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High Geocentric Orbit Space Debris Circular No.3
Coverage period ends on Apr 1, 2007 12:00 UTC

Introduction

This circular opens a new series of publications devoted to periodically summarizing the worldwide scientific activities in observations of space debris objects on high geocentric orbits (GEO, HEO and high near-circular non-GEO). Objects considered to be included into this publication are fragments (operational by nature, created in fragmentation events or as a result of larger objects' surface and construction deterioration due to environment conditions) having brightness fainter than 15th visual magnitude during most part of their observation time. This limit corresponds to approximately 1 m size object on geostationary orbit. It is possible that sometimes these objects can be brighter than 15th magnitude due to combination of their specific properties (surface reflectivity and attitude) and favorable observation conditions (good phase angle, high elevation etc.).

The goal of this publication is to give the world scientific community imagination about the status of high geocentric orbit space debris researches and to provide up to date data for each discovered object including orbital parameters, estimated standard magnitude and estimated area-to-mass ratio value. Those data can be included in existing space debris models as well as can be used for study of long-term orbital evolution and possible origin of the objects. The Circular will also serve as some reference document for scientists and amateurs involved in those objects observations and data analysis. Operators of spacecraft in high geocentric orbits (mainly in GEO) can use this publication in order to obtain a more realistic description of the situation around their orbital assets.

Observation planning, ephemeris support, processing and analysis of obtained data are made by researchers from Keldysh Institute of Applied Mathematics (KIAM) (Vladimir Agapov, Igor Molotov, Viktor Stepanyants, Vladimir Titenko) with invaluable help of Zakhariy Khutorovskiy (Vympel Corporation) and Vasiliy Yurasov (Institute for Precision Instrument Engineering, IPIE).

The presented results include discoveries stemming from surveys of the European Space Agency (ESA) utilizing the ESA Space Debris Telescope in Tenerife. Those surveys and all follow-up observations from the ZIMLAT telescope of the Astronomical Institute of the University of Bern in Switzerland (AIUB) are planned, run, processed, and analyzed by the AIUB.

All questions regarding cooperation in the joint research program for high geocentric orbit space debris studies should be sent to Prof. E. L. Akim, KIAM Deputy Director. All questions regarding observation schedule, required formats, ephemeris support, observations and orbital data processing, analysis and usage should be sent to Dr. V. M. Agapov. All questions regarding requirements for observation instruments, CCD frame processing software, possible help in the instrumentation upgrade in order to make possible participation in the research program should be sent to Dr. I. Ye. Molotov.

List of sensors

This list includes all sensors participating today in a joint program of observation and analysis of space debris objects on high geocentric orbits. Each sensor has its own identification number assigned in the KIAM space objects database. Most of the sensors are involved in minor planet observations as well, thus having the MPC-assigned identification code. But for the purpose of this research program it was decided to maintain a separate ID system permitting to describe all participating sensors regardless of their involvement in other research programs. Coordinates of sensors are given for reference purposes only and should not be used in real observation processing. In the column "Instrument", the common name, aperture (d, mm) and focal length (f, mm) of each instrument are given.

The list will be updated each time a new sensor will send observations for objects studied.

Table 1. List of participating sensors

Ref. ID	Longitude, °	Latitude, °	Height, km	Observatory/ Facility	Instrument
10003	100.919 E	51.622 N	1.998	Mondy	AZT-14 d480
10009	66.883 E	39.133 N	0.662	Kitab	DAZ-40 d400
10010	41.432 E	43.657 N	2.070	Arhyz	Zeiss-600 d600/f7500
10012	42.499 E	43.276 N	3.127	Terskol	Zeiss-2000 d2000/f16000
10016	30.273 E	46.397 N	0.010	Mayaki	RC-600 d600/f4800
10018	33.163 E	45.219 N	0.010	Yevpatoriya	AZT-8 d700/f2800
10019	33.997 E	44.403 N	0.340	CrAO/Simeiz	Zeiss-1000 d1000
10024	30.327 E	59.772 N	0.100	Pulkovo	RS-220 d220/f507
10031	34.016 E	44.726 N	0.585	CrAO/Nauchnyi	AT-64 d640/f900
10041	66.896 E	38.673 N	2.593	Maidanak	Zeiss-600 d600/f7500
10042	41.443 E	43.649 N	2.059	SAO/Arhyz	Zeiss-1000 d1000
10065	132.166 E	43.699 N	0.200	Ussuriysk	DA-40 d400/f1600
10071	64.624 W	21.596 S	1.865	Tarija	Zeiss-600 d600/f7500
10102	100.920 E	51.622 N	2.000	Mondy	Zeiss-600 d600/f7500
10103	100.919 E	51.617 N	2.025	Mondy	AZT-33IK d1500/f30000
10191	7.465 E	46.877 N	0.951	Zimmerwald	ZIMLAT-1000 d1000/f4000
10198	16.512 W	28.301 N	2.445	Teide/OGS	Zeiss-1000 d1000/f4470
10531	34.016 E	44.728 N	0.595	CrAO/Nauchnyi	ZTSh d2600/f10000
10532	34.017 E	44.730 N	0.595	GAISh/Nauchnyi	Zeiss-600 d600/f4680
10533	34.016 E	44.726 N	0.585	CrAO/Nauchnyi	PH-1 d220/f507

Note. The focal lengths value for ZIMLAT (Zimmerwald) and OGS (Teide) telescopes had been modified in this table in order to present "effective focal lengths" including the focal reducer optics as for the other telescopes. The original values published for these telescopes in the previous issues of the Circular were the focal lengths of the main telescope optics.

New objects

This section contains information on the objects newly discovered during the period Mar 1 – Mar 31, 2007.

There are two lists. The first one contains information on objects which have been successfully recovered in follow-up observations after initial detection and one-night tracking and for which orbital data and area-to-mass ratio (AMR) value have been determined with high

level of confidence. The second one contains information on objects having only one-night track of observations. A complete set of orbital data cannot be determined for these objects. Only some orbital parameters (mainly inclination and RAAN) are determined relatively accurately. The AMR values cannot be determined for these objects at all.

It should be noted that all one-night tracks have been tested to identify them with all other one-night tracks and with all known objects in the KIAM database having well determined orbits (both bright and faint). It is possible that the identification failed not only due to the absence of other tracks of the same object, but also due to uncertainty caused by an unknown AMR value which can result in very significant orbital evolution that prevents proper correlation of one-night tracks.

Each object listed in this section has two identifiers. The first one (column ID2 in the table below) is assigned by the observer who discovered the object and the second one (ID1) is assigned in the KIAM space objects database. Since no commonly agreed space debris identification system exists yet all identifiers provided can be regarded as temporary ones. As soon as such a system will be agreed upon, all objects will be assigned with the new identifiers.

Orbital elements are referring to True Equator Mean Equinox (TEME) coordinate system. Area-to-mass ratios are calculated assuming reflectivity coefficient equal to 1.3. Orbital elements for short tracks (Table 3) are obtained in two steps. In the first step an attempt is made to determine an orbit with zero eccentricity. In case of large residuals (more than the expected 3-sigma) the second step is applied. At this step the eccentricity is also estimated.

Table 2. List of newly discovered and confirmed objects

ID1	ID2	Date/time, UTC	*a*, km	*e*	*i*, °	Ω, °	*ω*, °	*u*, °	AMR, m^2/kg
43128	E07074D	17.03.2007 00:32:50.15	25998.12	0.6166549	7.264	348.806	14.882	170.760	0.41
90035	90035	31.03.2007 21:26:32.76	41840.59	0.0846527	9.169	329.177	29.708	212.120	2.84

Table 3. List of newly discovered objects having only a single one-night track of observations

ID1	ID2	Date/time, UTC	Track duration, hh:mm	*T*, min	*a*, km	*e*	*i*, °	Ω, °	*ω*, °
46166	g070309	09.03.2007	00:19	1446.09	42360.1	0.0190	13.297	005.08	056.28
46303	z070312	12.03.2007	00:03	1333.34	40128.7	0	06.908	081.06	160.98
46304	z070315	16.03.2007	00:18	1498.39	43375.4	0.3977	06.559	261.05	093.47
46203	M070316	16.03.2007	02:13	1418.52	41819.9	0.0119	10.341	333.37	250.97
46204	M070319	19.03.2007	00:06	1462.82	42686.2	0	08.815	317.14	295.31

New identifications

This section contains information on successful identification of newly and previously obtained single one-night tracks with each other as well as with objects having well determined orbits.

Table 4. New identifications

ID_new	ID_old	Observation date	Observer
No new identifications in Mar 2007			

Updated orbits

This section contains information on the latest orbital updates for objects discovered prior to Mar 1, 2007 and observed at least once in Mar 2007 or for which the latest orbital update was not published in the previous issues. 51 of previously discovered objects in total are observed in Mar 2007.

Table 5. Updated orbital parameters for objects observed in Mar 2007

ID1	ID2	Date/time, UTC	*a*, km	*e*	*i*, °	Ω, °	*ω*, °	*u*, °	AMR, m^2/kg
43007	EGEO07	16.03.2007 01:30:19.44	43518.68	0.0812416	16.278	1.677	346.094	139.833	1.38
43019	EGEO19	28.03.2007 22:32:59.92	42399.20	0.0067778	10.825	338.212	303.345	199.269	1.39
43031	EGEO31	20.03.2007 22:24:57.50	40191.73	0.1162488	11.991	337.393	337.101	213.119	1.22
43032	EGEO32	17.03.2007 16:45:40.37	39458.99	0.0936657	10.748	339.022	326.727	185.747	1.19
43033	EGEO33	29.03.2007 03:50:17.65	33194.70	0.3342822	8.247	70.053	257.979	129.123	3.39
43045	EGEO45	28.03.2007 21:49:49.80	42151.52	0.1302500	9.551	330.297	66.089	206.777	0.99
43046	EGEO46	21.03.2007 13:15:32.43	42325.88	0.0369521	9.865	331.306	251.953	196.985	0.95
43081	E06204D	28.03.2007 21:53:03.80	46766.58	0.3945815	9.597	129.072	310.490	65.647	8.46
43082	E06205C	17.03.2007 17:45:31.79	41417.79	0.0151279	13.824	344.710	247.034	216.329	1.75
43084	E06207B	16.03.2007 01:43:51.27	38328.07	0.1773065	10.091	335.430	358.116	171.398	21.5
43091	E06293A	11.03.2007 18:15:12.51	40262.58	0.2793148	5.308	125.982	212.402	27.542	11.3
43093	E06326A	29.03.2007 00:16:21.60	43588.01	0.0537862	9.115	333.184	345.860	190.906	3.57
43096	E06321D	20.03.2007 18:11:45.68	41425.42	0.0246903	8.815	321.077	290.373	207.324	1.74
43098	E06327F	09.03.2007 00:30:48.31	43309.35	0.0473359	9.617	333.784	290.976	156.320	2.05
43100	E06327E	13.03.2007 19:59:13.56	39991.21	0.0601624	12.498	344.474	254.530	179.150	0.40
43103	E06349B	16.03.2007 01:34:08.16	41891.32	0.0049002	13.902	6.095	102.322	129.106	0.021
43105	E07014A	14.03.2007 23:47:08.17	42142.76	0.2619789	16.766	329.218	353.018	227.800	12.3
43108	E07017B	16.03.2007 00:08:19.36	41738.17	0.0564714	8.437	315.806	342.872	208.611	1.00
43112	E07021A	13.03.2007 21:31:41.87	42227.90	0.0542447	10.729	337.420	290.024	105.432	1.45
43114	E07021D	13.03.2007 20:18:21.13	24758.06	0.7178567	4.996	68.032	288.385	69.246	-

ID1	ID2	Date/time, UTC	*a*, km	*e*	*i*, °	Ω, °	*ω*, °	*u*, °	AMR, m^2/kg
43116	E07042A	13.03.2007 20:37:44.45	41913.07	0.3693122	9.341	336.941	348.290	160.524	15.4
43117	E07042C	16.03.2007 20:37:57.48	41953.21	0.1304705	7.237	72.273	300.912	114.510	5.47
43118	E07043C	20.03.2007 22:27:48.02	39190.52	0.1882725	8.567	307.184	56.375	228.274	3.44
43119	E07045A	26.03.2007 18:24:20.28	21209.11	0.6624791	3.998	69.744	291.132	101.341	-
43120	E07045B	31.03.2007 23:53:22.40	42961.55	0.0321090	15.790	2.736	26.882	132.543	0.39
43121	E07045D	28.03.2007 21:47:39.62	42037.28	0.0195672	13.208	5.868	330.240	194.879	1.21
43124	E07047A	26.03.2007 19:44:46.55	39983.21	0.1781222	12.867	341.090	343.586	183.528	3.19
43125	E07048A	29.03.2007 02:39:36.40	44505.96	0.0722253	18.649	31.426	336.031	167.775	0.094
90005	90005	28.03.2007 21:46:17.00	42014.29	0.0538045	14.454	356.887	98.201	130.662	0.74
90006	90006	20.03.2007 21:06:58.54	42196.56	0.0011569	14.433	352.112	17.529	233.438	0.0077
90008	90008	20.03.2007 17:51:51.36	42151.26	0.0041040	14.342	357.938	105.103	171.701	0.0012
90009	90009	29.03.2007 21:57:46.30	42279.38	0.0029508	14.673	358.963	355.644	211.890	0.036
90014	90014	28.03.2007 19:38:55.37	42617.07	0.0095344	14.963	353.560	107.252	175.015	0.15
90019	90019	27.03.2007 22:43:30.22	42223.00	0.0071952	14.812	359.382	32.782	174.270	0.13
90021	90021	31.03.2007 23:05:18.41	42697.72	0.0224477	14.914	359.547	2.604	137.192	0.38
90022	90022	15.03.2007 18:34:22.19	42160.83	0.0034706	14.551	358.663	219.197	191.190	0.16
90023	90023	22.03.2007 00:04:09.31	40111.05	0.0428402	12.349	355.181	45.654	199.493	1.69
90025	90025	20.03.2007 21:31:01.96	41178.50	0.0331134	10.604	333.378	8.745	157.950	0.14
90028	90028	04.03.2007 01:00:26.01	42494.85	0.0129927	14.601	358.940	62.078	129.429	0.0058
90030	90030	20.03.2007 19:57:05.11	42255.84	0.0040719	5.785	73.691	38.711	166.434	0.11
90031	90031	28.03.2007 19:26:55.82	42152.20	0.0020707	13.825	7.377	207.037	167.524	0.0032
90032	90032	29.03.2007 21:29:14.56	42151.49	0.0188638	14.276	358.764	236.742	208.012	0.0059
90041	90041	16.03.2007 13:41:28.63	41990.73	0.0039743	11.456	29.332	10.239	111.894	0.086
90042	90042	16.03.2007 00:12:05.06	38706.08	0.0142701	11.381	335.582	299.965	234.136	3.00

ID1	ID2	Date/time, UTC	*a*, km	*e*	*i*, °	Ω, °	*ω*, °	*u*, °	AMR, m^2/kg
90043	90043	19.03.2007 16:17:43.38	41680.97	0.0055060	10.379	333.350	324.101	194.894	0.043
90047	90047	16.03.2007 00:47:10.82	43045.40	0.0970192	13.794	9.366	344.065	120.180	0.91
90049	90049	27.03.2007 01:09:06.84	38796.51	0.0421776	17.707	348.632	202.913	224.439	1.46
90050	90050	31.03.2007 22:50:35.02	42228.35	0.0596361	11.170	343.491	19.237	140.947	4.33
90051	90051	18.03.2007 23:24:31.18	42722.45	0.0235774	14.694	9.907	274.676	137.884	0.17
90052	90052	15.03.2007 17:28:25.26	41052.84	0.0078457	9.455	324.605	181.770	127.131	0.008
90053	90053	20.03.2007 20:45:47.62	41162.09	0.1983611	7.578	317.290	134.187	309.746	1.69

Master list of objects

The master list of objects includes all high altitude orbit faint objects discovered up today, with a description of the circumstances of the discovery and the last update of orbital information. Due to the large volume of the master list it will be distributed separately in electronic form only.

Observation statistics

This section contains general statistics on obtained measurements. It should be noted that additional portions of measurements obtained in Jan-Feb had been processed in March so the overall number of measurements includes those ones.

Table 6. Distribution of measurements obtained by each facility by year of observation (as of Apr 1, 2007 12:00 UTC)

Facility	2004	2005	2006	2007	TOTAL
Nauchnyi	1240	6478	12925	4353	24996
Zimmerwald	0	597	3389	1564	5550
Teide	0	624	2284	1553	4461
Maidanak	0	150	2166	988	3304
Mayaki	0	0	981	352	1333
SAO	0	258	524	307	1089
Terskol	0	0	475	0	475
Mondy	0	229	65	627	921
Yevpatoriya	0	0	272	0	272
Simeiz	0	0	213	0	213
Arhyz	0	0	115	11	126
Tarija	0	0	21	0	21
TOTAL	1240	8336	23430	9755	42761

Table 7. Observation statistics for Mar 2007

Facility	Number of nights	Number of observed earlier discovered objects	Number of discovered objects (including later confirmed)	Number of obtained single measurements	Number of tracks
Arhyz	-	-	-	-	-
Ketab	-	-	-	-	-
Maidanak	4	3	-	37	5
Mayaki	5	5	1 (1)	352	11
Mondy	8	18	2 (0)	395	38
Nauchnyi	10	29	1 (0)	919	76
Pulkovo	-	-	-	-	-
SAO	2	6	-	307	10
Simeiz	-	-	-	-	-
Tarija	-	-	-	-	-
Teide	3	9	1 (1)	80	11
Terskol	-	-	-	-	-
Ussuriysk	-	-	-	-	-
Yevpatoriya	-	-	-	-	-
Zimmerwald	13	37	2 (0)	690	128
TOTAL	**21**	**51**	**7 (2)**	**2780**	**279**

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