COPUOS Scientific and Technical Subcommittee,
the 53th Session. Vienna, February 15-26, 2016.

中国空间技术研究院
China Academy of Space Technology(CAST)

China Practices on Satellites Post Mission Disposals Toward Space Long Term Sustainability

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Outline

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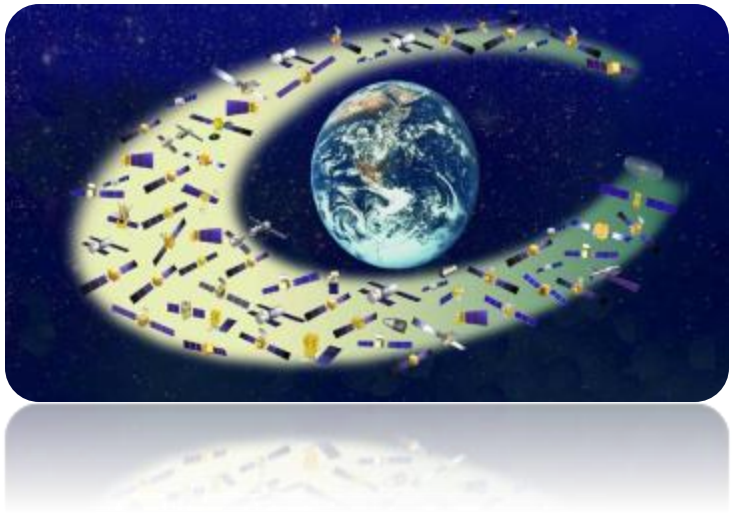
1 Overview of Space Debris Mitigation Activities in China

China Academy of Space Technology CAST

CAST is the largest base for space technology research & space products in China.
CAST is the most powerful backbone strength for China's space endeavor.

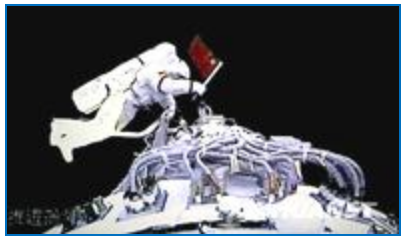
Main fields & Mission：

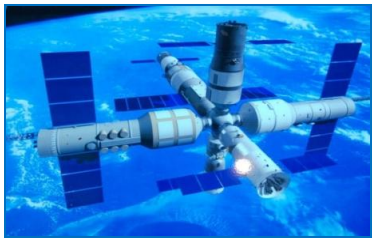


1. Human Spaceflight
2. Earth Observation
3. Telecommunications
4. Navigation
5. Space Science and Deep Space Exploration

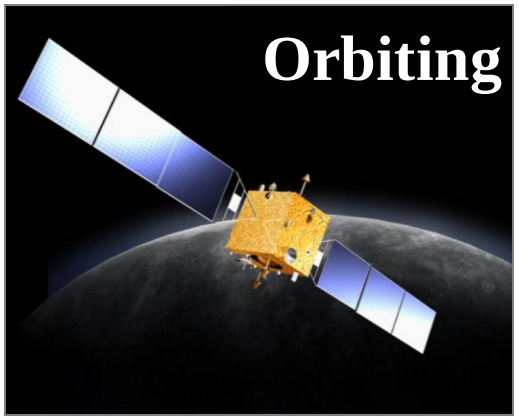
China Academy of Space Technology CAST

Extravehicular activity → Rendezvous & Docking → Space Lab



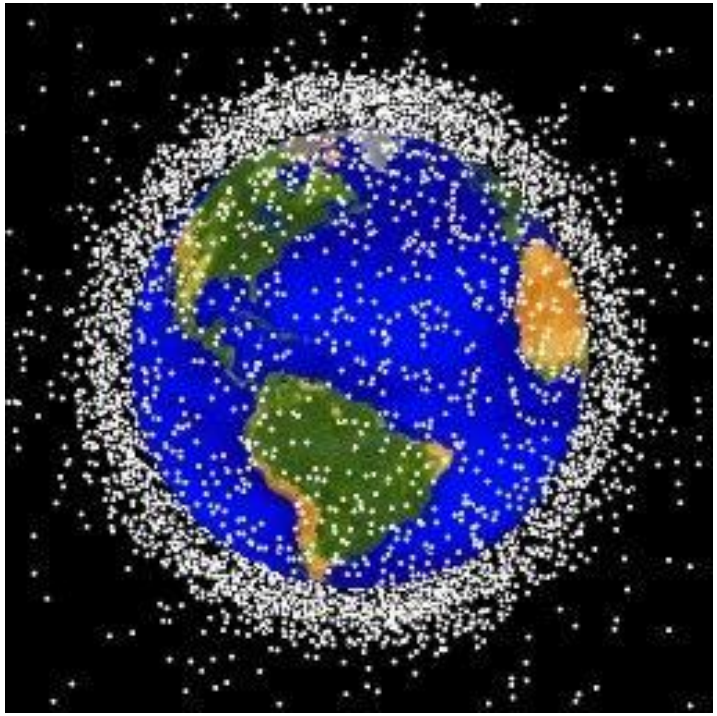


Experimental → Regional → International



The long-term sustainability (LTS) of space is in jeopardy

- More than 6000 satellites launched since 1957 till end of 2015.
- More than 240 times on-orbit break-up.
- Currently only 1200 operational satellites.
- Most of the space objects are unfounctional.
- Space debris is the key factor to influence the LTS

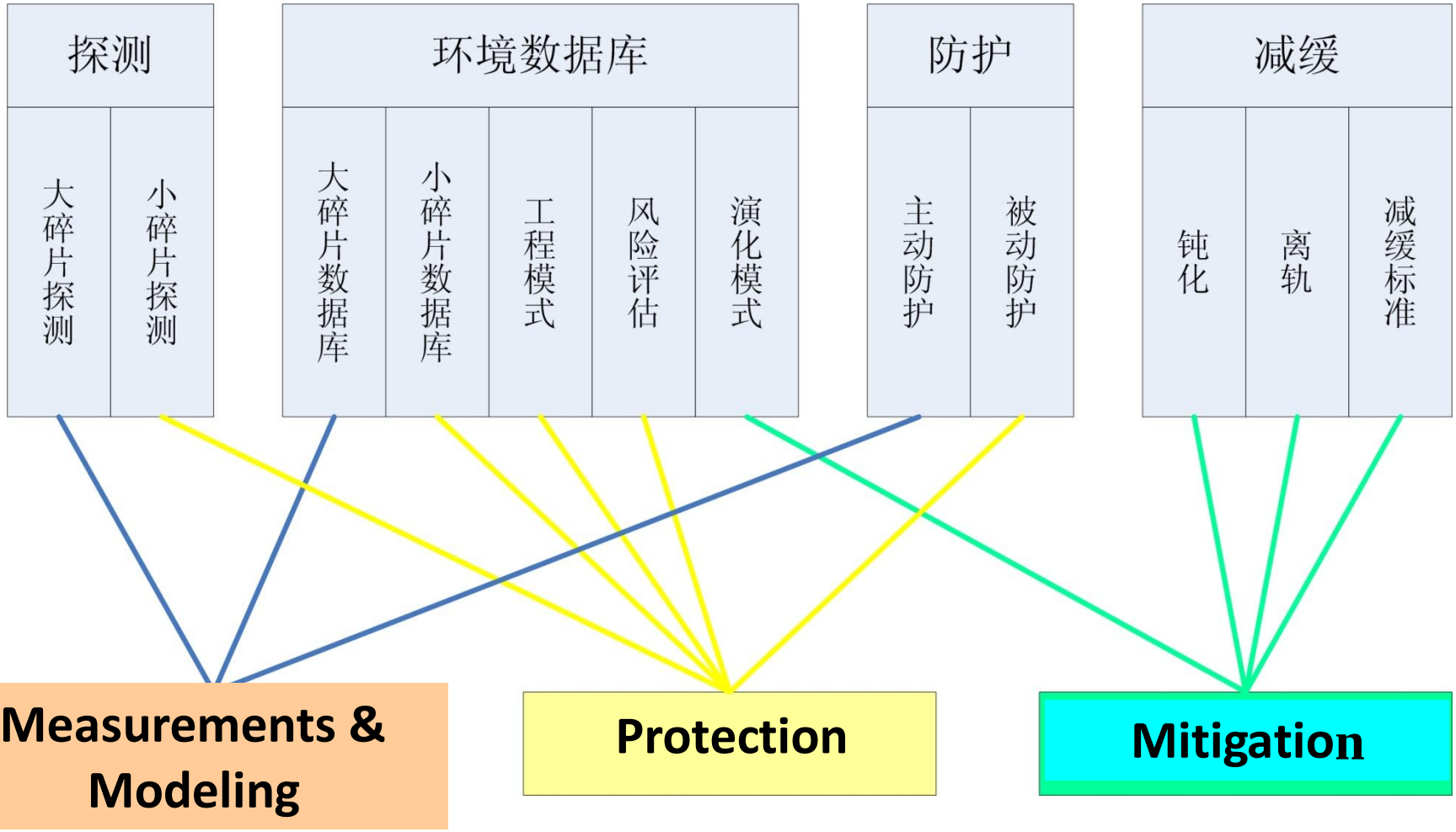


Space debris distribution in Low Earth Orbit

Space Debris Related Key Events in China CAST

- 1991:The Inter-Agency Space Debris Coordination Committee (IADC) founded.
- 1993:China National Space Administration (CNSA) joined IADC.
- 1993: installation of Chinese National Space Debris Office and Chinese Space Debris Advisory Group of experts, coordination of space debris research activities in China.
- 1999: formation of Chinese National expert committee of Space Debris research.
- 2000:Started special budget for Chinese Space Debris research.

Space Debris Research Project in China CAST



Space Debris Related Key Events in China CAST

- Since 1999: always actively participated in the IADC activities; Presented status report on space debris activities of China at IADC annual Meeting.
- The 32nd IADC Meeting was held in Beijing By CNSA from May 12-15, 2014.

Conferences on Space Debris in China

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2001: first Chinese Conference on Space Debris was held .The conference was opened and was held every two year.

2001: Haerbin
2003: Shanghai
2005: Beijing
2007: Nianjing
2009: Yantai
2011: Chengdu
2013:Kunming

2015: Beijing

Beijing International Topical Conference on Space Sustainability

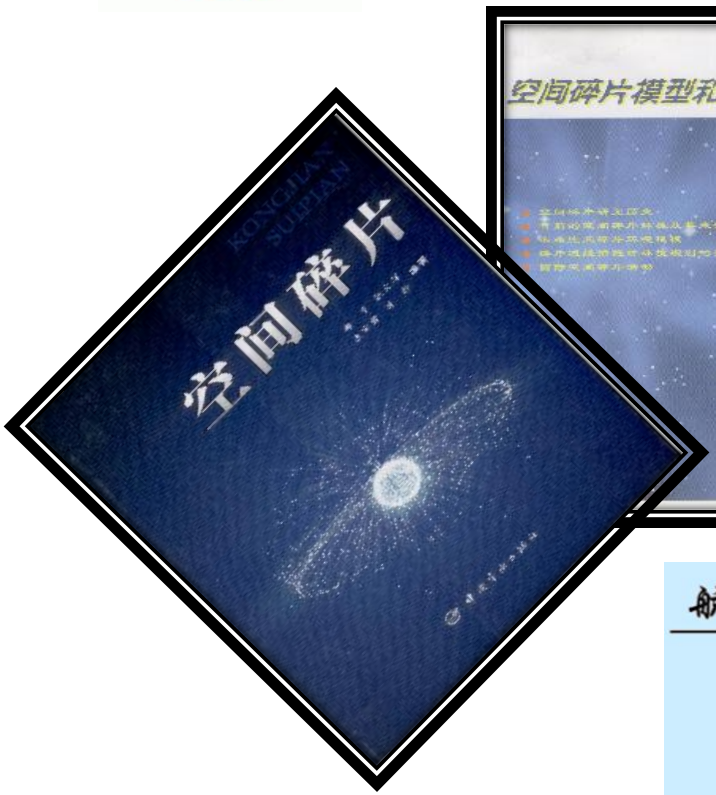
- **Beijing Orbital Debris Mitigation Workshop, October 18-19, 2010**
- **Beijing Space Sustainability Conference, October 13-14, 2011**
- **Beijing Space Sustainability Conference, November 8-9,2012**

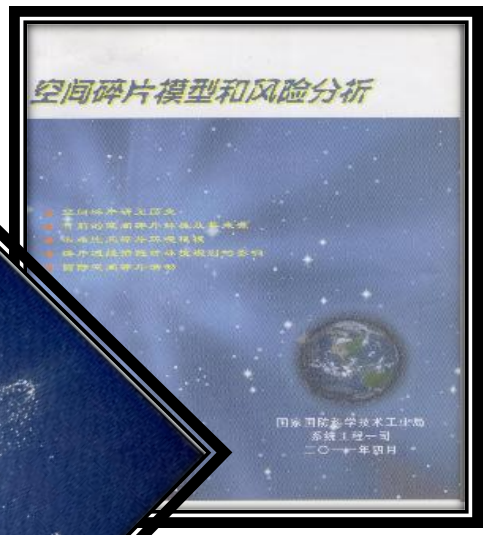
Chinese Journal of space debris research CAST

The one and only journal of space debris research in the world.

It's quarterly. Published since January, 2001.

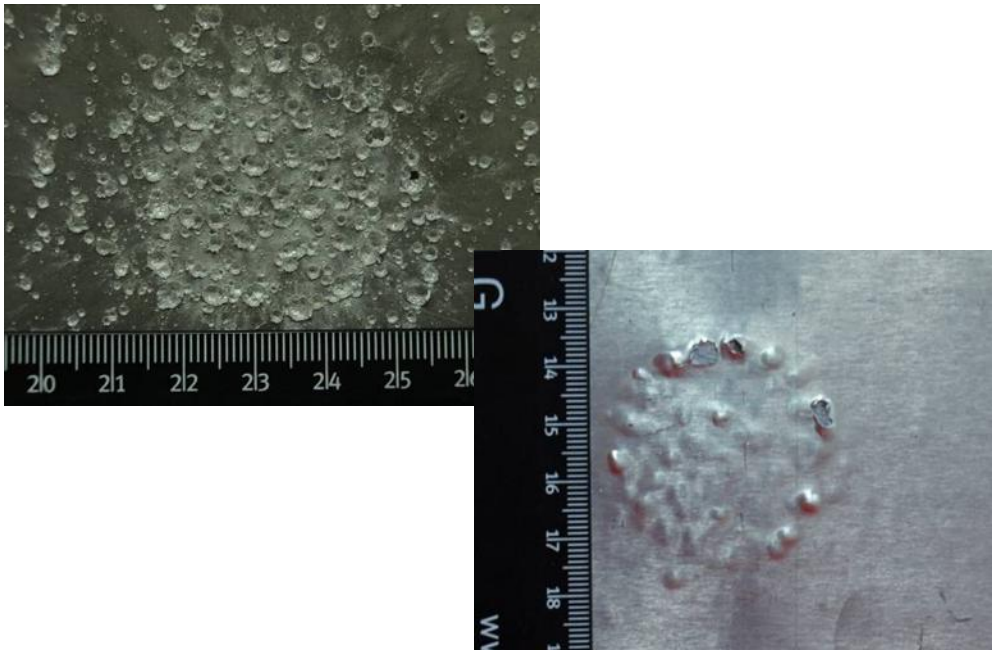
Other Space debris related publications CAST





Space Debris Related Research in China CAST

Hypervelocity Impact Testing Facility Cross Calibration between CNSA, NASA, and EAS.



Dr. Zizheng Gong and Dr. Eric L. Christiansen from NASA-JSC addressed the Hypervelocity Impact Testing facility cross calibration results at the 29th IADC Meeting.

Space Debris Related Research in China CAST

BUMPER: NASA, JAXA
ESABASE/DEBRIS: ESA
COLLO, BUFFER, PSC: ROSCOSMOS
MDPANTO: DLR
SHIELD: BNSC
MODAOST: CAST

Impact Risk Assessment Codes

Table 1 Calibration results for the cube

		BUMPER	ESAB./ Debris	MDPANTO	COLLO	SHIELD	MODAOST
NASA 2000	d > 0.1 mm	2.131E+01	n.a.	2.139E+01			2.143E+01
	d > 1.0 cm	2.876E-06	n.a.	2.872E-06			2.873E-06
	p > 1.0 mm	3.528E-01	n.a.	3.360E-01			3.368E-01
	single	1.714E+00	n.a.	1.642E+00			1.639E+00
	double	2.373E-05	n.a.	2.257E-05			2.303E-05
Meteoroid	d > 0.1 mm	2.221E+01	2.12E+01	2.164E+01			2.164E+01
	d > 1.0 cm	1.398E-06	1.30E-06	1.360E-06			1.362E-06
	p > 1.0 mm	1.013E-01	8.30E-02	9.064E-02			8.812E-02
	single	6.804E-01	6.00E-01	6.204E-01			6.018E-01
	double	1.354E-05	1.20E-05	1.142E-05			1.142E-05

Space Debris Related Research in China CAST

- Conducted the space debris impact risk assessment and designed the appropriate protection shield for China‘s first space lab module Tiangong-1.

(1) Mitigation Techniques of the Launch vehicle:

- Launch vehicle equipment passivation,
- Solid retro-rocket firing and other operational debris controlling,
- the active de-orbit of orbital stages,
- the relative standards

(2) Mitigation technology of Spacecraft:

- spacecraft passivation;
- spacecraft passive de-orbit ;
- Design and practice of lifetime 25 years limit of LEO space system,
- active removing of spacecraft and orbital stages that have reached the end of their mission operations in protected regions;
- Accurate measure and depletion technique of the residual propellants;
- Controlling techniques of discharging batteries, relieving pressure vessels, Self-destruct systems, terminated flywheels and momentum wheels during the disposal phase;
- Safety Assessment for Re-entry of space debris,
- the relative standards

Space Debris Mitigation Standards in China CAST

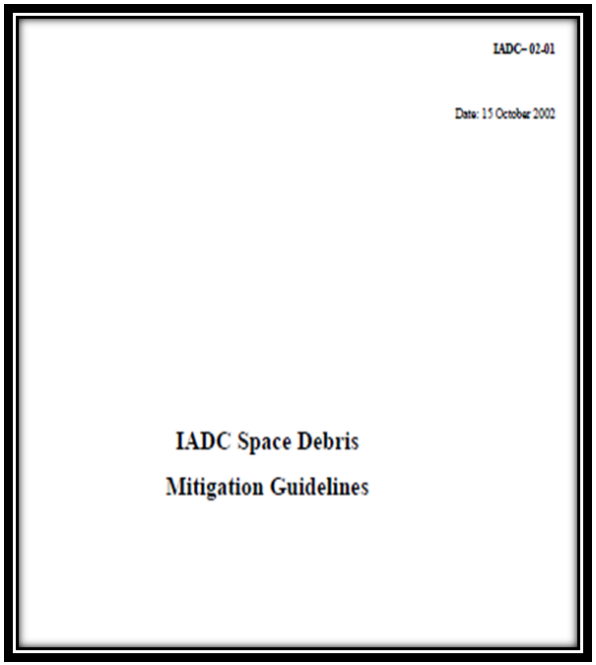
1. China National Industry standard QJ3221-2005 Requirements for Orbital Debris Mitigation (put into effect in 2006, and revised in 2015)
2. KJSP-T-1-01 Rules of Spacecraft Passivation Desgin (under approved)
3. KJSP-T-1-02 Requirements of GEO Spacecraft Treatment and Implement after Task (under approved)
4. KJSP-T-1-03 Requirements of LEO Spacecraft Treatment and Implement after Task (under approved)
5. KJSP-T-1-04 Control Requirements and Desgin Rules for Operational Debris of Spacecraft (under approved)
6. KJSP-T-1-05 Residual Propellant Measuring and Estimating of Spacecraft (under approved)
7. KJSP-T-1-06 Procedure Requirements and Risk Assessment of Reentry of Spacecraft (under approved)
8. KJSP-M-1-01 Management Requirements for Orbital Debris Mitigation of Spacecraft (under approved)

Space Debris Mitigation Standards in China CAST

- The China National industry Standard ---- «Requirements for Space Debris Mitigation» put into effect in 2006

It is revised in 2015.

- The requirements of the Standard were in line with the UN Space Debris Mitigation Guidelines and IADC Space Debris Mitigation Guidelines.



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2 Post Mission Disposals of China Satellites

1 Venting of residual propellants of the launch vehicle

● Up to now , Most of the launch vehicle took measures relevant to Debris Mitigation, the orbital stage of rockets completed the passivation operation, depleted thoroughly all the residual propellant after the separated of the satellite and the rocket, to eliminate the potential breakup on the orbit.

CZ-2D	Nov, 5, 2008
CZ-2D	Dec, 1, 2008
CZ-4B	May,27, 2008
CZ-4B	Oct,25, 2008
CZ-4B	Dec,15, 2008
CZ-2C	Sep,6, 2008
CZ-2F	Sep,25, 2008

● CZ-4B/C launched 4 times in 2010 and brought 7 satellites into the scheduled Orbital, , depleted thoroughly all the residual propellant after the separated of the satellite and the rocket.

2 De-orbit of upper stage

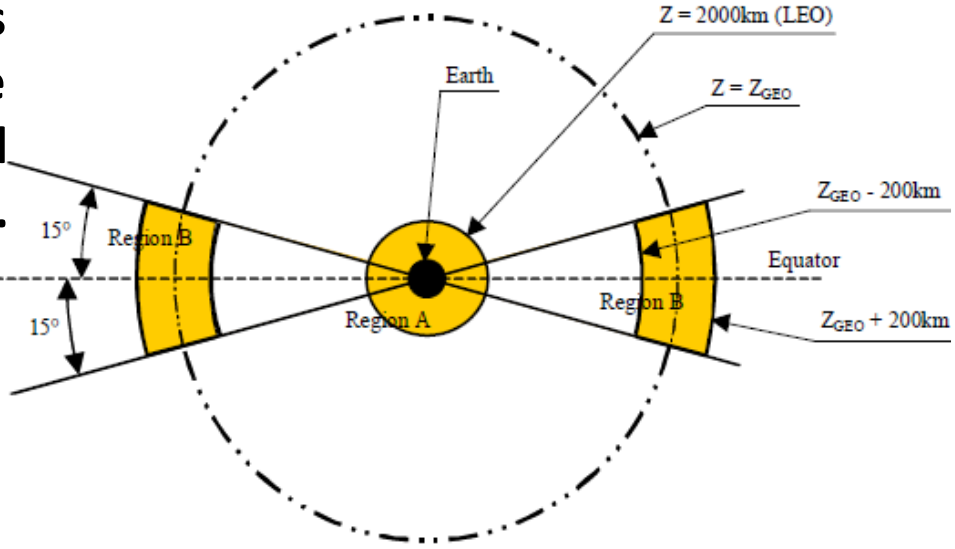
LV	Launch Date	De-orbit Effect
CZ-2C	Sep,9, 2008	660km→242km
CZ-2D	Nov,5, 2008	780km→306km
CZ-2D	Dec,1, 2008	640km→Direct Reentry

- CZ-2D launched 3 times in 2010 and actively took the de-orbit disposal after the successfully separated of the satellite and the rocket.

Why GEO ?

Geo mission: h=35,786 (km), i=0.1°, Ω=90°

The unique nature of the GEO region has ensure that this area of near-Earth space has become, and will remain , a vital and valuable resource for satellite operation. GEO orbit are highly utilized by both military and civil communication application, and to a lesser extent weather forecasting missions.



In theory, there only can contain 1800 satellites in GEO region, and post-mission satellite in GEO will keep over 100 year. So, it is most important to protection GEO region.

3 Post-mission De-orbit of China Satellites in GEO

Satllites	De-orbit time	De-orbit results
FY-2B	2006-08	Orbit raised 60 km, Venting thoroughly the residual propellant.
FY-2A	2007-11	Orbit raised 800 km, Venting thoroughly the residual propellant.
SinoSAT-2	2008-11	Orbit raised 300 km, Venting thoroughly the residual propellant.
BD-1(01)	2011-11-21	Orbit raised 328 km, Venting thoroughly the residual propellant.
BD-1(02)	2011-11-23	Orbit raised 306 km, Venting thoroughly the residual propellant.
ChinaSat-22(01)	2012-11	Orbit raised 286 km, Venting thoroughly the residual propellant.
BD-1(03)	2012-12	Orbit raised 140 km, Venting thoroughly the residual propellant.
BD-2T	2013-12	Venting thoroughly all the residu propellant.
SinoSAT-3	2014-11	Orbit raised 280 km, Venting thoroughly the residual propellant.

- **De-orbiting of SINOSAT-3:**
- **11:00 am (Peking time) on November 2nd 2014: a group of 5 eastward controls was performed to SINOSAT-3**
- **6:00 pm on November 4th :southward station-keeping at the descending node was carried out**
- **7:30am on November 5th :eastward control**
- **6:00pm on November 5th : the propellant tank pressure as well as the temperature of the thrusters appeared obvious fall while the attitude of the satellite suffered a fluctuation up to 1° during the N-S controls**

	Orbit Determination Results	**TLE**
Date	November 5th 2014	December 3rd 2014
Time	18:51:01.730	6:19:16.982
Semi-major Axis *a* （km）	42728.71	42715.82
Eccentricity *e*	0.00051	0.00034
Inclination *i*（° ）	1.886	1.666
Ascending Node （° ）	36.954	36.178
Argument of Perigee （° ）	191.290	122.926

- **Passivation Procedure of SINOSAT-3 :**
  - 8:30pm on November 5th: momentum wheels were stopped in the cruising mode.
  - the onboard active payload devices as well as the heaters were turned off
  - the discharge switches of the south and north batteries were disconnected while the reconditioning device was connected.
  - the charge switches of the batteries were disconnected
  - the final status of the thrusters was set.
  - The TM downlink of SINOSAT-3 was cut off at 9:57pm on November 5th
- **The passivation was then accomplished at the sign of the downlink telemetry's termination.**

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Views and Conclusions

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- The space debris situation is a real concern and is very important regard to long-term sustainability of outer space. Mitigation and Active Remove debris on-orbit are wise approaches keeping long-term sustainability of outer space activities. The UN Guidelines should be respected by all space users.

- China has been making unremitting efforts to protect space environment and is already implementing practical measures on space debris mitigation on a voluntary basis within its own national mechanisms, also taking into account the UN Space Debris Mitigation Guidelines and IADC Space Debris Mitigation Guidelines, had made and will still made its own contributions in this field. Facts showed that China is a responsible country.

- China is opened to promote exchanges and cooperation in various dimensions regarding space debris and long-term sustainability of outer space activities.

Thanks for your attention!