IV. Decay Epoch of the "Tiangong-1" Spacecraft. December 10, 2017

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The materials described below are the continuation of the same text name posted on the website “satmotion.ru” for November 1, 15 and December 1, 2017 [1, 2, 3].

The results of the December 10, 2017

For 60 earlier time points, updating the orbital parameters was made through the array of source measurements, which were as known TLE [4]. Following are the results of the most recent update (ID 4). Here the coordinates (km) and velocity (km/sec) are in Topocentric Equatorial Coordinate System (as in TLE).

21892.479047- modified Julian day = December 9 11^h 29^m 49.66^s
-6395.164593 - x
-1896.762580 - y
1.377077 - z
1.6063453443 - Vx
-5.4438813942 - Vy
5.2515444146 - Vz
0.00364 - Sb (ballistic coefficient, m^2/kg).

Figure 1 presents the assessment of ballistic coefficient, the index values of the geomagnetic perturbation (Kp) and criteria minimum for all previous time points of the orbital parameters updating.

Values of ballistic coefficient (Sb) vary in the range from 0.00305 to 0.00406 m^2/kg, i.e. 1.3 times. These assessments play an important role, as used as initial data for calculating burn up SC in the atmosphere. Substantial variations were observed in the time intervals December 4-5 (decrease) and 7-8 (increase). Black line marked by the average assessment of Sb at some previous time interval (moving average). They are used when generating initial data for prediction.

Shown in the figure criterion value have meaning the ratio of residuals to calculated RMS of errors, averaged on time interval of measurements. These values depend on the magnitude of the current residuals and vary between 0.39 to 2.61. Under perfect tuning algorithm parameters, their average value should be close to one.

Comparison of Sb values with geomagnetic perturbation indexes shows that the above mentioned variation are the consequence of an extreme geomagnetic activity at December 3-4 and 5-6 that has led to a corresponding change in atmosphere density.

The last smoothed ballistic coefficient value (0.00352 m^2/kg) was used as a constant value in the prediction of the SC motion until his entering the dense layers of the atmosphere. Feature of these data is monotonic decreasing smoothed estimates of

Sb values (15%). This is due to the low level of solar and geomagnetic activity over the 10-day interval until 5 December.

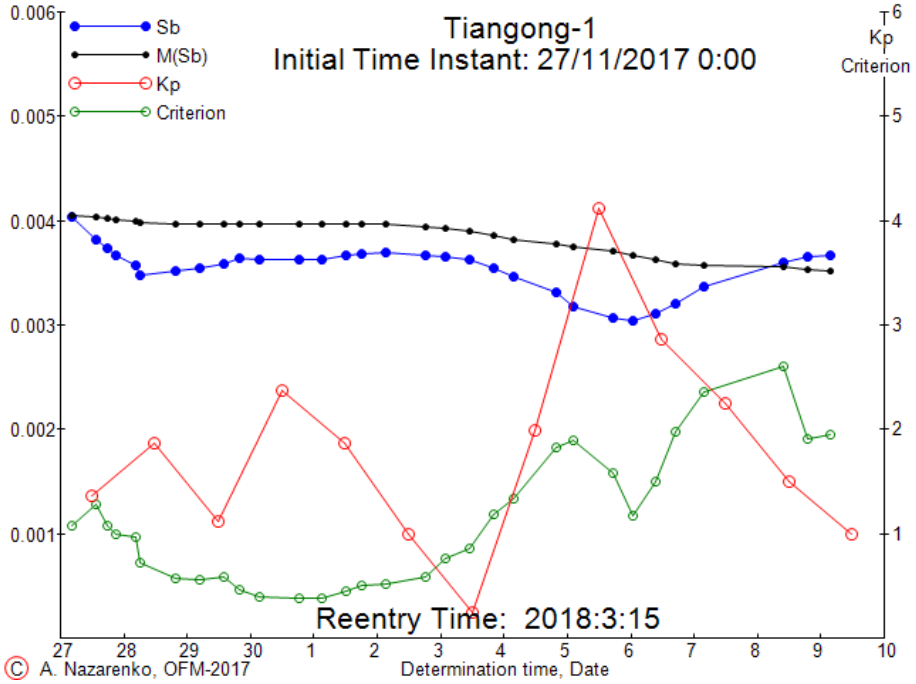


Figure 1. Values of ballistic coefficient, Kp and criterion

Criterion values (quadratic forms) are of important significance for checking the orbit determination. It is visible from figure that the maximum value are reached at instant of time when ballistic coefficient values are changes significant, i.e., at instant of significant unpredictable changes of atmospheric density. In these instants the consistency of measurements with the computational motion model deteriorates, which leads to an increase in residuals. The criterion value, averaged according to figure data, equals 1.19, that acceptable manner consistent with ideal value (1.0).

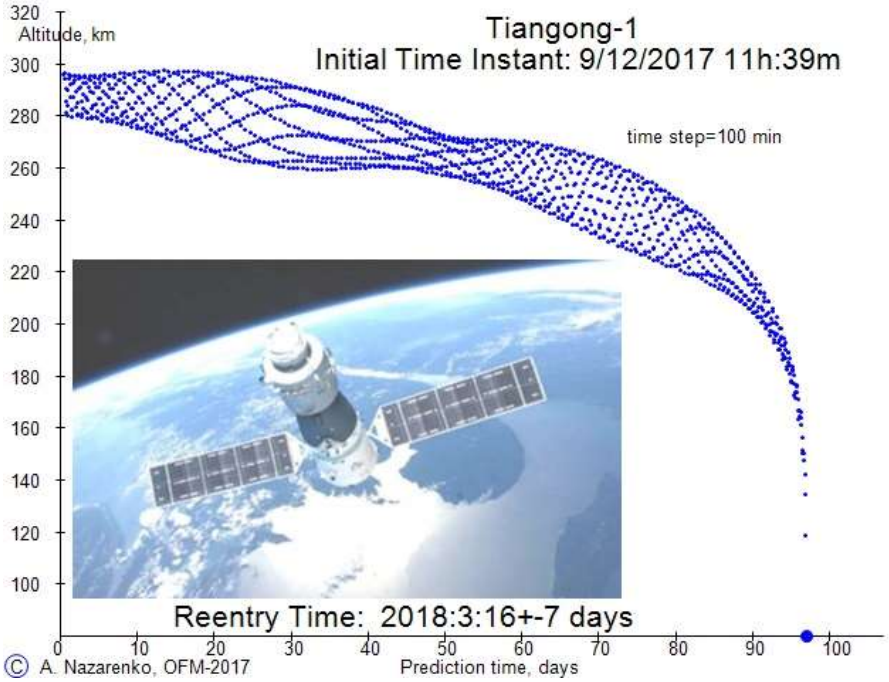


Figure 2. Altitude values as time goes on

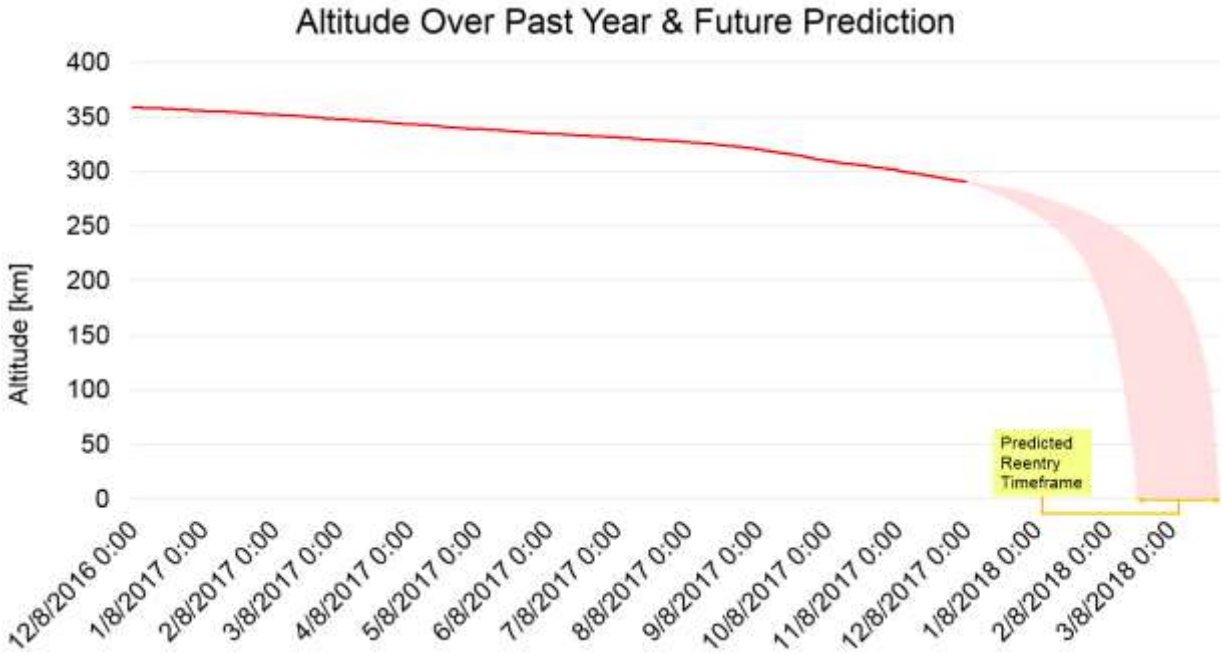
Relevant prediction results by the above initial data (ID 4) are shown in figure 2. When this scatter plot is prepared, the time step of 100 minutes was used. That is why the figure has a peculiar appearance.

Reentry Information.

Tianging-1 is predicted to reenter in 2018, March 16 ±7 days.

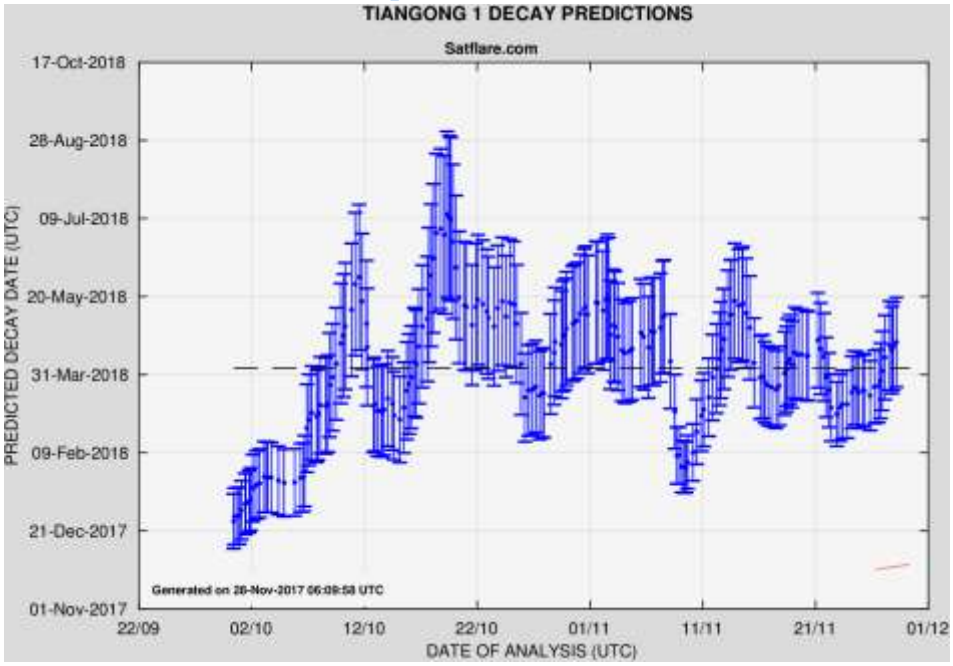
Recent publication

a) Tiangong-1 Altitude Prediction. This prediction was performed by The Aerospace Corporation on 2017 December 8.



Tiangong-1 is predicted to reenter in mid-March 2018 ± 3 weeks.

b) http://www.satflare.com/home.asp



By initial data for November 28 2017, the reentry time varies from **February 26** up to **May 20**, 2018

c) Data of V.S. Yurasov (private message).

TLE processing results over the preceding week interval and the forecast of the SC motion until the reentry:

Initial data time	Results	Atmospheric model		
		GOST 1984	NRLMSIS	GOST 2004
November 9 2017	t reentry	March **10** 02^h	March **9** 06^h	March **7** 00^h
	Sb, m^2/kg	0.00384	0.00386	0.00368
December 1 2017	t reentry	March **12** 03^h	March **9** 18^h	March **11** 22^h
	Sb, m^2/kg	0.00361	0.00389	0.00360
December 9 2017	t reentry	March **14** 00^h	March **16** 12^h	March **18** 06^h
	Sb, m^2/kg	0.00367	0.00373	0.00347

References

1. A.I. Nazarenko. Decay Epoch of the "Tiangong-1" Spacecraft. November 1, 2017. Site satmotion.ru

2. A.I. Nazarenko. Decay Epoch of the "Tiangong-1" Spacecraft. November 15, 2017. Site satmotion.ru

3. A.I. Nazarenko. Decay Epoch of the "Tiangong-1" Spacecraft. December 10, 2017. Site satmotion.ru

4. http://www.space-track.org