



56th International Astronautical Congress  
12-16 October, 2015, Jerusalem, Israel



## Earth Observation and Marine/Air Traffic Monitoring with a Multiple CubeSat Constellation

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## SECM- Shanghai Engineering Centre for Microsatellite

- **Founded by Chinese Academy of Science (CAS) and Shanghai City Government,**
- **Located in Pudong of Shanghai**
  - ✓ Offices: ~ 15,000 m<sup>2</sup>
  - ✓ AIT area: ~12,000 m<sup>2</sup>
- **To build a technical platform and innovation base for micro/small satellites**
- **Able to manufacture 20+ satellites simultaneously**








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## Missions Done



**Communication**



**Micro/Nano Satellite**

2003 · CX-1(01)



2008 · CX-1(02)



2011 · CX-1(03)



2014 · CX-1(04)



2008 · BX-1



2015 · STU-2 (TW-1) 3 CubeSats



**Over past 10 years, SECM has launched into orbit 9+ micro/small satellites, accumulated 30+ orbit-year of satellite operation.**

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**Missions Ongoing**

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

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**STU-2 Mission Requirements**

- Monitoring sea ice status in polar regions
- Gaining the maritime traffic information via AIS receiver
- Monitor civil aircraft traffic information via ADS-B receiver
- New technology demonstration & validation of Micro-propulsion, dual-band GPS-BD receiver, and Gamalink
- Demonstration of autonomous rendezvous (RVD) flight

Northern Sea route and current route  
Northern Sea route requires 35 days  
Current route via Suez Canal requires 48 days

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**microsat**



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## STU-2 Mission Configuration


- 3 Cube Satellites to carry different payloads
- 2 Ground Stations in Shanghai and Nanjing of China
- Orbit: SSO, 480km, 8:00am
- Launch: Sept 25<sup>th</sup> 2015  
Jiuquan, China






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## Main specifications for flight model

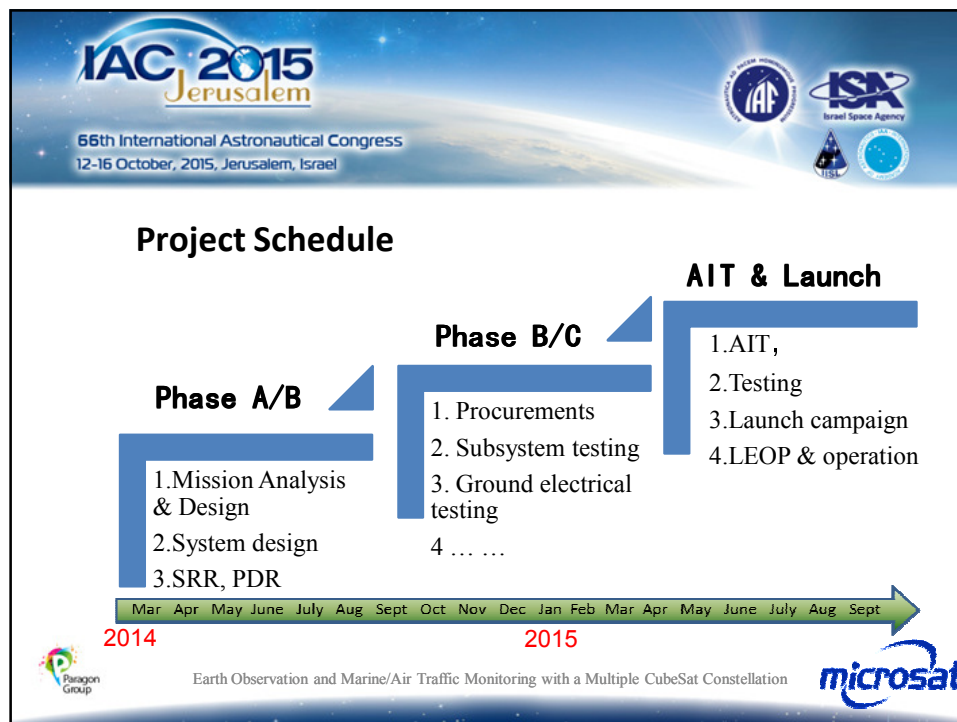
	STU-2A ( 3U )	STU-2B (2U)	STU-2C ( 2U )
<b>Payloads</b>	Camera Gamalink BD2/GPS	AIS Receiver Gamalink BD2/GPS Receiver	ADS-B Receiver BD2/GPS Receiver
<b>ADCS</b>	MTM, MTQ, Propulsion, 3 Wheels, Fine Sun Sensor, Star Tracker, GPS/BD APE 1.8° Stability 0.03°/s	MTM, MTQ, Sun Sensor, Momentum biased with wheels APE 8° Stability 0.04°/s	Magnetic control APE 13° Stability 0.04°/s
<b>TMTC Comm</b>	UHF: 4.8kbps S-band : 125kbps	UHF: 4.8kbps	UHF: 4.8kbps
<b>Mass/Power</b>	2.9kg/2.9 W	2.2kg/2.9W	1.7 kg/2.0W



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ISAC Israel Space Agency

### STU-2A Cubesat-platform

Subsystem	Item	Specification
Structure	Dimension [mm]	340.5x100x100
ADCS	Attitude Knowledge	1°(3σ)
	Pointing Accuracy	2°(3σ)
	Pointing Stability	0.1°/s
Thermal	Internal temperature	-10°C ~ +35°C
EPS	Bus voltage	13.2 V ~ 16.8 V
	Battery properties	2.6 Ah · 1 Year
TT&C	Frequency	UHF(435-438 MHz)
	Modulation	2-FSK
	Uplink	4.8 kbps
	Downlink	4.8 kbps
S-band transmitter	Date rate	125kbps
	Frequency	2.425GHz
	Modulation	QPSK
	BER	<10 <sup>-4</sup>
OBC	Process capacity	20 MIPS
	Process storage	RAM >2 M, Flash >256 K




Body mounting solar panel, 3-axis attitude stabilization and control based on momentum wheels and star tracker, UHF TT&C, and S-band transmitter.

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## STU-2A Cubesat-Payload


<b>Structure</b>	Mass	466g
	Dimension	90×90×85mm <sup>3</sup>
<b>Electrics</b>	Power	<8.2 W (ave) <9.5W (peak, <10ms)
	Revolution	93m
<b>Observation</b>	Swath	217.8km







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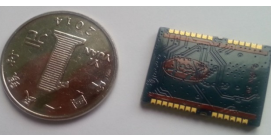




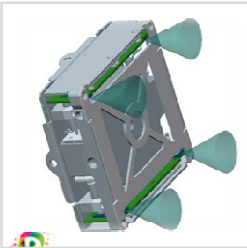
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## STU-2A Cubesat-Payload




<b>Structure</b>	Mass	4g
	Dimension	22.4×17×2.2mm <sup>3</sup>
<b>Electrics</b>	Power	0.5 W
	Horizontal	93m
<b>Position</b>	Altitude	217.8km
	Velocity	1 m/s




Four 1mN thrusters with closed loop thrust control  
 Thrust resolution: <10μN  
 Propellant: Butane  
 Total impulse: 40Ns  
 Isp: 90s  
 Size: 10×10×5cm<sup>3</sup>  
 Mass including the propellant: 330g  
 Power consumption: 3.2 W





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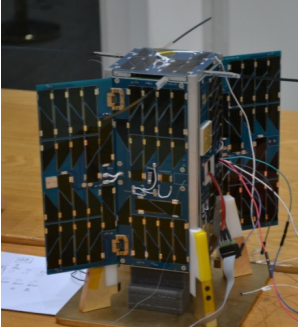
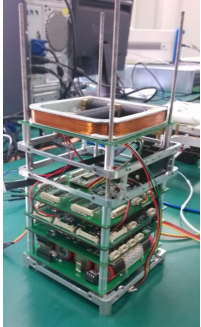



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## STU-2B Cubesat-Platform


Subsystem	Item	Specification
Structure	Dimension envelope	239 x 100 x 100 mm <sup>3</sup>
	Attitude Knowledge	5°(1σ)
ADCS	Pointing Accuracy	10°(1σ)
	Pointing Stability	0.5°/s
Thermal	Internal temperature	-10°C ~ +35°C
EPS	Bus voltage	6.4V ~ 8.4 V
	Battery properties	5.2 Ah, 1 Year
TT&C	Frequency	UHF (435-438 MHz)
	Modulation	2-FSK
	Uplink	4.8 kbps
OBC	Downlink	4.8 kbps
	Process capacity	20 MIPS
	Process storage	RAM > 2 M, Flash > 256 K





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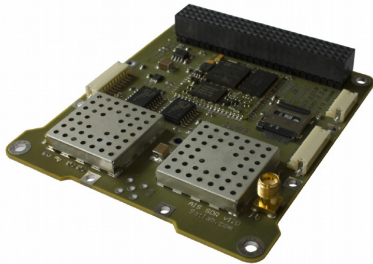



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## STU-2B Cubesat-Payload


The AIS receiver is provided by the Satlab Ltd from Denmark, with heritage from the AAUSAT3. The CubeSat-level AIS receiver is a fully self-contained SDR, which is suitable for LEO satellite missions. Weighing less than 50 g and using 0.7 W during full load, this versatile SDR offers the best performance possible given the typical constraints of a CubeSat.







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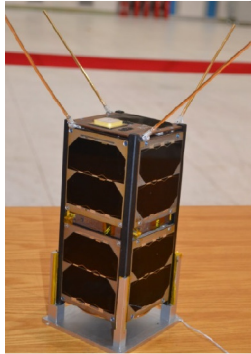




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## STU-2C Cubesat-Platform


Subsystem	Item	Specification
Structure	Dimension envelope	239 x 100 x 100 mm <sup>3</sup>
ADCS	Attitude Knowledge	5°(1σ)
	Pointing Accuracy	10°(1σ)
	Pointing Stability	0.5°/s
Thermal	Internal temperature	-10°C ~ +35°C
EPS	Bus voltage	12.0V ~ 16.8V
	Battery properties	2.6 Ah, 1 Year
TT&C	Frequency	UHF (435-438 MHz)
	Modulation	2-FSK
	Uplink	4.8 kbps
	Downlink	4.8 kbps
OBC	Process capacity	20 MIPS
	Process storage	RAM >2 M, Flash >256 K





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## STU-2C cubesat-Payload


STU-2C main payload is an ADS-B receiver, to monitor civil airplane flying within the nadir space region of the satellite. It is provided by GOMSpace, upgraded from the heritage and experiences of the GOMX-1 mission.

Another payload is a multi-channel inertial sensor. The inertial sensor is using the commercial component of ADIS16448 with including a triaxial gyroscope, a triaxial accelerometer, a triaxial magnetometer, and pressure sensors.



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## Launch Campaign and in-orbit results

The STU-2 mission with three CubeSats has been launched successfully into space on Sept 25th, 2015, on-board a newly developed small launch vehicle in China, the LoangMarch-11 launcher, towards the target LEO orbit of SSO, with an altitude of 481km, inclination of 97 deg, and LTDN at 8:00am





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On the second day after the launch, Sept 26th 2015, STU-2C captured ADS-B signals transmitted from 16 aircraft flying under the satellite. After one orbit, STU-2C has received **51665** ADS-B signals, transmitted from **405** different aircraft flying along the region below that satellite orbit.

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## ACKNOWLEDGMENT

This mission is designed and being implemented by a consortium led by the Shanghai Engineering Centre for Microsatellite in China, together with partners including the Nanjing University of Science and Technology (contributed for STU-2B platform), the **GomSpace** from Denmark (ADS-B and AIS receiver, as well as CubeSat components), the **NanoSpace** from Sweden (contributed the MEMS micro-propulsion module), and the **Tekever Space** from Portugal (contributed the Gamalink). The authors would like to express sincere appreciation and many thanks to these partners, together with them this mission has been made feasible and successfully implemented.



南京理工大学  
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