OPTICAL OBSERVATIONS OF BRIZ-M FRAGMENTS IN GEO

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ABSTRACT

On January 21, 2016 the Joint Space Operations Center (JSpOC) of the US Strategic Command was informing about a possible breakup of a Briz-M upper stage in the geostationary ring. This upper stage with the International Designator 2015-075B is associated with the launch of the Russian Cosmos 2513 which took place only 6 weeks earlier on December 13, 2015. The same day, ESA together with the Astronomical Institute of the University of Bern (AIUB) prepared for a survey campaign using the 1-meter Space Debris Telescope (ESASDT) at ESA's Optical Ground Station on Tenerife and AIUB's sensors at the Zimmerwald Observatory. The selection of the survey strategy to search for fragments of this event was based on a synthetic debris cloud, assuming a hypothetical fragmentation epoch (the real fragmentation epoch was not known at this time). Observations with the ESASDT were performed on January 23 and 24, and in additional two nights in February. The uncorrelated objects found during this campaign were followed-up with the Zimmerwald sensors. We will present the observation results and the challenges related to the association of the candidate fragment tracklets with each other, the initial orbit determination, and the determination of the breakup epoch.

1. INTRODUCTION

On January 21, 2016 AIUB was informed by ESA about the possible breakup of a Briz-M upper stage in the geostationary ring. At the same time AIUB was mandated to perform searches for fragments of this breakup with the 1-meter Space Debris Telescope (ESASDT) at ESA's Optical Ground Station (OGS) on Tenerife during the following two nights. AIUB in turn decided to use its own sensors at the Swiss Optical Ground Station and Geodynamics Observatory Zimmerwald to support this activity. In particular the1-m Zimmerwald Laser and Astrometry Telescope ZIMLAT (Figure 1) was used to perform follow-up observations of objects discovered with the ESASDT (Figure 1). In order to design the survey scenario, ESA created a fragmentation population assuming a breakup epoch close to the communicated detection epoch of 21-01-2016 19:00 UTC. The median value of the of the velocity of the fragments of 55km/s was then used to create 5 different sets of pseudo-objects assuming an isotropic velocity distribution for the fragments (Figure 2). The pseudo-objects within these sets were generated by varying their mean anomaly to emulate an along-track search.

2. ESASDT SURVEYS AND DISCOVERIES

A total of 11 objects were discovered by the ESASDT during the nights of the 16nd and 23rd of January 2016. These were objects which have been observed at least three times during the discovery night, including the discovery itself. The objects and their osculating orbital elements are listed in Table 1, including the elements of the nominal parent body 2015-075B. The table contains only objects which were observed at least three times during the discovery night, including the discovery itself.

Observations performed by Zimmerwald observatory were correlated with the ESASDT observations and used for the orbit improvement. Further correlation showed that some of the ESASDT discoveries were actually multiple discoveries of the same objects, namely 16023A and 16023F, which are identical with the nominal object 2015-075B. Further, objects E16022A and E16023B are the same object. After correlation there were in total 5 GEO and 3 GTO discoveries.

A comparison using the pre- and post-event TLEs provided by JSpOC indicated a different epoch for the break-up event than originally assumed (Figure 3). The same holds for the comparison of the pre-event TLE with the hypothetical fragment E16022A (Figure 4).

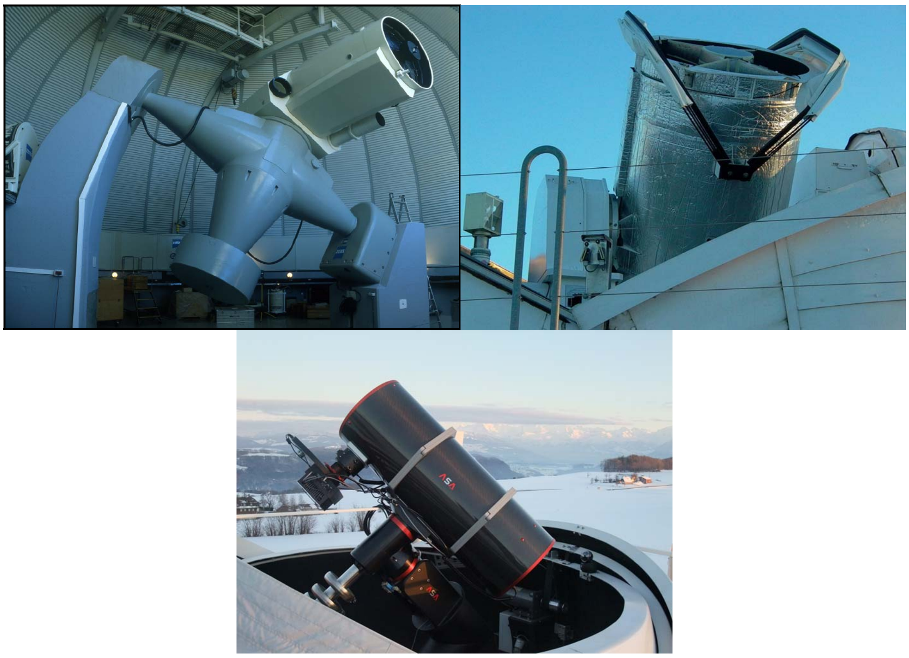

Figure 1: ESA 1-meter Space Debris Telescope (ESASDT) on Tenerife (top left), AIUB's 1-meter ZIMLAT telescope (top right), and the Zimmerwald Small Robotic Telescope ZimSMART (bottom).

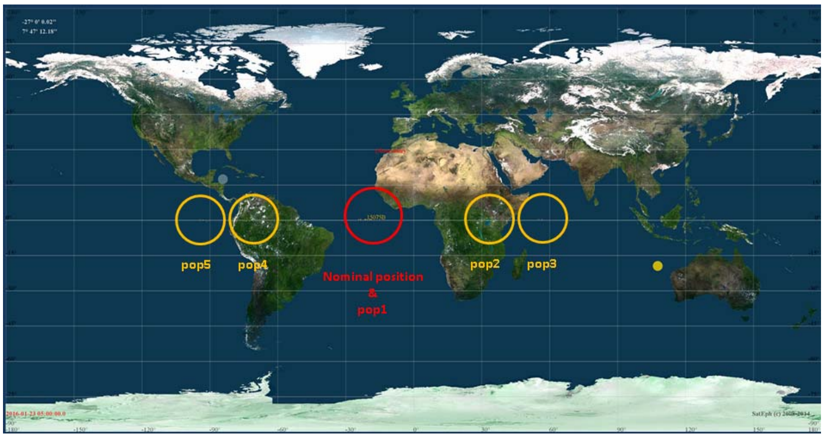

Figure 2: Geocentric positions of the 5 sets of pseudo-objects used to design the survey scenario.

Name	Type	Mag	a	e	i	O	Obs Arc [day]
E16022A	GEO	17.6+-0.4	40983	0.0247	0.3700	166.53	2.71
E16022B	GEO	15.9+-1.5	39648	0.0901	9.2500	-23.66	0.44
E16023A	GEO	12.9+-0.3	41001	0.0327	0.2800	107.99	0.36
E16023B	GEO	17.8+-0.4	41017	0.0254	0.6400	150.05	2.73
E16023C	GEO	17.1+-0.5	40933	0.0427	3.3400	-39.55	0.32
E16023D	GEO	15.1+-0.5	40216	0.0478	0.8300	-48.54	0.37

E16023E	GTO	13.0+-0.7	25132	0.6902	0.1200	170.97	0.27
E16023F	GEO	12.5+-0.8	40970	0.0322	0.2800	107.91	0.35
E16023G	GEO	12.9+-0.3	45858	0.0511	2.7200	77.78	0.45
E16023H	GTO	12.7+-0.5	25063	0.6916	0.1200	166.48	0.43
E16023I	GTO	14.3+-1.1	25784	0.7367	15.4400	2.39	0.18
Nominal object							
15075B	**GEO**	**12**	**40985**	**0.0328**	**0.2900**	**108.63**	**4**

Table 1: List of ESASDT discoveries including data for the nominal object 2015-075B.

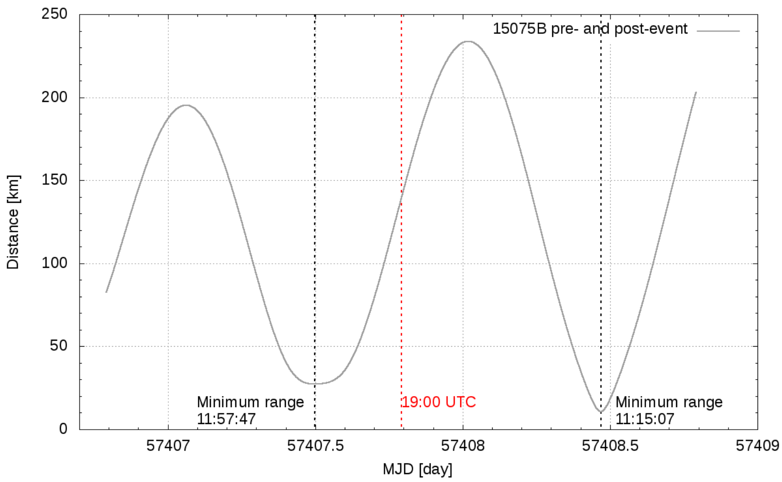

Figure 3: Distance between positions generated by SGP model and pre- and after-event TLEs of 15075B. Closest distance indicates the hypothetical epoch of the event ("pinch point").

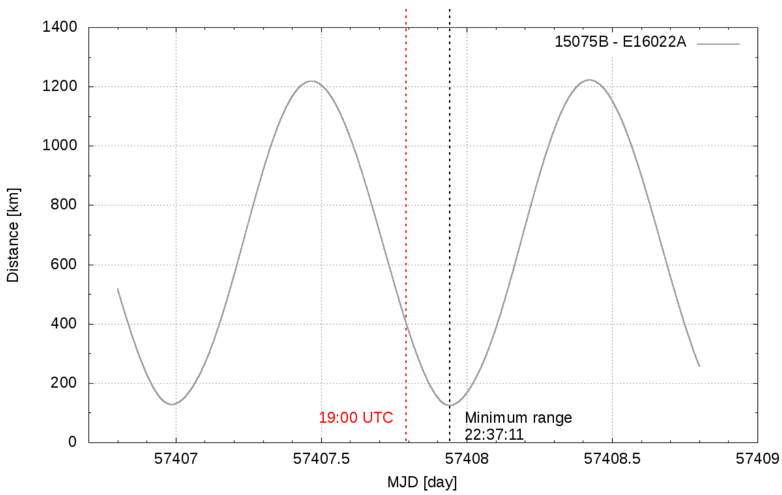

Figure 4: Distance between 15075B by using SGP and pre- event TLE and object E16022A.

ESASDT surveys were performed during additional 2 nights on February 16 and 17 2016. The analysis of the pre- and post-event orbits of the parent object available at that time indicated a breakup epoch of 15-01-2016 06: 42 UTC. Additional 4 objects were discovered during these nights. Unfortunately all of these objects could be followed up only during the night of discovery and were lost afterwards. As a consequence, the orbits determined for these objects are very inaccurate and we cannot exclude that some of the objects are identical with objects discovered in January 2016.

3. PHOTOMETRIC LIGHT CURVES

Immediately after AIUB was notified about the fragmentation event, a short photometric campaign was planned and performed in order to extract apparent spin rates of objects related to this event. Due to the low magnitude of some of the newly discovered targets and due to the bad weather conditions at Zimmerwald, light curves could only be obtained for object 15075B. In order to compare the shape of the reconstructed phase [1] with other upper stages of the same type, light curves of object 15042B, a Brize-M upper stage launched 3.5 months earlier than 15075B, were acquired. The observed light curves of 15075B and 15045B, as well their reconstructed phases are given in Figure 5 and Figure 6. The apparent spin period determined for object 15075B is 0.9s, which is a very high spin rate for an upper stage. For the object 15045B the observed apparent spin period was 6.4s. However, high spin rates seem to be typical for Brize-M upper stages. Observations of the Briz-M upper stage 15060B indicate a spin period between 0.9s and 1.2s.

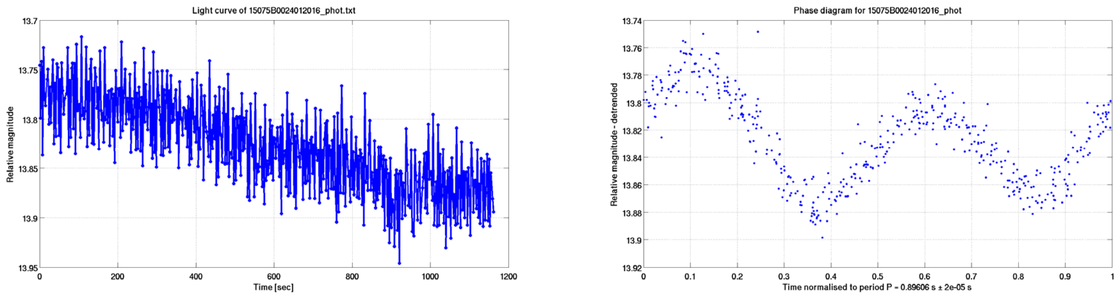

Figure 5: Light curve (left panel) and reconstructed phase (right panel) of object 15075B acquired by the ZIMLAT telescope on 24th of January 2016.

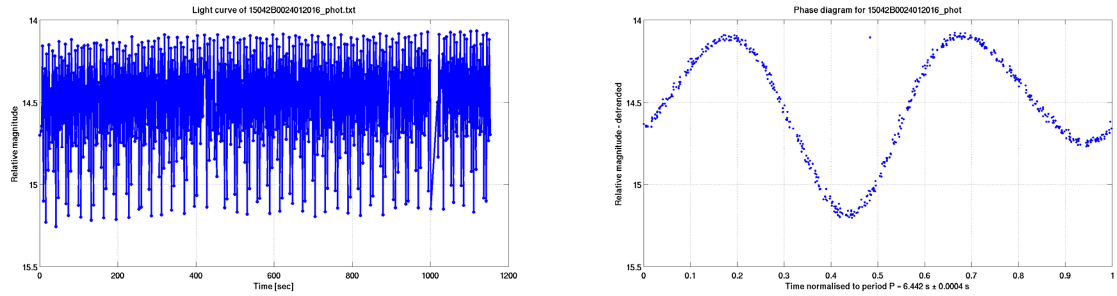

Figure 6: Light curve (left panel) and reconstructed phase (right panel) of object 15042B acquired by the ZIMLAT telescope on 24th of January 2016.

4. SUMMARY

AIUB on behalf of ESA designed and conducted a successful optical survey campaign to search for fragments of the Briz-M upper stage (International Designator 2015-075B) which experience a breakup on January16, 2016. First observations with the 1-meter ESASDT telescope at ESA's Optical ground Station (OGS) at Tenerife and AIUB's ZIMLAT and ZimSMART sensors were performed during two nights immediately following the JSpOC announcement of a possible breakup on January 21, 2016. Additional surveys were done during two nights in February. A total of about half a dozen candidate fragments objects were discovered. Unfortunately, with the exception of one object (E16022A), all of them were lost after the night of discovery or shortly thereafter, although they all had at least three series of observations during the discovery night.

5. ACKNOWLEDGEMENTS

We would like to thank all the night observers and the technical staff at the Swiss Optical Ground Station and Geodynamics Observatory Zimmerwald and at the ESA Space Debris Telescope.

6. REFERENCES

[1] Linder E., Silha J., Schildknecht T., Hager M., Extraction of Spin Periods of Space Debris from Optical Light Curves, IAC-15.A6.1.2, 66th International Astronautical Congress, Jerusalem, Israel, 2015, 12 – 16 October.