6th European CubeSat Symposium

16 Oct 2014, Estavayer-le-Lac, Switzerland

TW-1: A Cubesat constellation for space networking experiments

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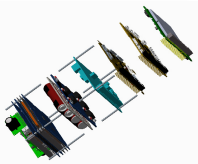

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Outline

- *MicroSat: Shanghai Engineering Centre for Microsatellites*
- *TW-1 Mission Overview*
- *TW-1 Tasks*
- *Satellite Configuration*
- *Project Schedule*
- *Summary*

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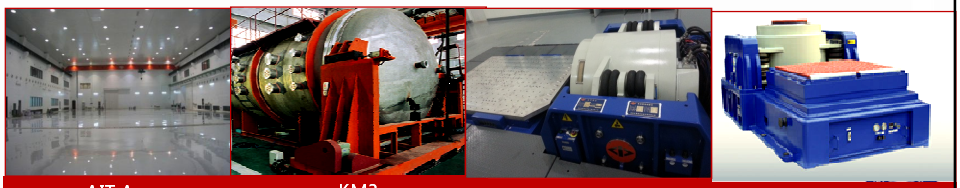
Shanghai Engineering Centre for Microsatellites

- **SECM was founded on Sep.15, 2003**
  - Founded by Chinese Academy of Sciences (CAS) and Shanghai City Government
  - To build a technical platform and innovation base for micro/small satellites

- **Located in Pudong of Shanghai**
  - ✓ Offices: ~ 15,000 m²
  - ✓ AIT area: ~12,000 m²
- **Able to manufacture 10+ satellites simultaneously**



AIT Area | KM3 | 20T Vibration table | 10T Vibration table

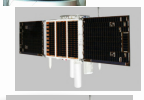
3

SECM Missions accomplished

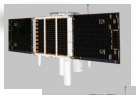
Commni-cationu

2003 · CX-1(01)

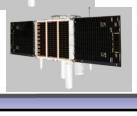
2008 · CX-1(02)



2011 · CX-1(03)

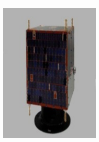


2014 · CX-1(04)



Micro/Nano Satellite

2008 · BX-1



Over past 10 years, SECM has launched into orbit 5+ micro/small satellites, accumulated 30+ orbit-year of satellite operation.

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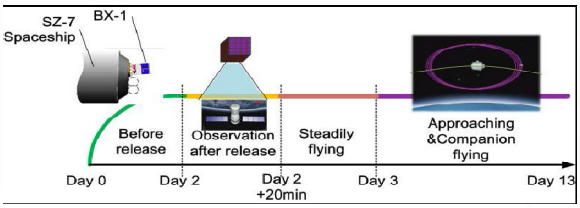
BX-1: Companion satellite for SZ-7

- 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



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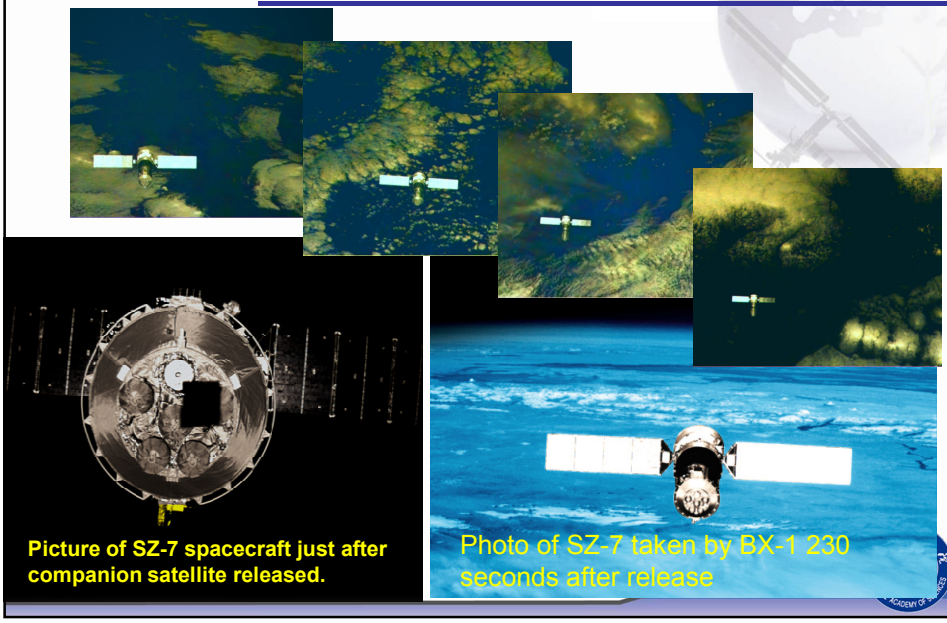
Photos of SZ-7 by BX-1



Picture of SZ-7 spacecraft just after companion satellite released.

Photo of SZ-7 taken by BX-1 230 seconds after release

SECM Missions Ongoing

Navigation	Micro/Nano satellite	Science	Others
Nav-1 (2015) [ca.900kg]	TW-1 (2015) [3U,2U CubeSat]	TanSAT(2016, 600kg)	.....
Nav-2 (2016)	BX-2 (2016) [50kg]	DMaHS(2016, 1800kg)	
		QUESS (2016, 500kg)	
		SVOM (2021, 950kg)	

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Developing Trends of Satellite

- **Development of small satellite**
  - ✓ Multi-functional Minisat (more than 100kg) is beginning to play a very important role in high-requirement mission
  - ✓ Micro-nanoSat, **CubeSat** is opening a new revolution in space technology and industry

Developing Trends of Satellite

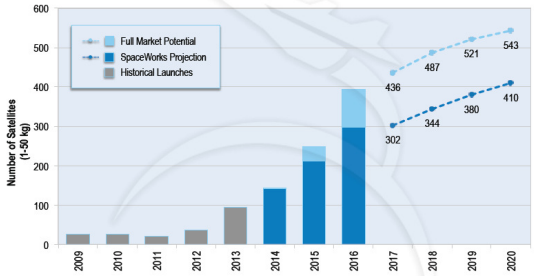
Cubesat Era

- ✓ Faster building time
- ✓ Lower cost of manufacture
- ✓ Easiness of mass production

- ✓ Ability to be launched in groups or 'piggyback'
- ✓ Minimal financial loss in case of failure

Nano/Microsatellite Launch History and Projection (1 - 50 kg)

Projections based on announced and future plans of developers and programs indicate between 2,000 and 2,750 nano/microsatellites will require a launch from 2014 through 2020



Cubesat is Changing the Economics of Space

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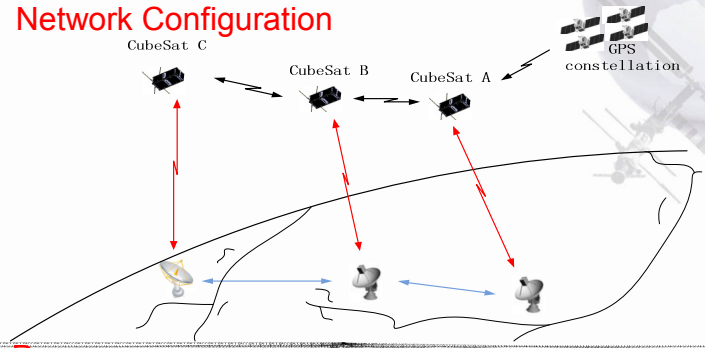
TW1 Mission Overview

Network Configuration



Mission Purpose:

- ✓ IOD of GAMALINK, MEMS micro-propulsion, BD/GPS receiver, …
- ✓ Validating space SDR technologies and extending the cubesat application fields by CubeSat networking
- ✓ Building the bridge between China and international player

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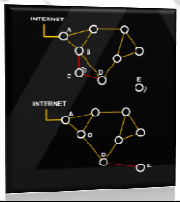
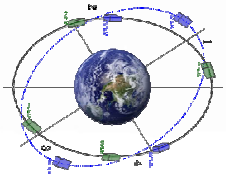
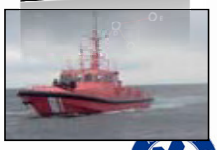
TW1 Mission Targets/Tasks

Mission Definition:

- 3 cubesats networking based on Gamalink and CSP
  - ✓ 3U cubesat (1) + 2U cubesats (2)
- Monitoring sea ice in polar region
- Gaining the maritime traffic information in polar region
- Demonstration of autonomous formation flight
- In-orbit demonstration & validation of ADS-B / Gamalink / Micro-propulsion / GPS-BD receiver
- Orbit: 480km, 8:00am, SSO
- Launch time: 2015.06

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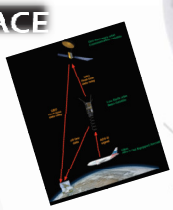
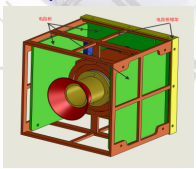
TW-1 Payloads Configuration

Gamalink

ADS-B



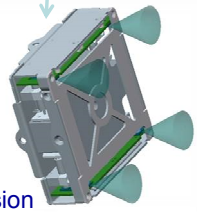
Optical Camera



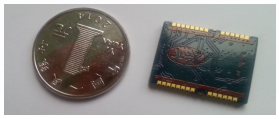
Payloads

AIS

NANO SPACE



Cold-gas micro-propulsion



BD2/GPS dual mode GNSS

SATLAB

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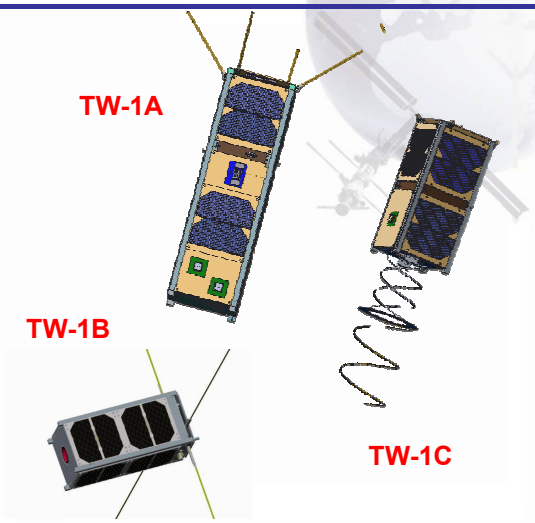
TW-1 Satellites Configuration

- TW-1A: 3U CubeSat
  - ✓ Gamalink
  - ✓ Camera
  - ✓ GPS/BD Receiver
  - ✓ Micropropulsion
  - ✓ S-band transmitter
- TW-1B: 2U CubeSat
  - ✓ Gamalink
  - ✓ AIS receiver
  - ✓ GPS/BD receiver
- TW-1C: 2U CubeSat
  - ✓ Gamalink
  - ✓ ADS-B Receiver
  - ✓ GPS/BD receiver



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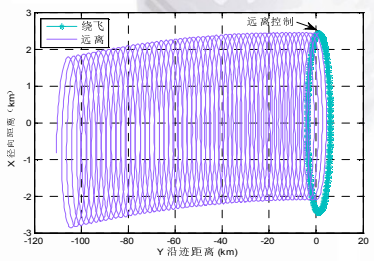
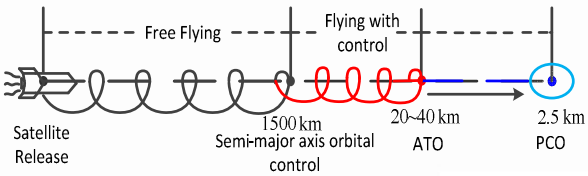
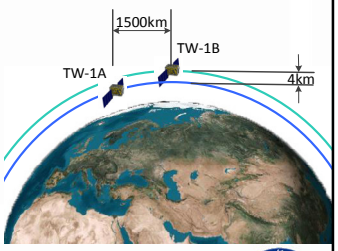
Mission Task 1

Formation Flying Demonstration

- Performer: TW-1A and TW-1B
- Relative Distance: 2.5 km
- Orbit Maneuver: multi-low impulse







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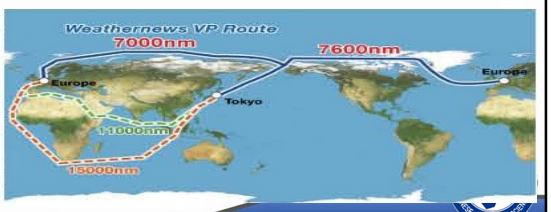
Mission Task 2

Monitoring Sea Ice in Polar Region, for marine application

- Performer: TW-1A
- Imaging Time per Orbit: < 11 minutes
- Resolution: 100 m - 200 m
- Swath: 200 km -400 km



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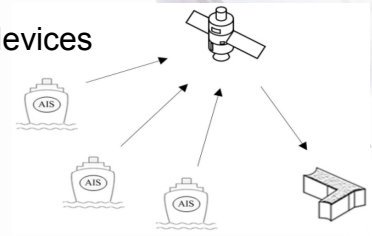
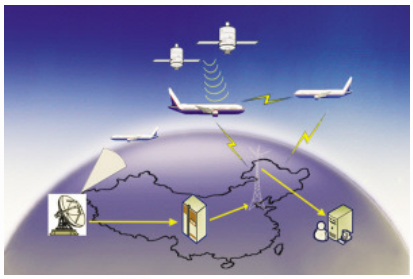
Mission Task 3

Data Collection System for Marine and Aircraft

- To cover shortage of shore-based devices
- Performer: TW-1B/C
- AIS receiver + ADS-B receiver





Shore-Based AIS Space-Based AIS

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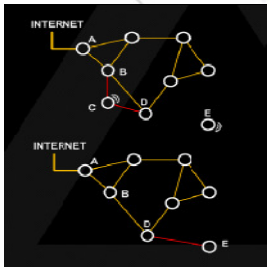
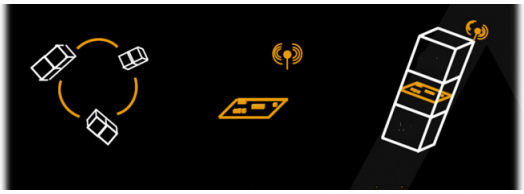
Mission Task 4

Building Space Ad hoc Network Based on Gamalink

- Space Node：TW-1A，TW-1B、TW-1C
- Ground Node：Shanghai，Brazil and Portuguese
- ISL : 60 kbps @ 600 km
- Sat-Ground Link: 333 kbps@ 2000 km





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Mission Task 5

Space-ground/space-space Network Based on CSP

- CSP: a small network-layer delivery protocol designed for Cubesats similar to TCP/IP model.
- Topology: Satellites segments (TW-1A, TW-1B, TW-1C)
  Ground segments (Shanghai, Nanjing, Lisbon)
- CSP node distribution: SAT1: 0-7, SAT2: 8-15, SAT3: 16-23,
  GS1: 24-27, GS2: 28-31
- static routing table programmed into the source-code of each sub-system
- Cubesat internal communication network expand to a bigger network involving cubesats and ground stations

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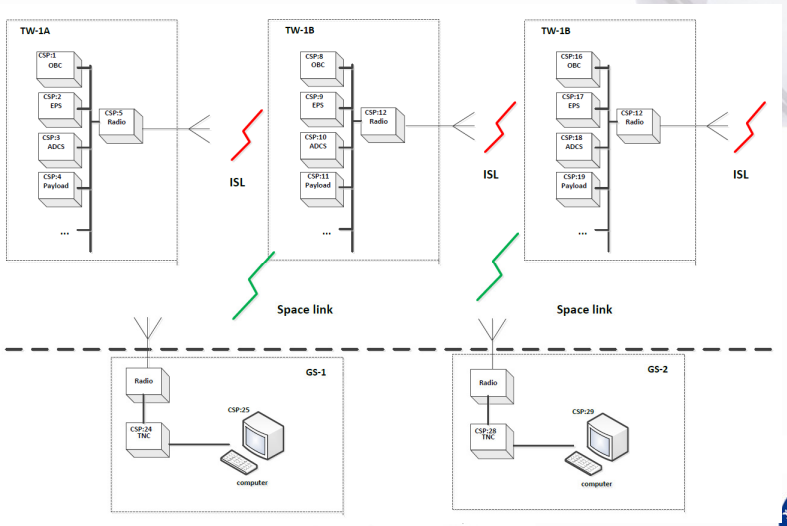
Mission Task 5

Network Based on CSP



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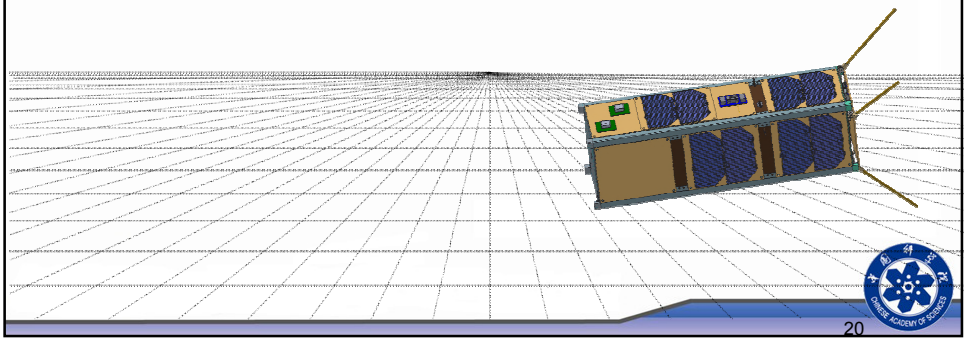
TW1 Satellite Configuration



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Satellite Specifications

TW-1A (3U)

- Mass: 3.5 kg
- Attitude Knowledge: 1° (3σ)
- Pointing Accuracy: 2° (3σ)
- Pointing Stability : 0.1° /s
- Data Storage: 4 G
- Uplink/Downlink: 115.2 kbps
- S-band Data Downlink: 1 Mbps
- △V capability : 10 m/s
- Life time: 0.5 Year

TW-1B/C(2U)

- Mass: 2.3 kg
- Attitude Knowledge: 5°
- Pointing Accuracy: 10 °
- Pointing Stability : 0.5° /s
- Data Storage: 2 G
- Uplink/Downlink: 115.2 kbps
- Life time: 0.5 Year

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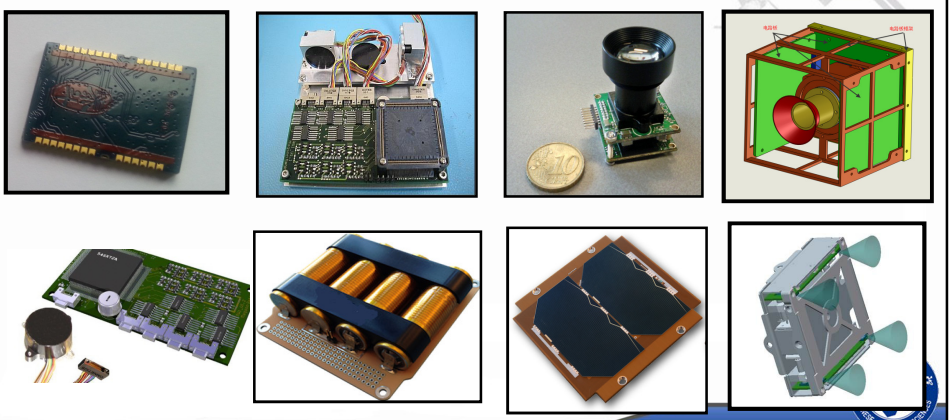
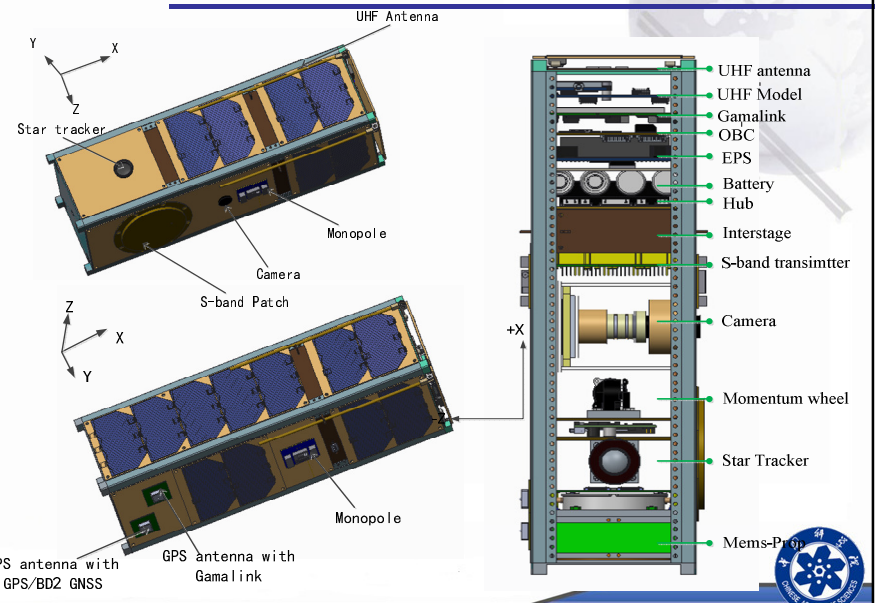
TW-1A

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.



TW-1A



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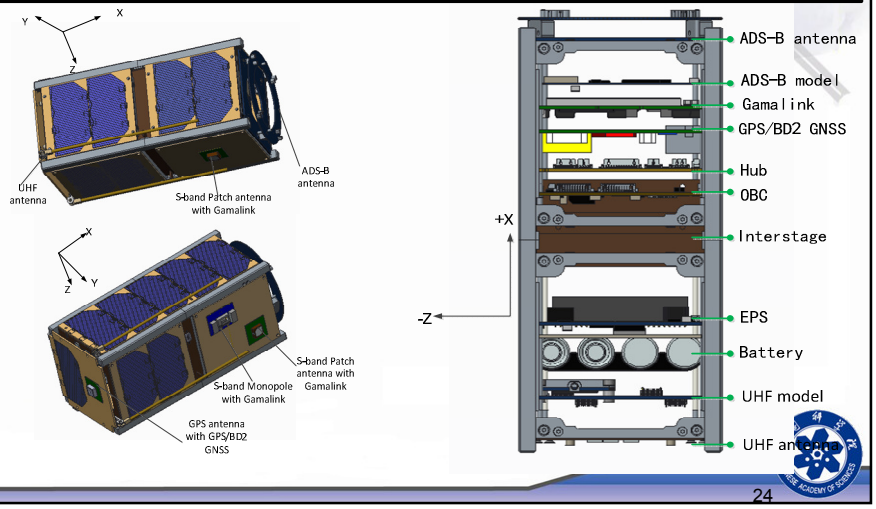
TW-1B/C

2U cubesat, mounting solar panel, attitude stabilization and control based on the magnetic control, with UHF TT&C



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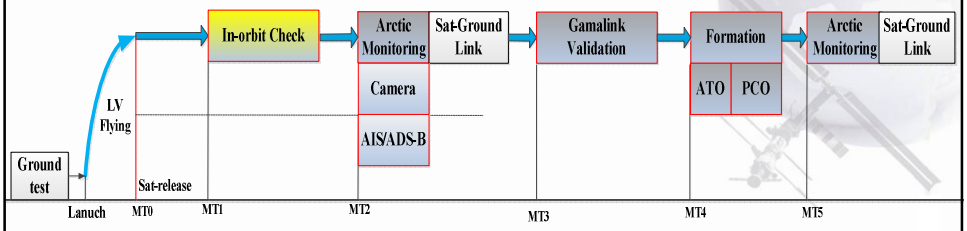
In-orbit Test Process



- MT0：Satellite release;
- MT1：Entering the in-orbit check mode after antenna release, detumbling modes and satellite attitude stability;
- MT2：Short in-orbit test of Arctic monitoring ;
- MT3：Building the space Ad hoc network based on Gamalink ;
- MT4：Demonstration ATO and PCO formation based on Micro-propulsion;
- MT5：Returning into Arctic monitoring mission in the left lifetime.

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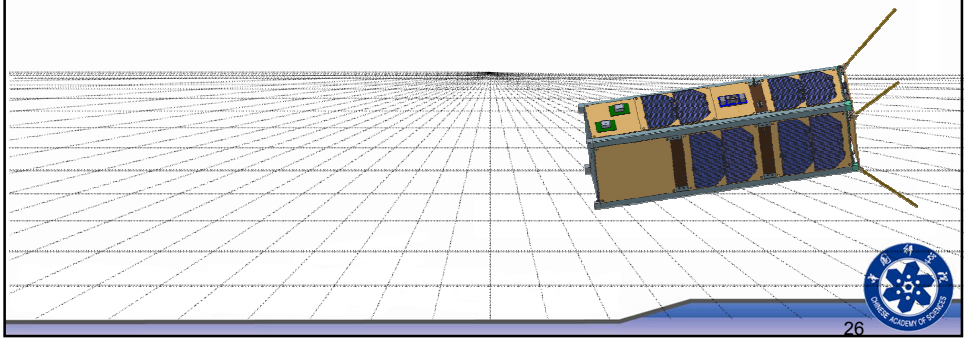
Challenges



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microsat

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NANO SPACE

GOMSPACE

南京理工大学 Nanjing University of Science and Technology

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Challenges

- ✓ Maybe the first cubesat space Ad hoc networking
- ✓ Maybe the first polar observing mission with cubesats
- ✓ Maybe the first cubesat formation

Astro- und Feinwerktechnik Adlershof GmbH

CLYDE SPACE

GOMSPACE

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Thank You for Your Time !
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