The Accuracy Verification for GPS Receiver of ZY-3 Satellite by SLR

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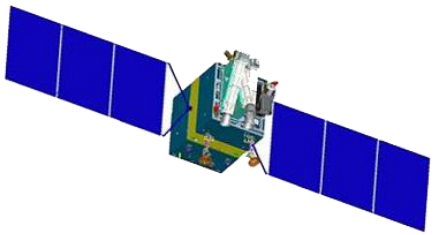

Outline

- Overview of ZY-3
- Orbit Determination Using GPS Data
- Accuracy Evaluation by SLR Data
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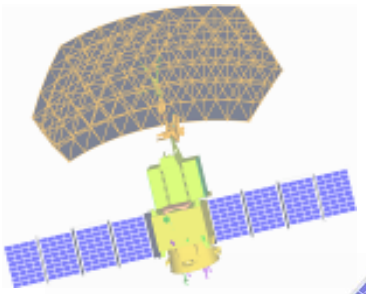
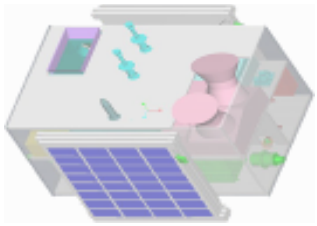
Mapping Satellite

Mapping Satellite: generally the earth observation satellite with mapping capability, including planar, vertical and even gravity computation function.

The main feature is the high geometric precision

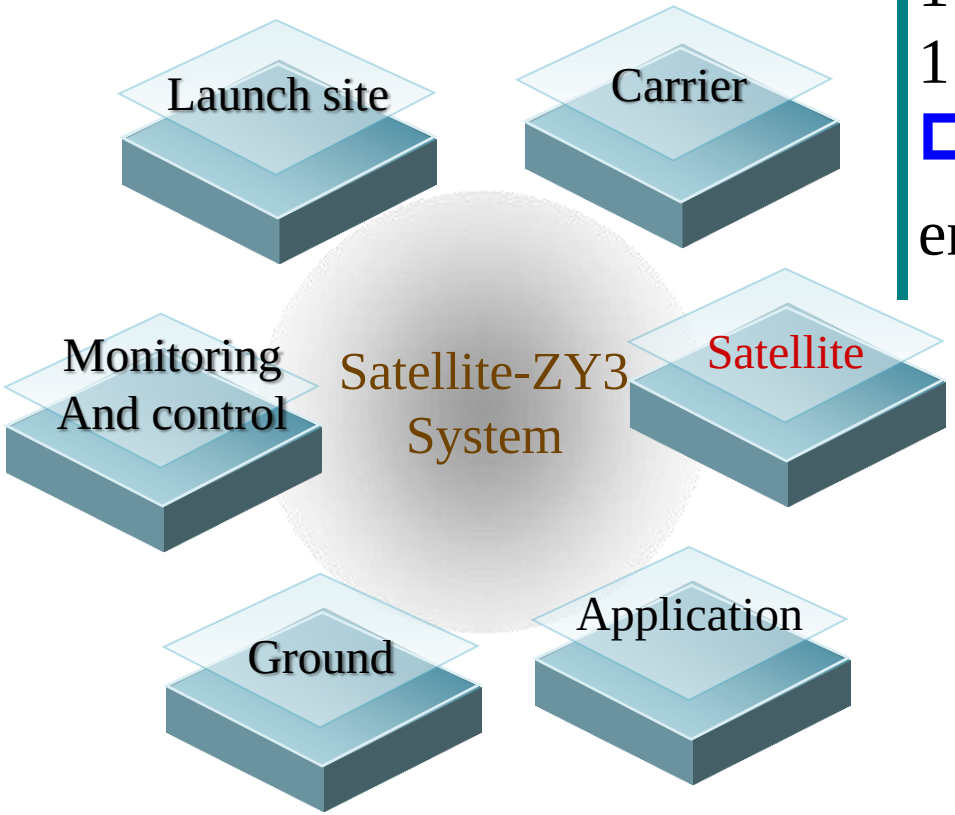




Mapping Satellites

Optical mapping satellite	For a variety of scale topographic mapping
Radar mapping satellite	For a variety of scale topographic mapping
Laser altimeter satellite	For high precision elevation measurement
Gravity satellite	For the retrieval of earth's gravity，improve the precision of vertical datum
Navigation and positioning satellites	For the plane and elevation of high-precision positioning

Satellite-ZY3



- The first civilian high-resolution optical stereo mapping satellite
- objectives: mainly used for 1:50,000 terrain mapping and 1:25,000 map update
- others: remote sensing and environmental applications

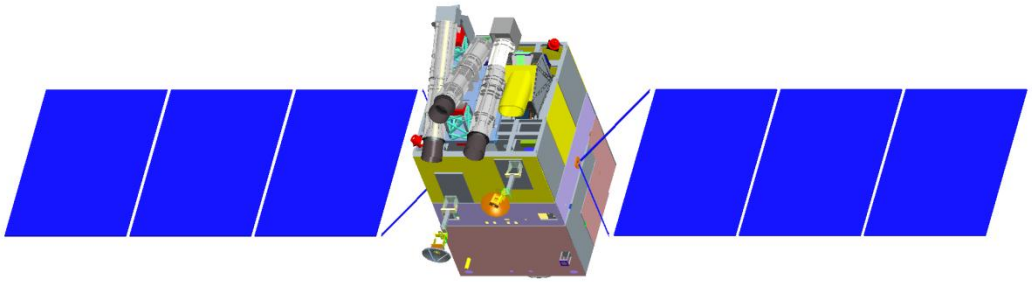
Technical Parameters

Elevation Accuracy 5m

forward、backward resolution 3.5m Nadir 2.1m

Multispectral 5.8m

Be Equipped with Three-line array mapping camera and one Multispectral camera



Regression Cycle:59days
Revisit Cycle:5days
Mission Duration:5years
Weight:2630kg

Inclination: 97.421deg

Three high-precision star sensors, Two dual-frequency GPSs, High-precision gyros

Orbit type: Sun synchronous circular orbit Height: 505km

Successful launch

- Launch time 2012-01-09 11:17:09.979 am

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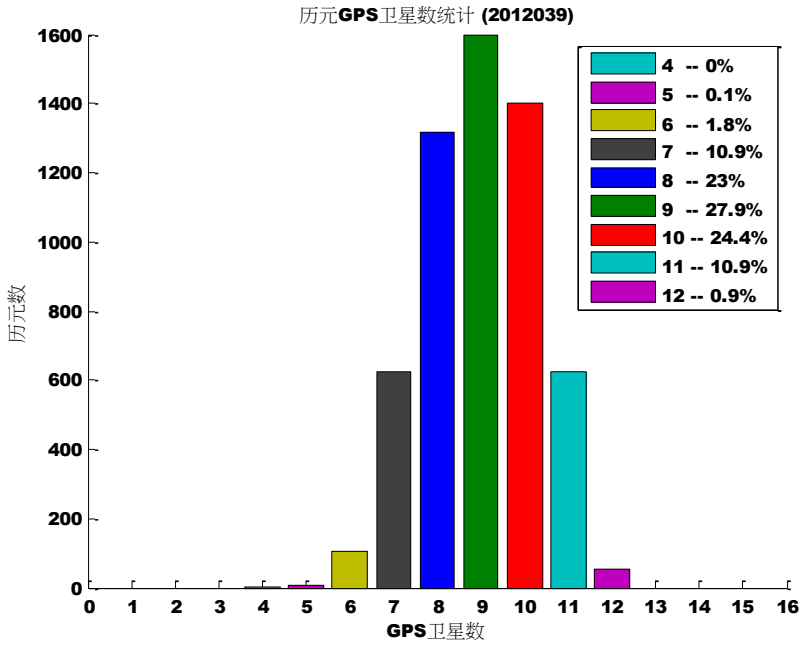
GPS Data Integrity

GPS data integrity rate is 93.88

date	Observations loss	Total observations	Data integrity (%)
2012.03.03	**46351**	**749885**	**93.82**
2012.03.04	**47274**	**753952**	**93.73**
2012.03.05	**47900**	**760151**	**93.70**
2012.03.06	**47360**	**755132**	**93.73**
2012.03.07	**48379**	**758192**	**93.62**
2012.03.08	**39210**	**674446**	**94.19**
2012.03.09	**50307**	**760640**	**93.39**
2012.03.10	**45579**	**752138**	**93.94**
2012.03.11	**44708**	**757251**	**94.10**
2012.03.12	**45441**	**759821**	**94.02**
2012.03.13	**43300**	**758036**	**94.29**
2012.03.14	**43766**	**757333**	**94.22**
2012.03.15	**47915**	**758465**	**93.68**
2012.03.16	**44714**	**755092**	**94.08**
2012.03.17	**47278**	**752992**	**93.72**
Total	**689482**	**11263526**	**93.88**

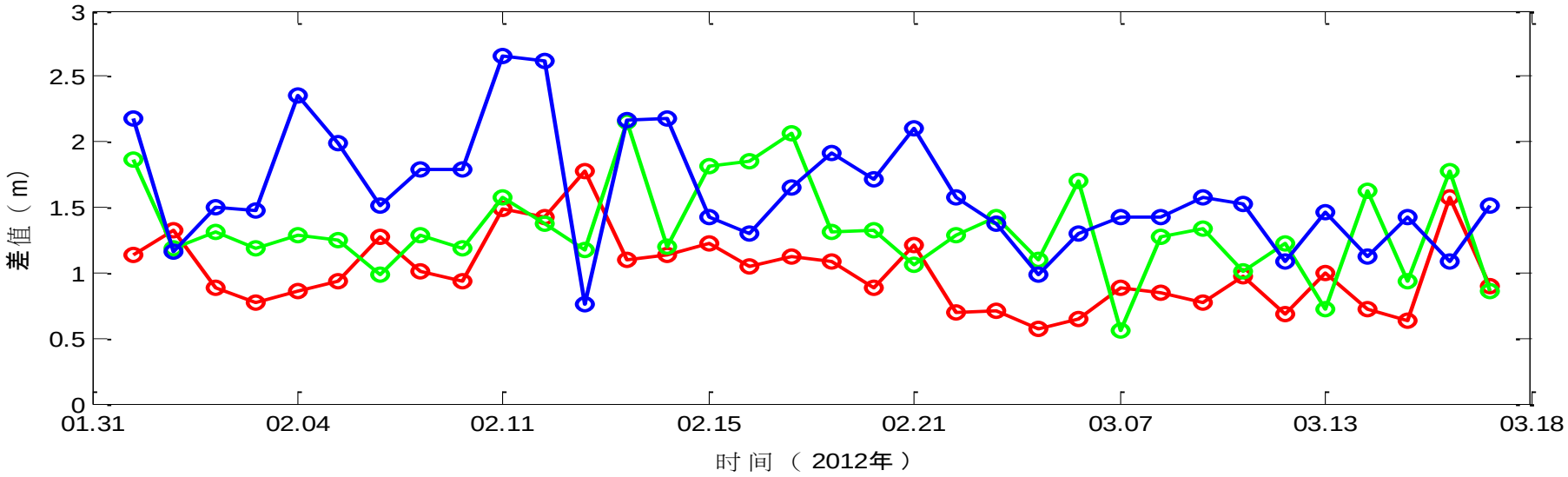
GPS Data Quality



date	MP1/m	MP2/m
2012.03.06	**0.40**	**0.36**
2012.03.07	**0.43**	**0.38**
2012.03.09	**0.40**	**0.35**
2012.03.10	**0.42**	**0.37**
2012.03.11	**0.41**	**0.37**
2012.03.12	**0.40**	**0.37**
2012.03.13	**0.43**	**0.39**
2012.03.14	**0.41**	**0.36**
2012.03.15	**0.42**	**0.38**
2012.03.16	**0.41**	**0.35**
2012.03.17	**0.40**	**0.37**

- **More than seven GPS satellites can be observed by the spaceborne GPS receiver in the more than 97% of epochs;**
- **Multi-path errors of L1 and L2 observation: less than 0.5m and 0.75m of IGS experience value, respectively.**
- **The quality of all data is in line with the international standards.**

Real-time Positioning



Single point positioning: The precision statistical results show that the autonomous localization precisions of space borne receiver are better than 2m on the X and Y components, which is better than 3m on the Z component.

Three dimensional positioning precision is better than 4m.

Orbit Precise Determination

Table 1. Various Types of Data used in Orbit Determination

Data Items	Source	Description
Spaceborne GPS data	Satellite Surveying and Mapping Application Center, NASG	Raw data of 1s sampling rate
GPS precise ephemeris and satellite clock corrections	ftp://ftp.unibe.ch/aiub /CODE/	Precise ephemeris and satellite clock corrections of 30s sampling rate
SLR data	ILRS	Normal point data
GPS receiver antenna phase center offset	ZY-3 satellite development file	Biases between receiver antenna phase center and satellite mass center in satellite-fixed coordinate system
SLR reflector offset	ZY-3 satellite development file	Biases between SLR reflector geometric center and satellite mass center in satellite-fixed coordinate system

Orbit Precise Determination

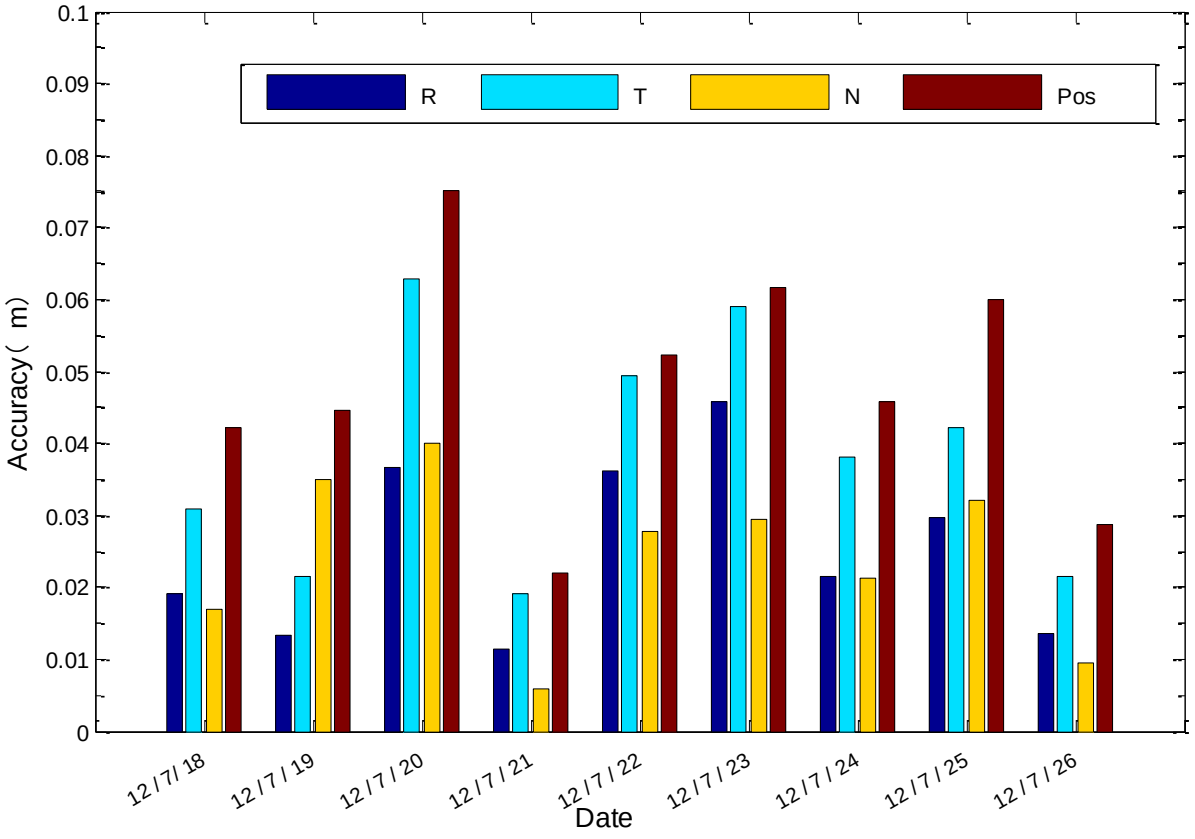
Table 2. Dynamical Model and Estimated Parameters

Perturbative force and Estimated Parameters		Description
Perturbative force	Earth gravity field	GGM02c（100×100）
	Planetary ephemeris	DE405
	Solid earth tide	IERS2003
	Ocean tide	CSR3.0
	Solar radiation pressure	BERN 9-parameter model
	Stochastic pulse parameter	A group parameters every 15 minutes in R、T、N direction, a total of 96 groups
Estimated Parameters	Initial orbit	Position and velocity
	Solar radiation pressure parameters	9 parameters
	Stochastic pulse parameter	96 groups every day

Orbit Precise Determination

Overlap Arc Test: the length of orbit arc is set to 30 hours, 6 hours' overlap arc

- Spaceborne GPS data: July 17-27, 2012
- A total of 9 overlapping arcs
- The position accuracy of overlapping arc is between 2.30 and 7.91cm.
- The variation of orbit determination accuracy also reflects the accuracy and stability of spaceborne GPS data to some degree.



Accuracy of overlap comparison

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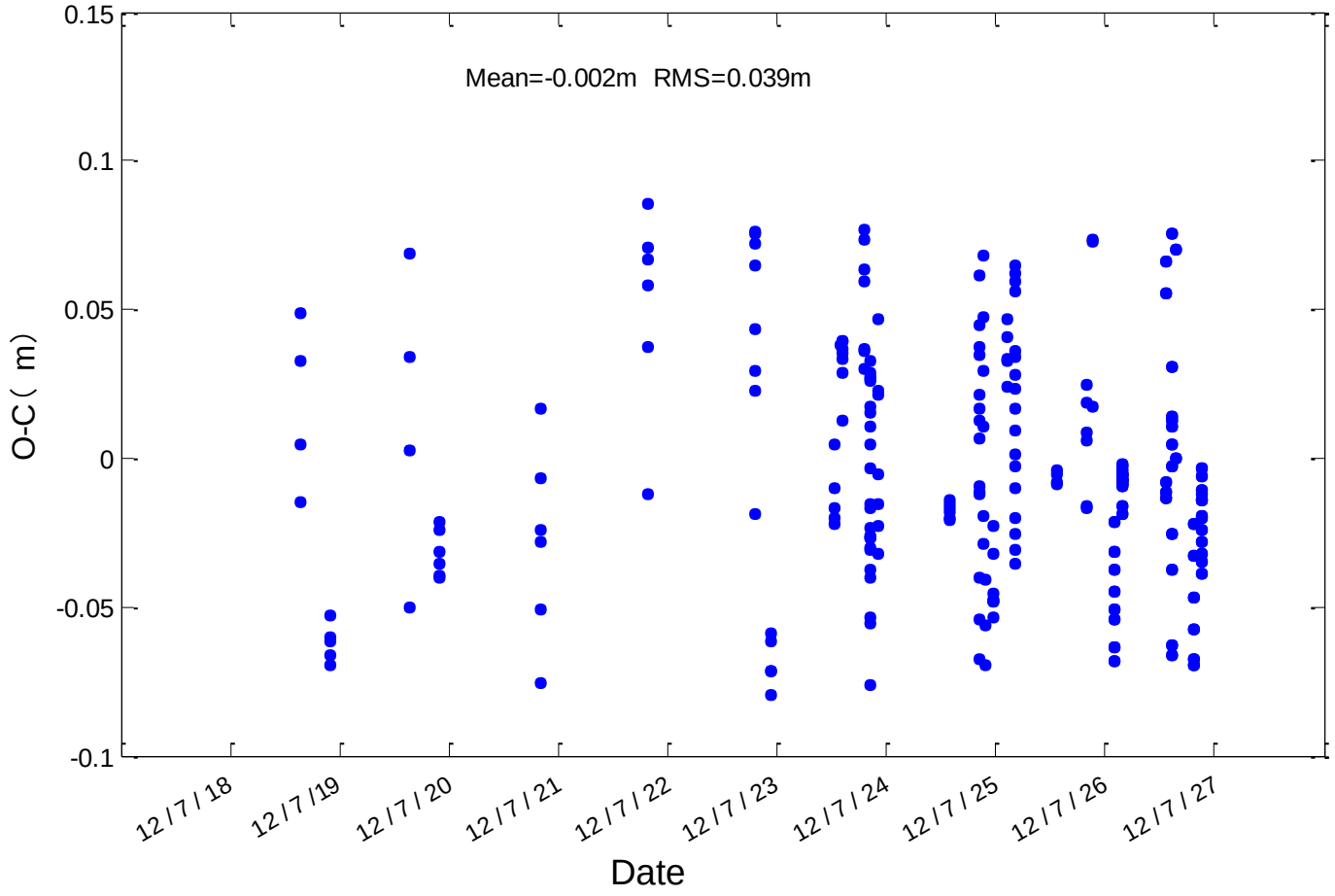
Accuracy Evaluation by SLR Data

ZY-3 SLR Campaign:

With the support of ILRS, the restricted laser tracking to ZY-3 Satellite was carried out. ZY-3 should only be tracked during nighttime conditions at the station to avoid damaging sensors. Thanks to ILRS support, twenty SLR stations participated in the ZY-3 SLR campaign. 184 passes and 1654 data points were obtained from July 9, 2012 to September 5, 2012.

Table 3. List of Participating Station for ZY-3 Tracking

SLR Stations	ID	Nation
Simeiz	SIML	Ukraine
Katzively	KTZL	Ukraine
Yarragadee	YARL	Australia
Greenbelt	GODL	USA
Monument Peak	MONL	USA
Haleakala	HA4T	USA
Tahiti	THTL	French Polynesia
Changchun	CHAL	China
Beijing	BEIL	China
Arequipa	AREL	Peru
San Juan	SJUL	Argentina
Hartebeesthoek	HARL	South Africa
Shanghai	SHA2	China
San Fernando	SFEL	Spain
Mt Stromlo	STL3	Australia
Graz	GRZL	Austria
Herstmonceux	HERL	United Kingdom
Potsdam	POT3	Germany
Matera	MATM	Italy
Wettzell	WETL	Germany



Comparison between SLR data and GPS-determined orbit

The average of O-Cs is only -0.002m and the standard deviation of O-Cs is only 0.039m. There is no significant systematic error.

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Conclusion

- Based on the satellite dynamics principle and batch processing mode, the orbit of ZY-3 satellite was determined using spaceborne GPS data. The analysis result using the overlapping method revealed that the position accuracy of overlapping arc varies between 2.30 and 7.91cm.
- When verified by SLR data, the standard deviation of difference between GPS-determined orbit and SLR data was superior to 4cm, which meant that there was no significant systematic error between the SLR and GPS data.
- The result of this analysis also shows that ZY-3 GPS receiver can provide correct positioning information and is absolutely able to meet the requirement of ZY-3 satellite mission.

Thank you for your attention!