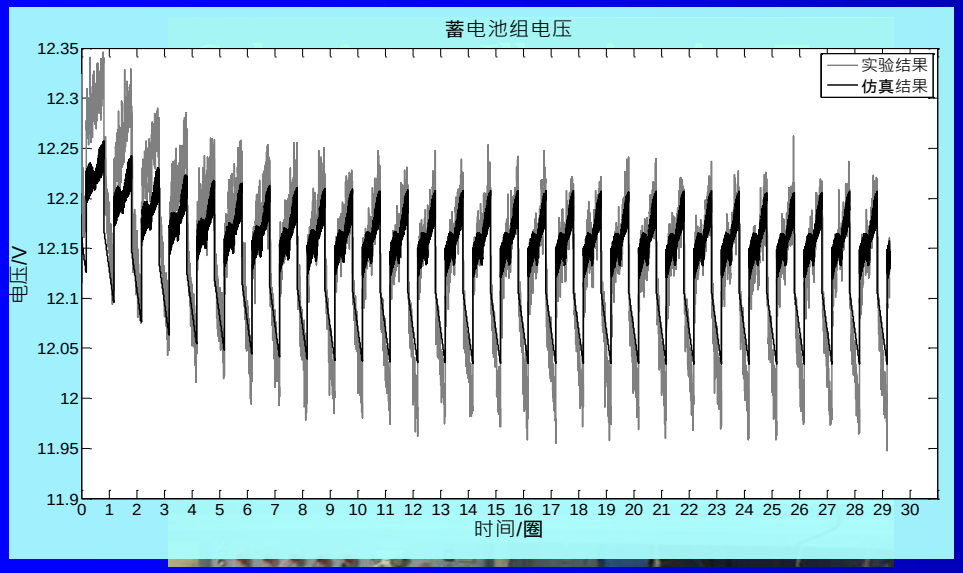


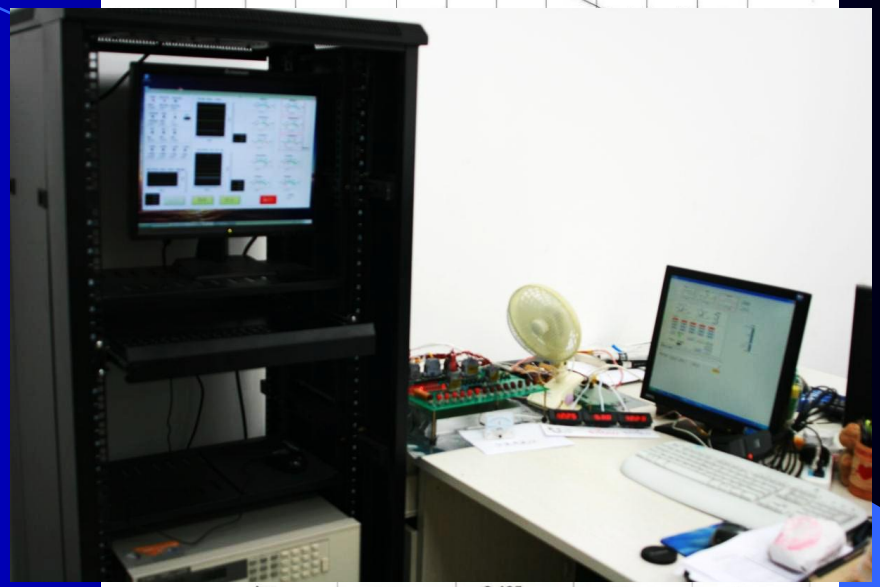


Suggested Cooperation Sub-projects

EPS development and Test

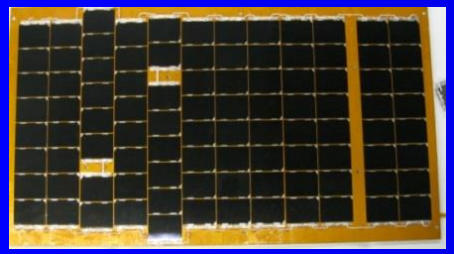
- EPS Energy Balance Test
- Solar Array Illumination Test





Isc	---	2.465	---	---
Voc	20.59	---	---	---
MaxP	17.35	2.164	37.53	0.7398
Test	12.00	2.400	28.79	---

Temperature: Ambient 20.5 °C Corrected 25.0 °C



Solar Array Panel

Power controller

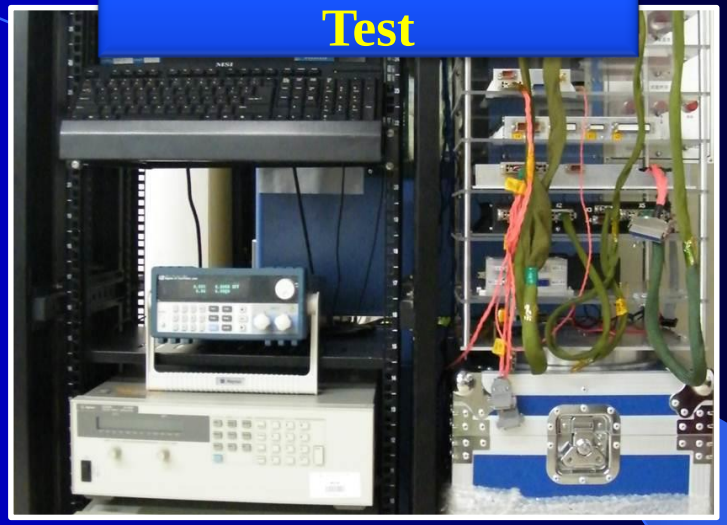
Li-ion Battery

Suggested Cooperation Sub-projects

OBDH development and Test

Flat-Satellite Test

Energy Balance Test

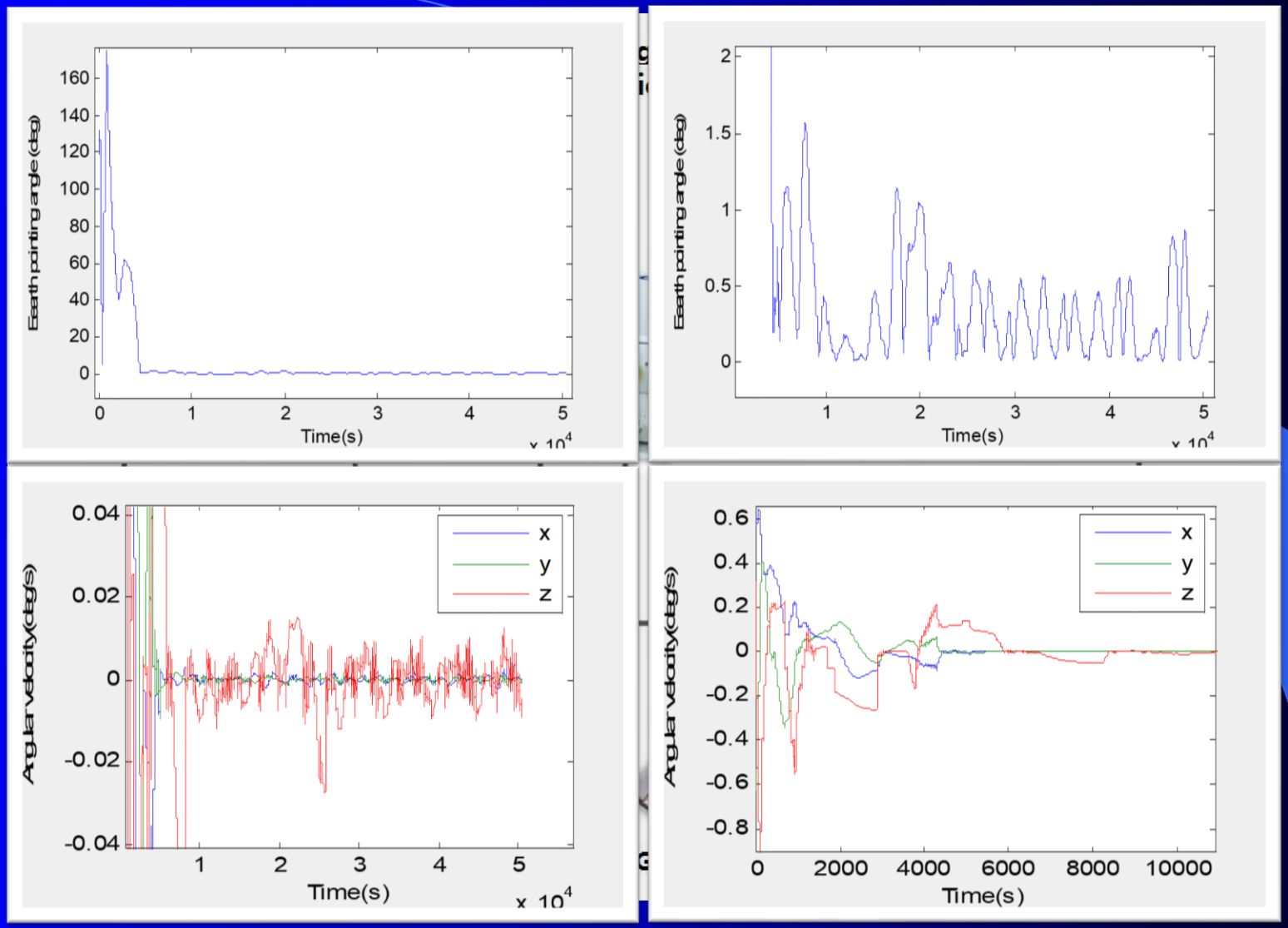


Camera Imaging Test

Mast Deploy Test

Suggested Cooperation Sub-projects

ADCS design and Simulation

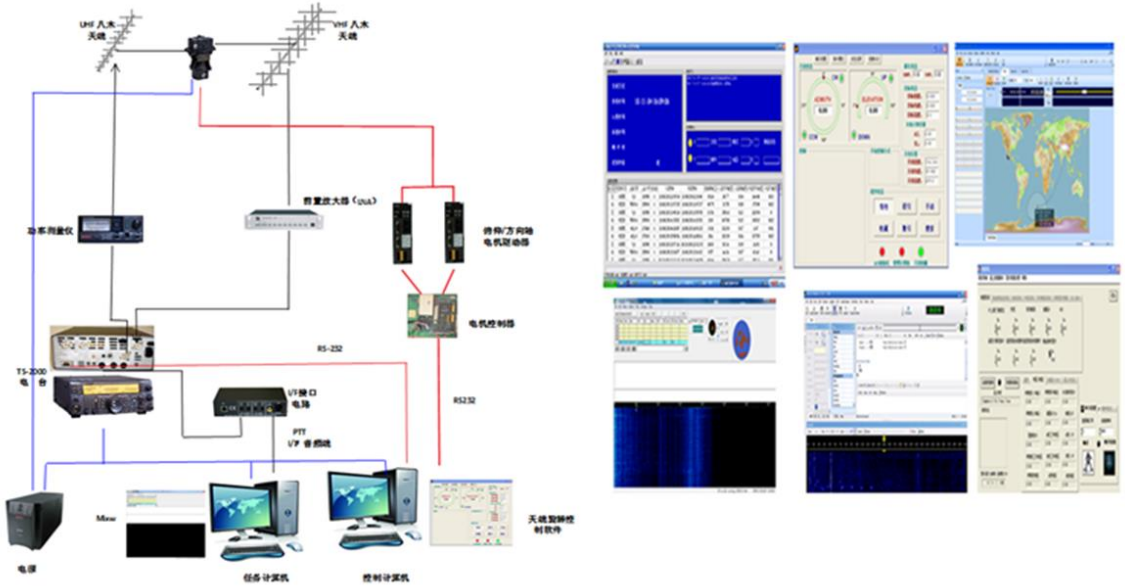


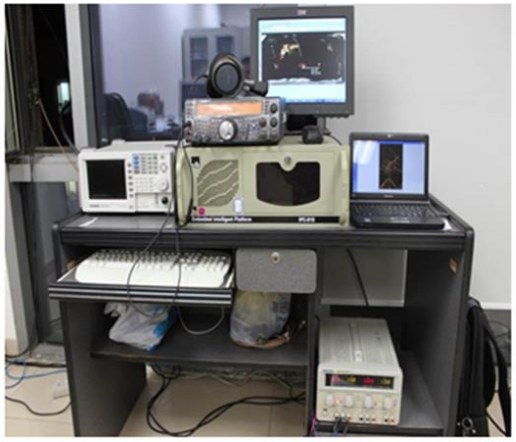
Suggested Cooperation Sub-projects

Ground Stations (BUAAGS)

Location：BUAA

Country	Satellite	Downlink Frequency(MHZ)
China	Hope-1	435.79
Japan	CO-55	436.84
Japan	CO-57	436.85
Japan	CO-58	437.47
Japan	CO-65	437.39
Japan	CO-66	437.49
Japan	PRISM	437.25
Hungary	MASAT	437.35
Turky	ITUPSAT	145,93
Spain	XATCOBEO	437.37
Netherland	DELFI-C3	145.87
India	HAMSAT	145.86
Swiss	SWISSCUBE	437.51
Japan	FO-29	435.80
Japan	KKS-1	437.39
Japan	STARS	437.30





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GroundStation Callsign Approved

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

CAMSAT_BUAASat-1	Updated: 19 Dec 2012		Responsible Operator	Alan Kung BA1DU
Supporting Organisation	Chinese Amateur Satellite Group			
Contact Person	camsat@vip.163.com.nospam			

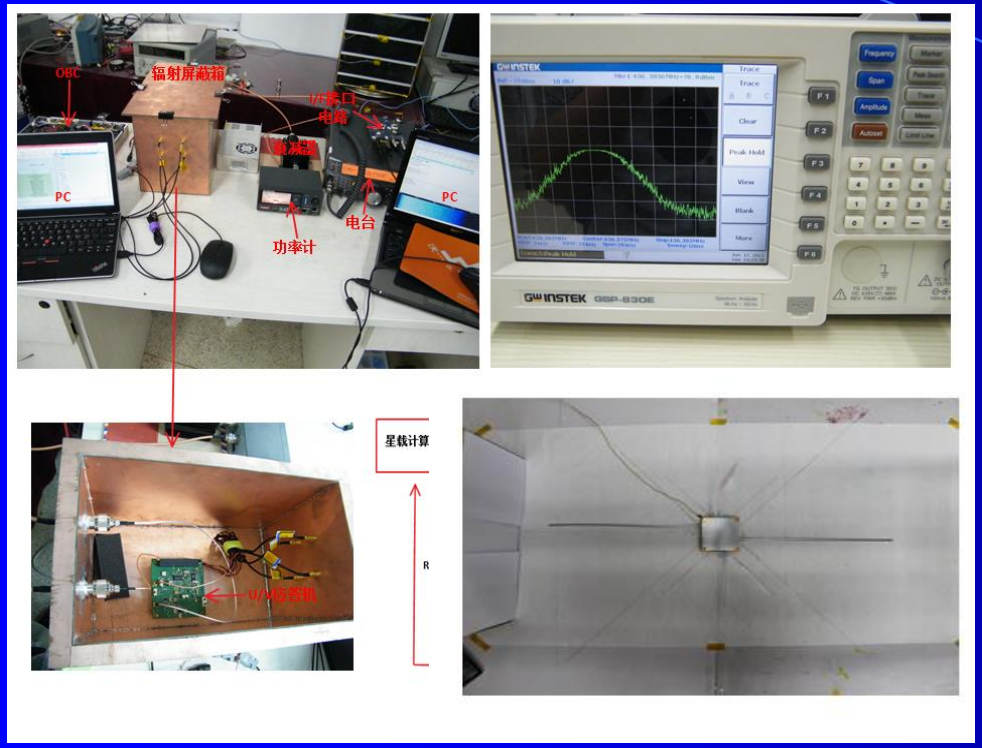
Headline Details: A 35kg microsat with 2 metre CW beacon at 20dBm, a 2 metre AX25 beacon at 27dBm and a U/V FM voice transponder at 27dBm.The spacecraft will have gravity gradient stabilisation. Planning a launch into a 800km sun snycronous orbit from Taiyuan in late 2014.** The following downlinks have 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

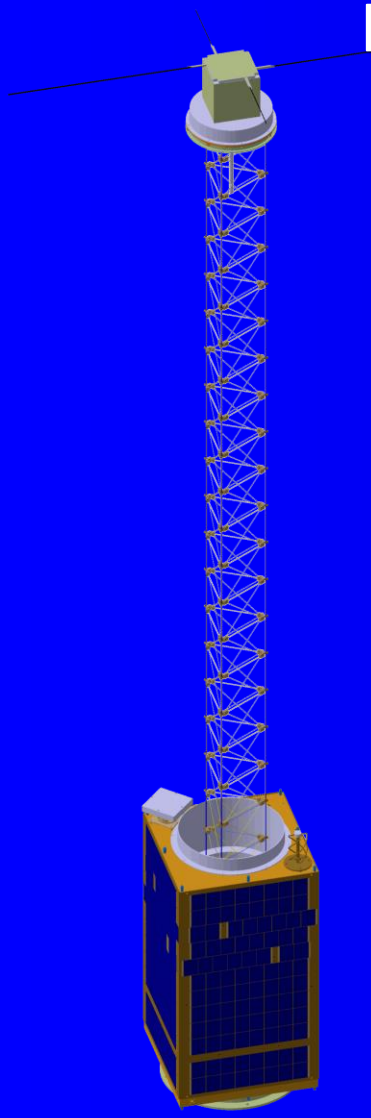


UHF/VHF Test
（Indoor and Outside）

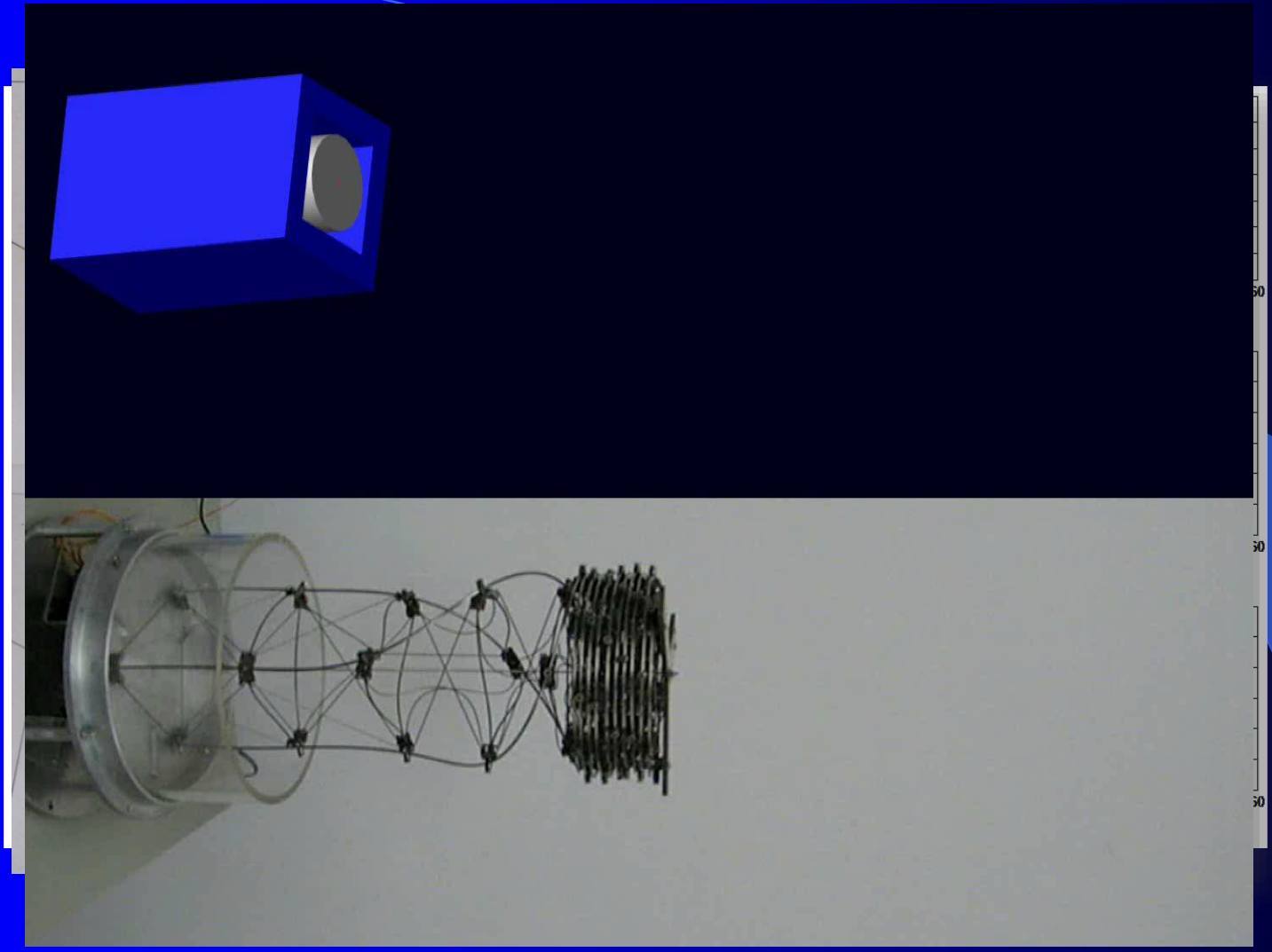
USB Test

Suggested Cooperation Sub-projects

Integrated Demonstration System



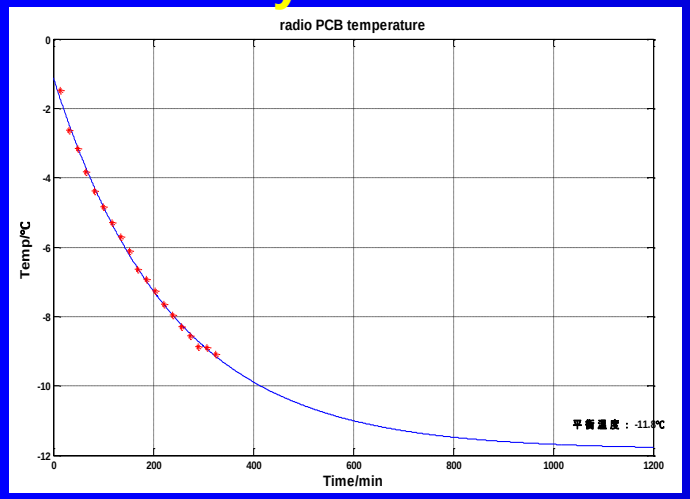
Suggested Cooperation Sub-projects
Coilable Mast Analysis and Test



Suggested Cooperation Sub-projects

Thermal Simulation

Battery Test Results

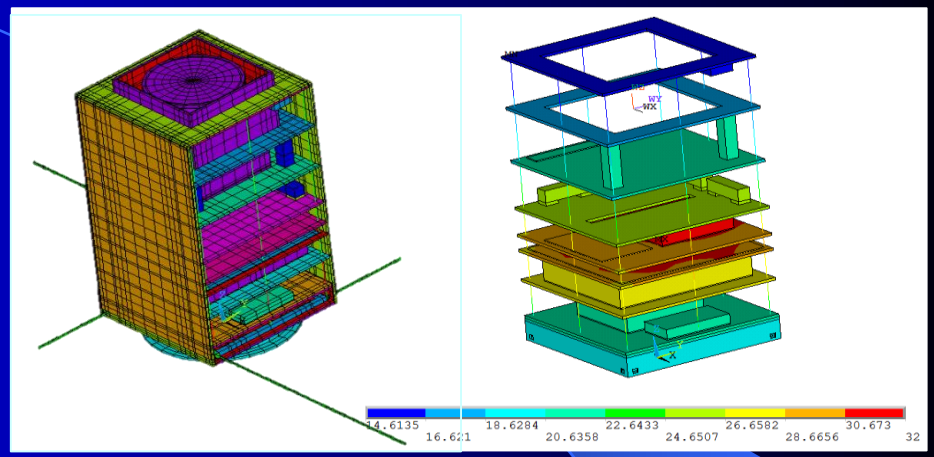


Compartment Temperature (180°/ min spin)

Component	Temp（℃）
Solar Array	-40~20
Battery pack	13~22
OBC	26~32
Camera	0~13
Sub-sat	-7~5
Coilable Mast（Stowed）	-12~2

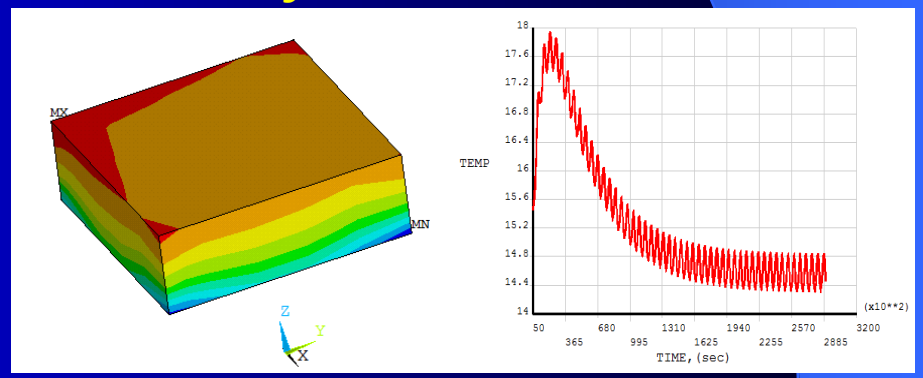
Model Modification

Modified Thermal Model



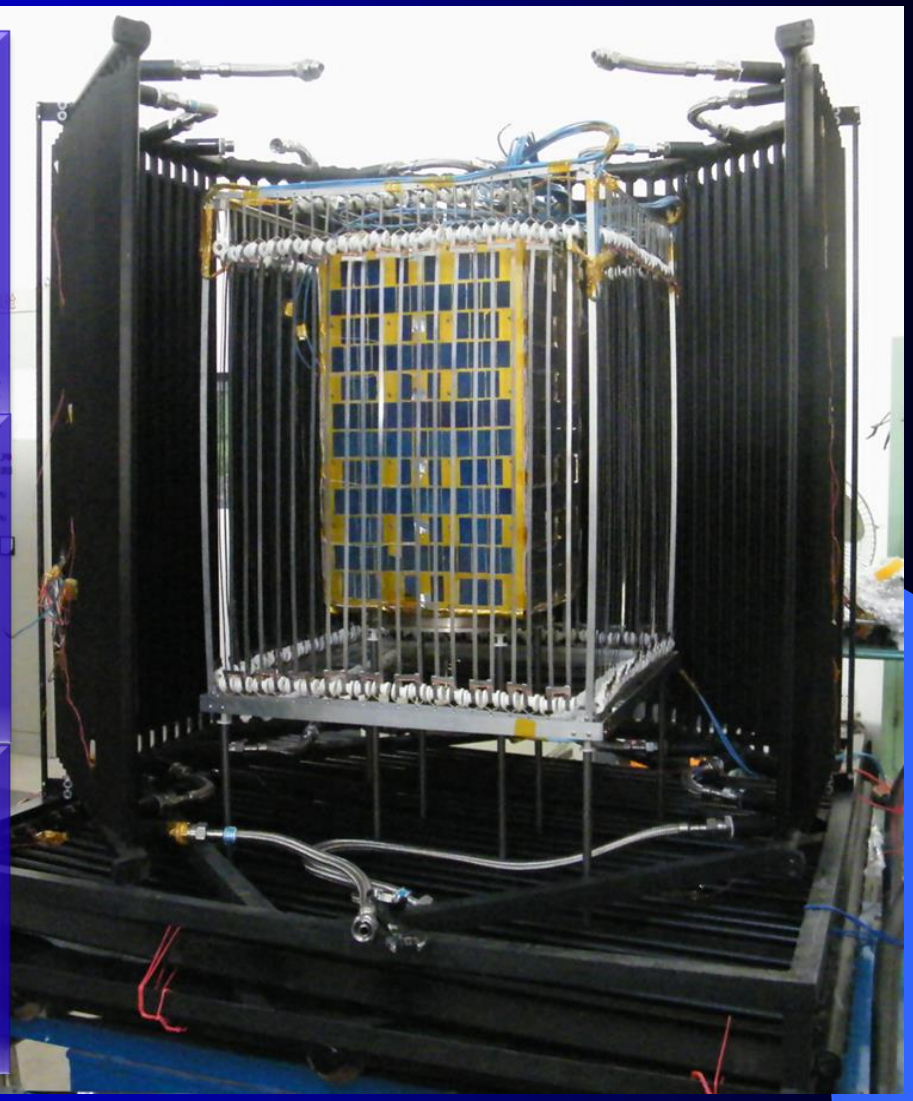
Simulation

Battery Simulation Results



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 ℃
  - Sensor Measurement Accuracy：0.5℃
  - Infrared Heating Cage
- **Thermal Model Satellite**
  - MLI
  - Temp Sensor Accuracy: 0.5℃
  - 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

Training Program for APSCO

- 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

Training Program for APSCO

- 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

Training Program for APSCO

- 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

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

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 !