THE IADC RE-ENTRY TEST CAMPAIGN OF EAS AT PMO

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ABSTRACT

In November 2008, Purple Mountain Observatory, Chinese Academy of Sciences took part in the IADC reentry test campaign 2008/1 representing China, which is called EAS.

This paper presents a new reentry prediction method which estimates the reentry time. By this method 20 reentry predictions were carried out and the results were uploaded to the IADC Common and Reentry Database.

1. INTRODUCTION

The space objects will enter the earth's atomosphere and be burned up when its orbit lifetime is over. But some with heavy mass or anti-high-temperature coat. If these objects reentry the aerosphere, they cannot burn-up completely and might collide with the earth. So, it could threaten the human beings' safety. These kinds of space objects are called risk-objects, and its reentry prediction and track is called "risk-object re-entry". In 1995, CNSA joined in IADC and took part in several reentry prediction campaigns during 1998 and 2007, especially in the reentry prediction campaign for MIR in 1998. Chinese prediction results reported at the IADC annual conference won a very high praise comparing with other countries' results. And in the following campaigns, we also got preferable results.

In October 2008, the IADC promoted the reentry test campaign 2008/1, and the name of the campaign is EAS(the Early Ammonia Servicer). Purple Mountain Observatory took part in this campaign representing China National Space Administration, CNSA.

The test object for the IADC Re-Entry Prediction Test Campaign 2008-1 is the Early Ammonia Servicer (1998-067BA, #31928), which was launched from KSC on STS-105 on Aug.10, 2001. It was installed on the ISS P-6 truss during that mission, and it was later jettisoned from ISS on July 23, 2007.The Early Ammonia servicer (EAS) has a mass of 640 kg, and dimensions of 2.5m x 1.2m x 1.7m. Its orbit at campaign start on Oct. 22, 2008, was 216 km x 230 km at 51.64 deg inclination.

China, America, Germany, Italy, Russia, India, Japan and so on took part in this campaign. The IADC reentry test campaign of EAS officially began on 22 October 2008 and ended on 3 November 2008.

Figure 1. EAS

2. REENTRY PREDICTION MOTHOD

20 IADC reentry predictions were obtained using the the following dynamic models.
1) Earth Gravity Field Model : 50×50 JGM3
2) atmospheric density model: MSIS1990
3) solar radiation pressure
4) lunisolar perturbations
5) tidal perturbation.

When the satellite's altitude is larger than 180km, the value of Cd is a constant number 2.2. When the altitude is smaller than 180km, Cd's value should be changed according to the altitude. At present, there were not very good analytical formulas to calculate its value, so we used the following approximate formulas to compute Cd:

$$Cd = 2.2 - 1.5 \times 10^{7} \times \rho \,, 120km<H<180km \quad (1)$$

$$Cd = 1.9 - (1.2/50) \times (120-H) \,, H \leq 120km \quad (2)$$

where H is the satellite's altitude(km), ρ is the atmosphere density at this altitude.

The accuracy of Area to Mass ratio(AM) has a huge influence on reentry prediction precision. So before the campaign, it is necessary to estimate the most probable AM value using the satellite's orbital data in the past. However, in order to reduce the influences of different atmosphere models, we must assure that the atmosphere model used to estimate Am and predict the reentry time must be the same. According to the changes of semi-major axis, the average AM of EAS is 0.0029905m2/kg. If the satellite is higher than 120km, we use semi-analytical, semi-numerical method to predict. When the

satellite is lower than 120km, we take the numerical integration method to predict .We assume that the time when the satellite altitude is 0 km is the reentry time.

3. RESULTS OF REENTRY PREDICTION

The IADC reentry test campaign of EAS officially began on 22 October 2008 and ended on 3 November 2008.
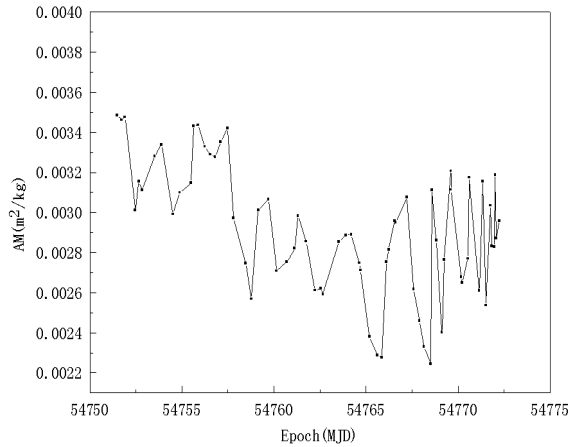Used the past orbits of EAS,AM of EAS is determined . the average AM of EAS is 0.0029905m2/kg.

Figure 1. EAS' AM according to orbit

Used the average AM and orbit go from the IADC Common and Reentry Database, Purple Mountain Observatory uploaded 20 prediction results to the IADC Common and Reentry Database. According to the final observational data of EAS, IADC gave the predicted reentry time as 4:58 (UTC), November 3, 2008.

Table 1 Prediction results

uploaded time (m/d h:m)	Epoch (m/d h:m)	Prediction reentry time (m/d h:m)	Prediction Error (Δt, hour)	Prediction error (%)
10/29 09:18	**10/29 03:23**	**11/05 07:07**	**50.15**	**41.2%**
10/29 09:54	10/28 14:07	11/03 11:12	6.23	4.6%
10/29 09:56	10/29 03:23	11/03 12:49	7.85	6.5%
10/30 07:25	10/29 12:14	11/03 14:24	9.43	8.4%
10/30 07:26	10/29 13:42	11/03 11:25	6.45	5.8%
10/30 07:27	10/29 19:36	11/03 11:12	6.23	5.9%
10/30 08:35	10/30 02:57	11/03 12:58	8.00	8.2%
10/30 08:37	10/30 05:54	11/03 11:12	6.23	6.6%
10/31 04:17	10/30 14:44	11/03 10:35	5.62	6.5%
11/1 07:52	10/31 03:58	11/03 10:51	5.88	8.1%
11/1 07:53	10/31 05:26	11/03 10:46	5.80	8.1%
11/1 07:54	10/31 12:47	11/03 08:27	3.48	5.4%
11/1 07:55	10/31 14:15	11/03 06:46	1.80	2.9%
11/2 09:58	11/1 12:15	11/03 06:00	1.03	2.5%
11/2 09:59	11/1 22:45	11/03 05:49	.85	2.8%
11/2 10:01	11/2 00:16	11/03 05:58	1.00	3.5%
11/2 10:02	11/2 01:52	11/03 05:52	.90	3.3%
11/2 10:03	11/2 05:49	11/03 05:56	.97	4.2%
11/3 02:47	11/2 23:27	11/03 05:16	.30	5.6%
11/3 02:49	11/3 01:08	11/03 05:14	.27	7.0%

The mean percentage error during the whole campaign is 7.35%. The first prediction error is quite large because the 10.7cm flux data don't update. After updating Flux data, the predictions are normal.
The following table shows the overall statistics obtained in this campaign.

Table 2 Prediction results of all the agencies

Agency	All Predictions		Last 48h Predictions	
	Count	Error Δt (%)	Count	Error Δt (%)
ASI	24	5.76	11	8.53
BNSC	9	18.89	5	9.18
CNES	12	5.96	4	7.92
CNSA	20	7.35	11	4.85
DLR	16	9.06	7	6.79
ESA	20	8.50	12	7.75
ISRO	28	7.30	13	8.20
JAXA	7	4.28	.	.
NASA	7	6.51	4	6.37
ROSCOSMOS	27	5.54	13	5.30
total	170		80	

4. CONCLUSIONS

According to the reentry predictions for the Early Ammonia Servicer(EAS) , under normal conditions the percentage error is better than 10%.