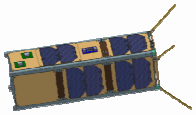
67th International Astronautical Congress, Sept 2016



IAC16-B.4.4.11

# Antarctic Glacier and Sea Ice Observation With a Chinese Cube -Satellite

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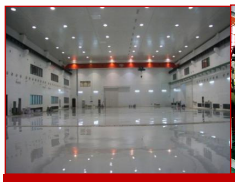
## Contents



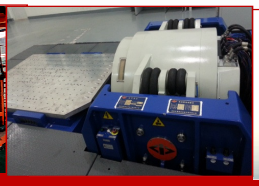
## SECM: Shanghai Engi Centre for MicroSat

- **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 20+ satellites simultaneously**


AIT Area


KM3


20T Vibration table


10T Vibration table

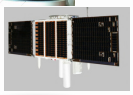


## SECM: Mission Accomplished

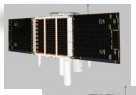
**Commni-cationu**

2003 · CX-1(01)

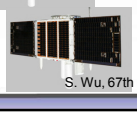
2008 · CX-1(02)



2011 · CX-1(03)

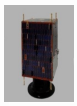


2014 · CX-1(04)

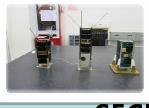


**Micro/Nano Satellite**

2008 · BX-1



2015 · STU-2
(TW-1) 3 CubeSats



**Navigation & Science**

2015 · Nav-1
2016 Nav-2
2016 DarkEnerge
2016 Quantum

**Over past 12+ years, SECM has launched into orbit 15+ micro/small/large satellites (2-1800kg), accumulated 40+ orbit-year of satellite operation.**

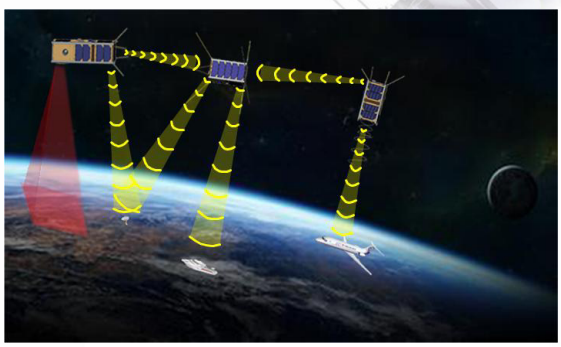
## STU-2 Mission Requirements

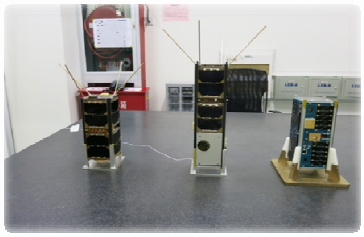
- Monitoring sea ice status in polar regions
- Gaining the maritime traffic information via AIS receiver
- Monitor civil aircraft traffic information via ADS-B receiver
- New technology demonstration & validation of Micro-propulsion, dual-band GPS-BD receiver, and Gamalink
- Demonstration of autonomous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




## STU-2 Mission Configuration

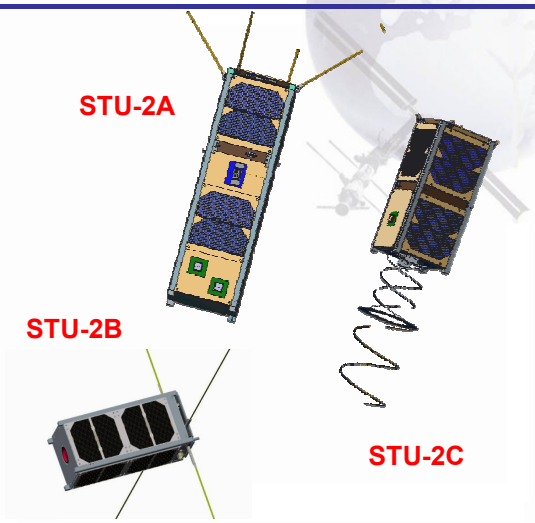
- 3 Cube Satellites to carry different payloads
- 2 Ground Stations (UHF band) in Shanghai and Nanjing of China
- 1 Data Receiving Station (S-band) in Shanghai
- Orbit: SSO, 480km, 8:00am
- Launch: Sept 25th 2015
  Jiuquan, China





## Satellites Configuration

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






## Project Schedule

**Phase A/B**
1. Mission Analysis & Design
2. System design
3. SRR, PDR

**Phase B/C**
1. Procurements
2. Subsystem testing
3. Ground electrical testing
4 … …

**AIT & Launch**
1. AIT,
2. Testing
3. Launch campaign
4. LEOP & operation

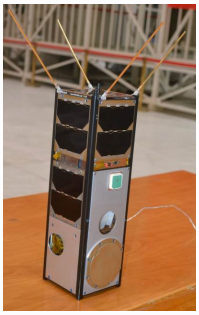
Mar Apr May June July Aug Sept Oct Nov Dec Jan Feb Mar Apr May June July Aug Sept

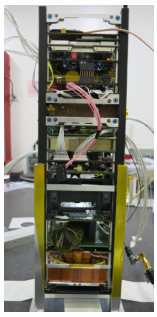
2014 2015

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

## STU-2A CubeSat

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





STU-2A

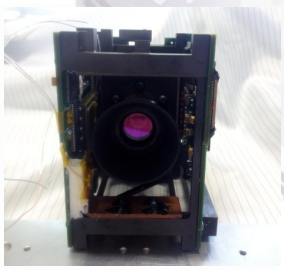
| Subsystem | Item | Specification |
|---|---|---|
| Structure | Dimension [mm] | 340.5x100x100 |
| ADCS | Attitude Knowledge | 1° (3σ) |
| | Pointing Accuracy | 2° (3σ) |
| | Pointing Stability | 0.1°/s |
| Thermal | Internal temperature | -10℃～+35℃ |
| EPS | Bus voltage | 13.2 V～16.8V |
| | Battery properties | 2.6 Ah，1 Year |
| TT&C | Frequency | UHF(435-438 MHz) |
| | Modulation | 2-FSK |
| | Uplink | 4.8 kbps |
| | Downlink | 4.8 kbps |
| S-band transmitter | Date rate | 125kbps |
| | Frequency | 2.425GHz |
| | Modulation | QPSK |
| | BER | $<10^{-6}$ |
| OBC | Process capacity | 20 MIPS |
| | Process storage | RAM >2 M, Flash>256 K |



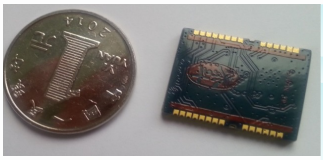
## STU-2A Cubesat-Payload

### Optical Camera

| | | |
|---|---|---|
| **Structure** | Mass | 466g |
| | Dimension | 90×90×72mm$^3$ |
| **Electrics** | Power | < 8.2 W (ave)<br>< 8.75W (peak,<10ms) |
| **Observation** | Resolution | 94.4m |
| | Swatch | 222x160km$^3$ |



### BD/GPS Receiver



| | | |
|---|---|---|
| **Structure** | Mass | 4g |
| | Dimension | 22.4×17×2.2mm$^3$ |
| **Electrics** | Power | 0.5 W |
| **Position** | Horizontal | 93m |
| | Altitude | 217.8km |
| | Velocity | 1 m/s |

## STU-2A Camera Design

**Table 1 Mission Requirements on Camera**

| | | |
|---|---|---|
| Imaging function | Swath | >200km@481km |
| | GSD | <100m |
| | spectrum band | 0.43-0.67um |
| | fps(tunable) | 1/5 1/10 1/15 |
| | image type | RAW/RGB |
| | exposure time | manual/auto |
| | image size | 512×512, 1024×1024<br>2352×1728 |
| | image number one time | manual set |
| Hardware | Dimension | <0.72U |
| | Power consumption | <8W(average) |
| | Weight | < 485g |
| | Mass memory | > 4GB |
| Interface | Interface between transmitter | SPI |
| | Interface between OBC | I2C |



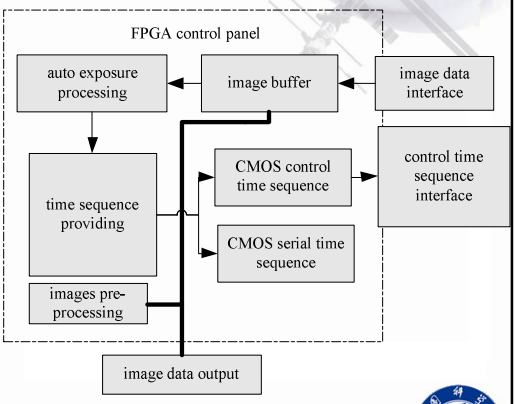
## Camera Electronic Design

Detector: CCD vs CMOS APS

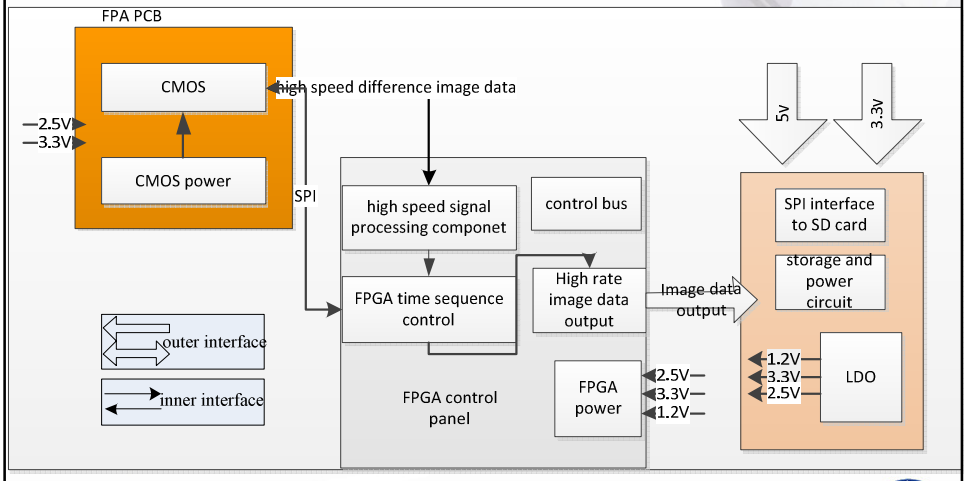
Table 3 parameters of the CMOS sensor

| | |
|---|---|
| pixel number | 2352×1728 |
| pixel size | 7.4um×7.4um |
| data rate | 160MHz×2 |
| Fps | 62 fps at full resolution |
| dynamic range | 57dB |
| ADC | 8/10bit |
| Shutter | global electronic shutter |
| power consumption | 2.2W(62 fps) |
| Power | 3.3V |

Control Panel: FPGA

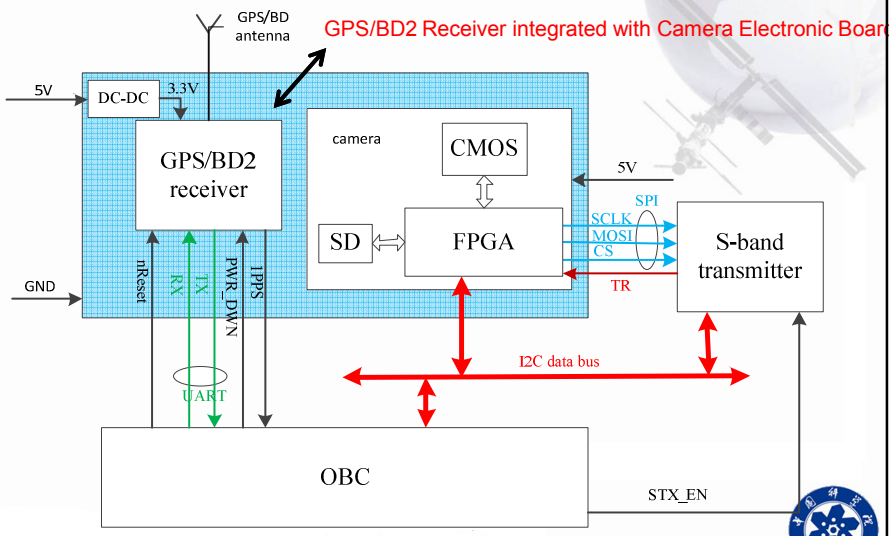


## Camera Electronic Design






## Camera Interfaces & Information Flow

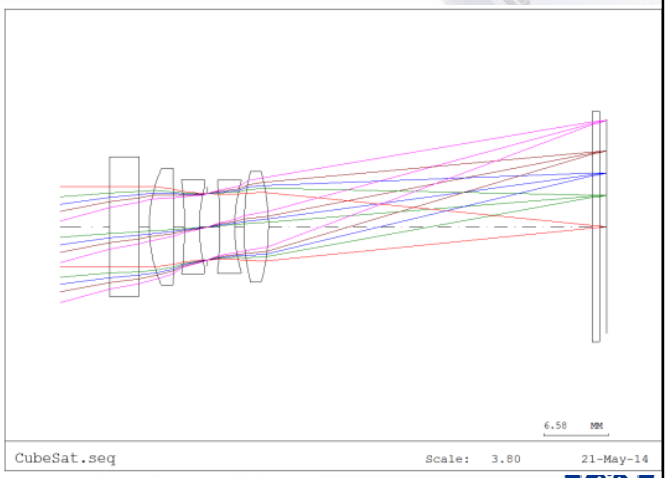


## Camera Optics Design

**Table 4 Lens Parameters**

| | |
|---|---|
| Satellite altitude | 481km |
| Pixel size | 7.4um |
| F | 37.8mm |
| F | 1/5 |
| GSD | 94m |
| Swath | 221km×162km |
| FOV | 26°×19° |

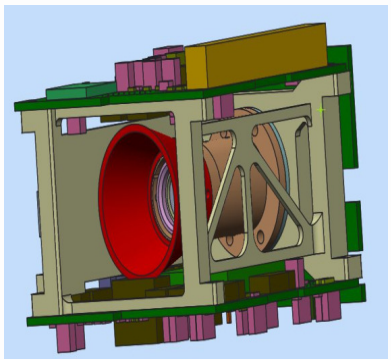
**Fig.5 optics structure of 6 lens**






## Camera Structure Design

Titanium alloy and hollowing material

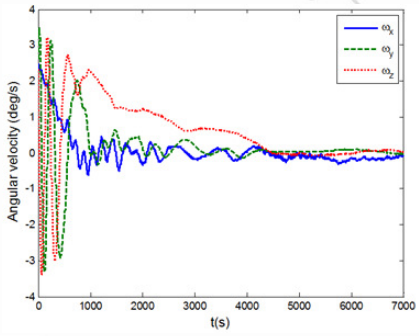


## In-Orbit Data Analysis

### ●Detumbling Phase

94 minutes after launch, the first received signals showed that the satellite had completed rate damping (three axis angular velocity have been reduce within 0.3°/s) within one orbit period time and entered Sun Pointing Mode automatically.

The in-orbit result was in conformity with simulation.

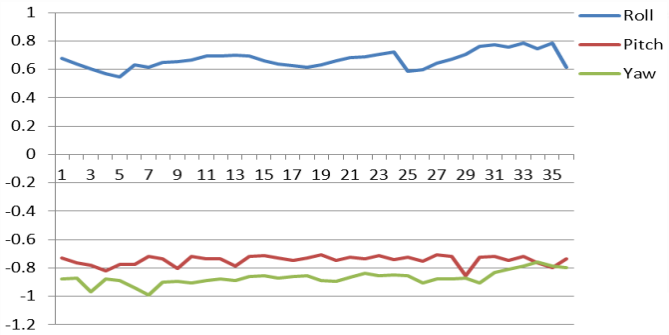





## In-Orbit Data Analysis

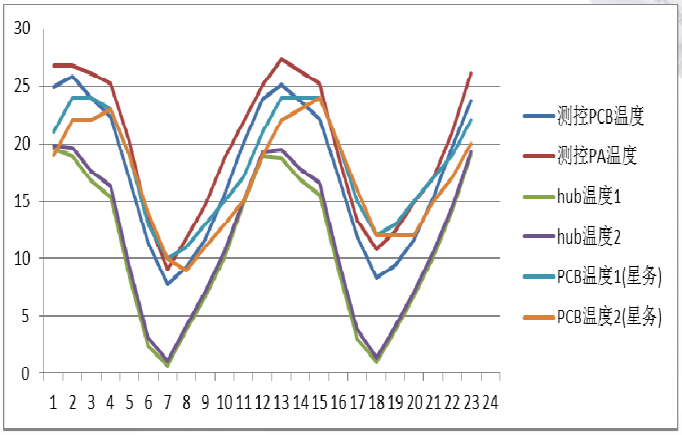
### ●Nadir Pointing Mode

Three attitude angles were constrained within 1°.
The time period is from 08:20 to 08:26, 30th Sep, 2015.



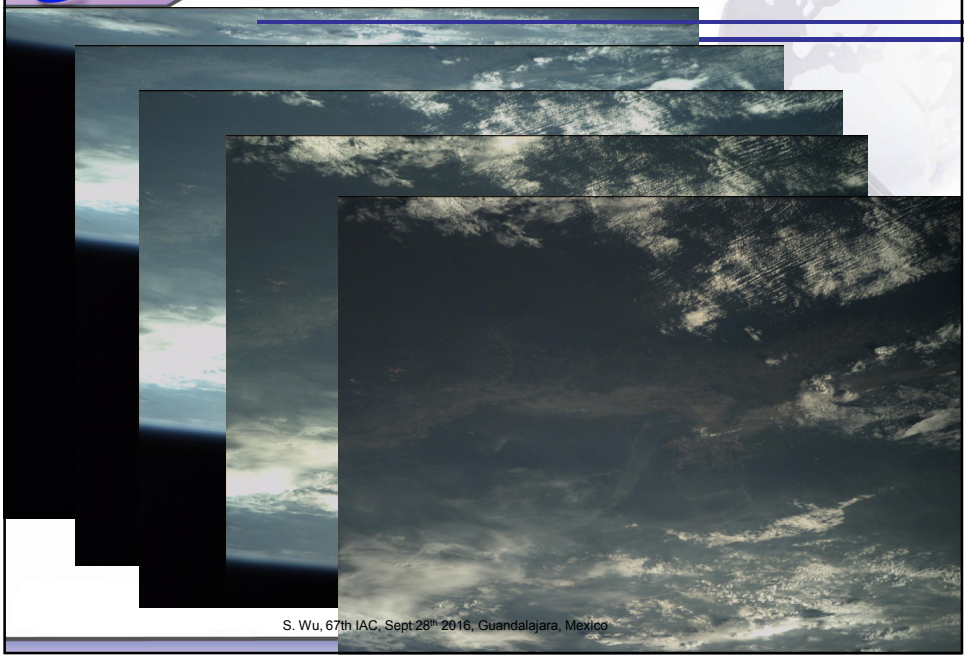
## In-Orbit Data Analysis

●Thermal Behavior (STU-2A)



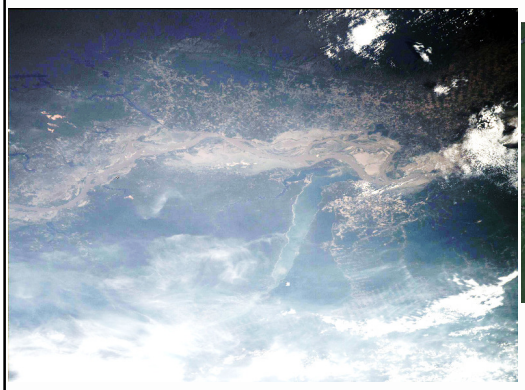



## In-Orbit Results



## Earth Observation: Nov 2015

**STU-2A Imagine**



**Google Map**

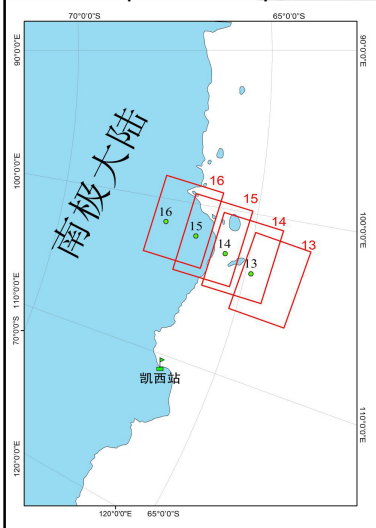
**STU-2A Orbit & Location**

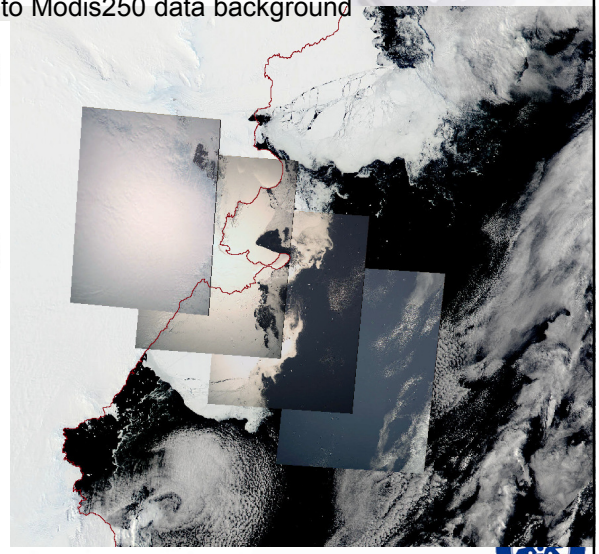
**Location: North Brasil, crossing region of the Tapajos river joining the Amazon river**



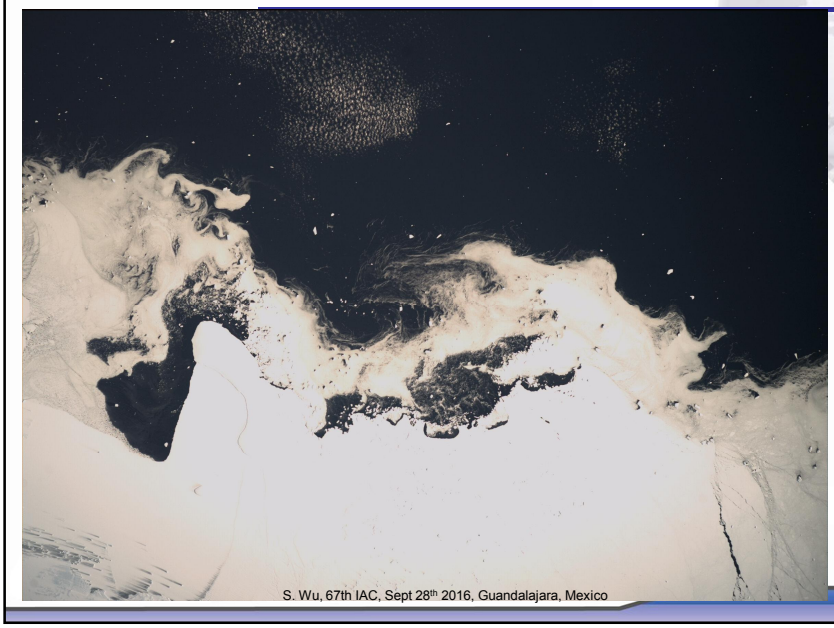
## Antarctic Observation: Feb 20 2016

STU-2A pictures as placed into Modis250 data background



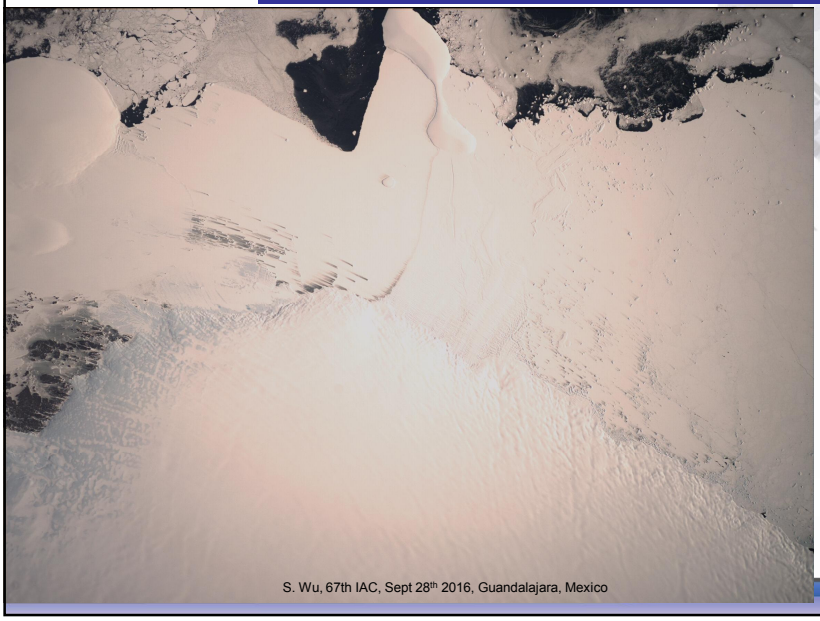



## Imagine No 15, Feb 20 2016

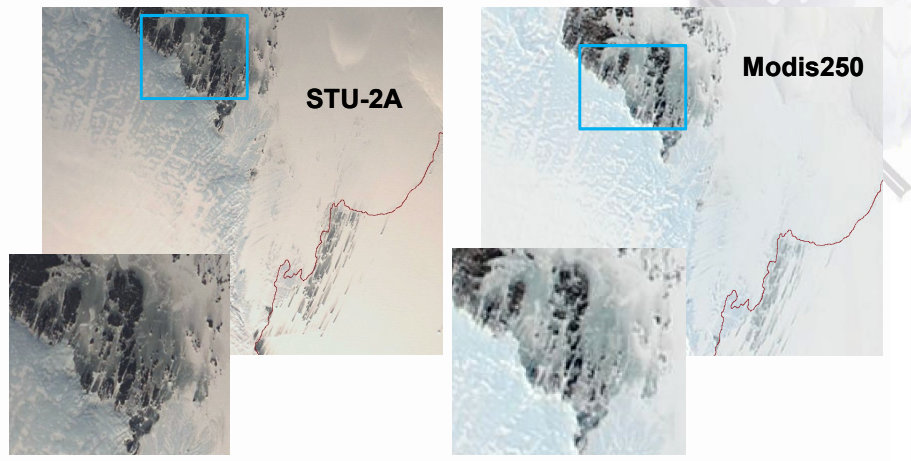




## Imagine No 14, Feb 20 2016



## Comparison of STU-2A with Modis250 image

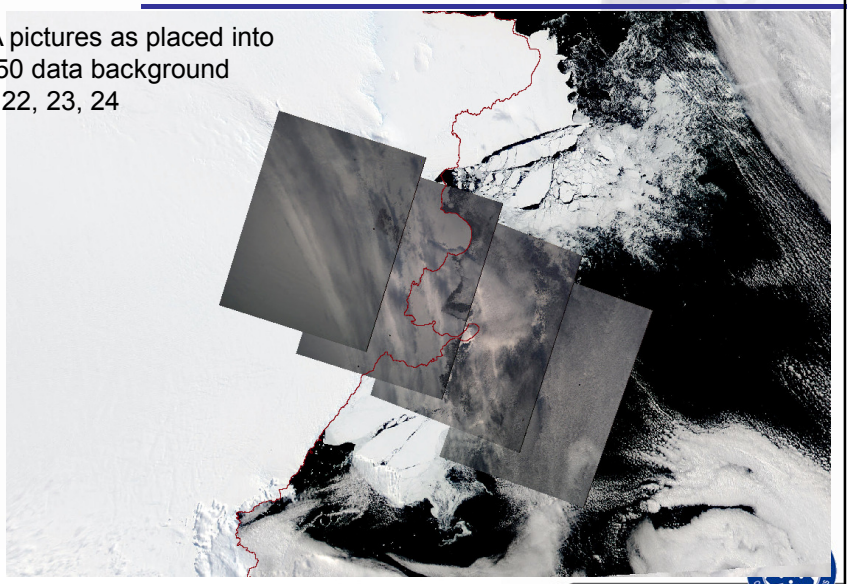



STU-2A's image has a resolution at 100m, much better than the resolution of 250m of the Modis250 imagines

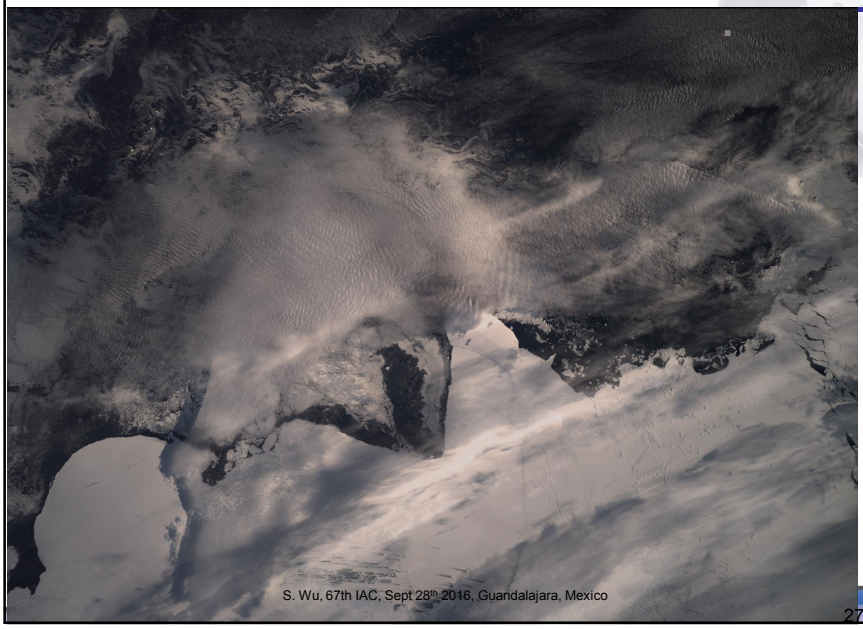


## Antarctic Observation: Feb 23 2016

STU-2A pictures as placed into Modis250 data background
No. 21, 22, 23, 24

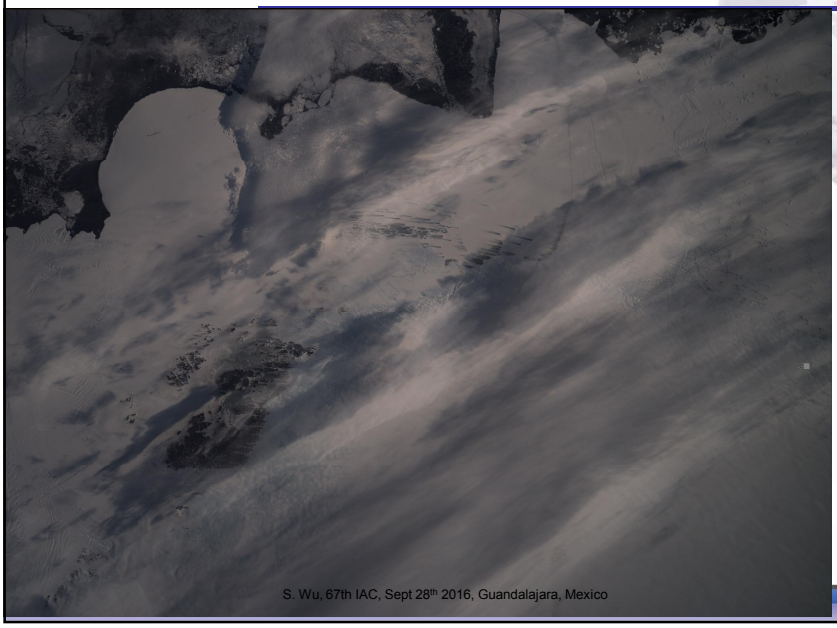


## Imagine No 22, Feb 23 2016





## Imagine No 23, Feb 23 2016



## Lessons Learned

- Structure design must careful to avoid the interferences between electronic boards and optical structures: components height might be bigger in reality
- Vibration tests and thermal vacuum tests are essential for the camera development, to avoid potential mechanical interference and electrical short-cut
- EMC is a critical issue in system design and final testing
- Redundant key sensors/actuators could greatly improve the reliability, providing more measures to tackle irregular cases
- The impact of magnetic residual remains to be very critical.
  it can affect attitude stability
- Magnetometer should be placed as far as possible from large current devices, e.g. PC-104 socket, batteries, etc.



## Summary & Acknowledgement

1. CubeSat is successfully used for polar region observation
2. NanoSat at 2.9kg can perform sensible tasks like glacier operation
3. IOD of a few new technology/products: BD/GPS receiver, Cold-gas micro-propulsion module from NanoSpace, …


Thanks!
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Shanghai Engineering Centre for Microsatellite
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