CATALOGUES OF POSITIONS AND ORBITAL ELEMENTS OF GEOSYNCHRONOUS SPACE OBJECTS OBSERVED IN 1983–2003 AT MAO NASU AND SRL UNU

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We present a short survey of the nine catalogues of positions and orbital elements of the geosynchronous space objects obtained by photographic method at the Main Astronomical Observatory of the National Academy of Sciences of Ukraine and the Space Research Laboratory of the Uzhhorod National University in 1983–2003. The information about seven of these catalogues you can read in detail on [http://www.mao.kiev.ua]. The GOCK-2003 catalogue will be presented in our web-site in the near time. The data of these catalogues can be used to update the catalogues of orbits of geostationary satellites, to identify objects more precisely by combining our observations with those obtained at other stations.

13 300 geosynchronous objects observations were obtained at the Space Research Laboratory of the Uzhhorod National University (SRL UNU), one of the oldest station of the satellites observations, during 1977–1996 using the SBG camera ($D = 0.43$ m, $F = 0.76$ m).

The first 2 520 photographic observations, obtained during 1983–1992 using the double wide angle astrograph of the Main Astronomical Observatory of the National Academy of Sciences of Ukraine (MAO NASU) ($D = 0.4$ m, $F = 2$ m) were presented in [2, 6]. At that time we didn't have the software for satellites identification. That's why only the right ascension and declination reduced using the SAO star Catalogue in J1950.0 reference frame and those reduced to the observations moments are given.

As a result of collaboration MAO NASU and SRL UNU five catalogues of geosynchronous objects were set up beginning from 1994 [http://www.mao.kiev.ua]. Each catalogue has preface with a detailed reference of the obtained observations. We present a shot survey the works that may be fulfilled using the observations of these catalogues.

In the first our catalogues [1, 7] the problem was discussed associated with compiling a Catalogue of geosynchronous satellites, with corrections of operational satellites, and the use of the survey observations made at SRL UNU for observations of some selected satellites at MAO NASU.

The independent objects identification of the observations obtained in 1996 was performed by two methods and the results were compared and discussed [7]. The numerous orbital manoeuvres of the controlled satellites have been detected using these observations. But the erroneous combination of the collocated satellites, *i.e.*, the satellites separated by less than 0.1 in the longitude, can lead to large rms residuals, when there is no orbital manoeuvre of any of them. Such situation can takes place for satellites observations of Astra, Hot Bird type and so on (Figs. 1 and 2).

Many objects not present in the international catalogues. So, there is object observed in the longitude 60.0°, with the exception of 90056*A*, during many years but this one not given in catalogues. The analysis shows that this objects is controlled satellite collocated with the other satellites which elements are presented in the ESA/ESOC catalogue.

Some peculiarities of the controlled geosynchronous objects identification are discussed in [4]. The main deficiency of modern international catalogues is that they do not give an information about all orbital satellites manoeuvres. The satellites longitude and orbital inclination may to change at more large value in this case. That's why the Laplace plane is used for the objects identification. In this case the orbital inclination, when there is no orbital manoeuvres, changes linearly.

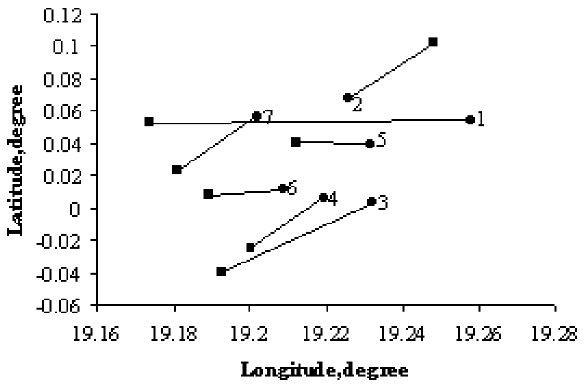

Figure 1. The motion of seven satellites of Astra type using the observations obtained during March 30–31, 2001. Points-the initial positions, squares-the end positions

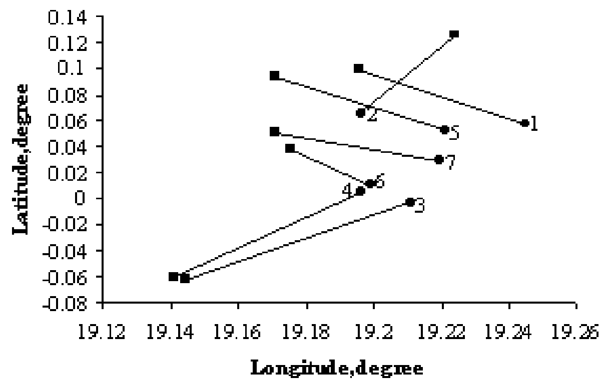

Figure 2. The motion of seven satellites of Astra type using the observations obtained during August 15–28, 2001. Points-the initial positions, squares-the end positions

The problem of the space debris is a very actual now. Therefore, the identification of the uncontrolled objects is a main task of all catalogues [3, 5, 8, 9]. First of all it is need to determine the uncontrolled object from all observations. The uncontrolled geostationary objects are difficulty identified because these objects with a large longitude drift are observed frequently only during one night. The method was presented in [9] for determination of the topocentric object drift using the condition that the longitude drift of such objects more than $0.01°$/day and having the accurate satellite right ascension and declination. Using this method 178 uncontrolled objects observed during 1989–2001 in Uzhhorod and Kyiv station were identified. The suggested method may be used for prognosis of the declinations and time angles change needed for future observations. A conclusion is made that for the small time interval, frequently during one night, when the Moon and Sun influence and the nonuniformity of the Earth's gravitation field is small the orbit elements of the uncontrolled object are changed inessentially. As an example the change of the time angle versus time is shown for the librating satellite $93062D$.

The evolution of the orbital elements caused by the different revolving forces during the 2836 days was investigated using the free librating object $86027A$. A dependence of periods and amplitudes of long-periodical perturbations for all orbital elements by resonance harmonics of a geopotential, by the Moon, the Sun, and solar radiations was presented in detail [3]. A distribution of the observed geosynchronous objects upon the drift and orbit inclination to the equator depending on the subsatellite longitude and so the object height on the time angle is given. Some limits of the change of the appearance declinations of the objects with an orbital inclination, the calculation of the object visibility depending on the Sun position were obtained by the way of the investigation of the uncontrolled objects evolution. The problem of the hazard of collision of the controlled satellites with other objects can be solved. It is proposed the method of motion parameters calculation for all objects and determination the objects approachment in every moment of time [5]. As a result the more conveniently time of the uncontrolled objects observations, their time angles, declinations and ephemerides for these observations were determined. All orbital elements and the object longitude were presented by the sum of the linear and periodic terms, the values of which change essentially for orbital inclinations near the $0°$ and $180°$. The orbital elements as a time function allowed to extrapolate its values in two-three years ahead. This method allows to increase the number of uncontrolled objects observations, to correct the prognosis their visibility and motion, to appreciate the hazard of collisions in geostationary orbit.

It is considered in detail the peculiarity of the uncontrolled objects motion using as an example the motion of the observed objects $95063D$, $91064A$, $95045D$:

1. The simple libration near the stable object position.
2. The complex libration near the two stable points.
3. The circulation with different values of the longitude drift.

The prognosis of the longitude and its drift using the alignments given in [5] enables to find the longitude interval of the object visibility and to identify the objects with a large longitude drift. The corresponding calculations were carried out for the drifting uncontrolled satellite $95045D$. The equations of connection between the parameters of the main harmonic of the subsatellite longitude change for the uncontrolled libration satellites of ℓ_1 type are derived. Some examples of the investigation of corrections of the geostationary objects based on the concordance of the longitude change function with the results of satellites observations are given.

The equations presented in [8] enable to obtain a dependence of the subsatellite longitude versus time, *i.e.*, to determine the longitude change when the satellite correction is finished.

According to international agreement the change of the controlled satellite position along the orbit relatively of the subsatellite point must not to exceed of 0.1°. The calculation presented in [8] showed that the satellite Hot Bird-2 changes in longitude on 0.1° during 10 days when its correction was finished. That's why it is necessary to correct such satellite every 10 days to hold it in the provisional longitude. Using the observation of 1999 the longitude change during two days was determined for the satellites of Hot Bird type founding in the collocate zone with a radius of 0.3°. The conclusion was made: there was no correction of four satellites during two days of observations. The correction takes place at some days before observations. Only for one satellite of this type the correction was made during two days of observations.

As may be seen the data of these catalogues can be used to decision many tasks connected with a problem of space debris, update the catalogues of geostationary satellites orbits, to identify objects more precisely by combining our observations with those obtained at other stations.

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