EVOLUTION OF ORBITS OF GEOSTATIONARY OBJECTS AND PROBABILITY OF THEIR COLLISION

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A statistical dependence of change of 300 geosynchronous satellites semi-major axis with a launch time and so with a subsatellite longitude drift is presented. The computing a probability of collision of satellites in the geostationary ring is outlined.

The observations of high orbital objects the semi-major axis (a) of which are more than 20,000 km are still actual now. The monitoring of the geostationary ring performed by photographic method at MAO (Kyiv) and SRL (Uzhgorod) allow to determine the orbits and identify the objects [1, 2].

It is known that resonance perturbations in the satellite movement causes a longitude drift and a pendulum-like movement of satellite relative to the stable point of libration. The passive objects evolution takes place according to celestial mechanic laws. The orbital plane is precessing with a period of 52 years and amplitude of 15° [3].

A catalogue of geostationary objects [4] was used for study of satellites orbits evolution. The objects with $da = (a - 42164 \text{ km}) > 100$ km are included for study. Fig. 1 presents the objects semi-major axis according to the year of their launches during the 35 years.

Here the dotted line is parabola approximation, which has been computed by the least square adjustment: $da = -6.671253\,r^2 + 26482.812\,r - 26281514.9$, where r is the date (year) of launch. A dependence between the satellite semi-major axis and longitude drift is straightforward: $da = -78.7471\lambda - 3.0436$ with a high correlation coefficient, $p = 0.99985$.

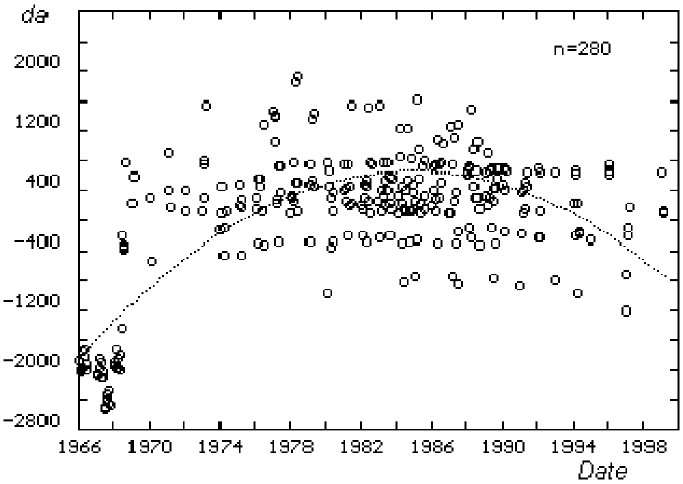

Figure 1: Change of objects semi-major axis according to the year of their launches

Dependences above mentioned show that the object's evolution is taken place. Up to 2017 year the geostationary objects of the first launches will reach the maximal angle of the orbital inclination to the equator. Only systematic positional observations of geostationary objects would allow this evolution to be investigated. After satellite identification the satellites should be enter to catalogue [1, 2]. However, there are objects having companions located closer than 0.1°–0.3° that are so-called "collocated" satellites. The catalogues analysis [4] showed that there are 140 "collocate" zones from 5° to 292°, each of them have from 2 to 8 objects. That's why there is a possibility of the collisions. Figs. 2–3 show that the risk of such collision is large enough.

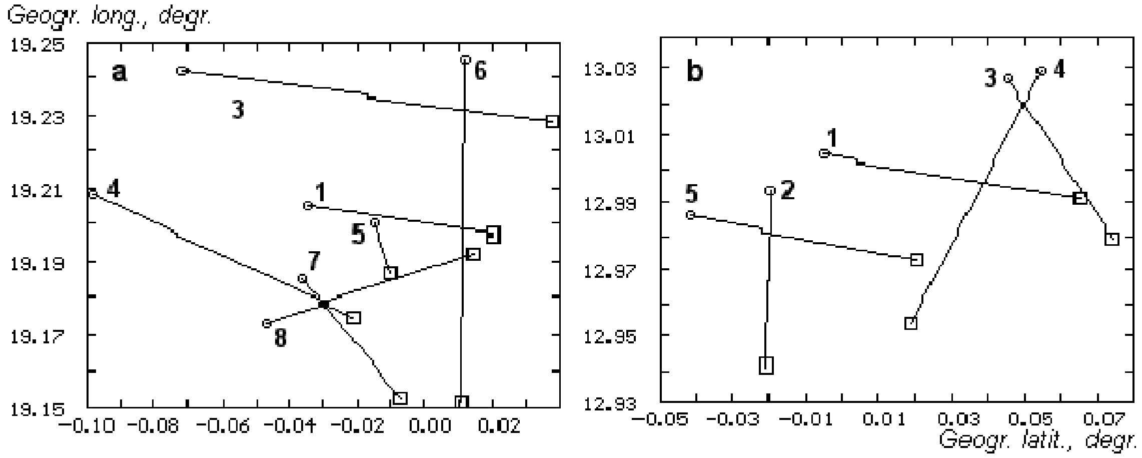

Figure 2: The movement of 8 geosynchronous satellites of Astra type (a) and 5 geosynchronous satellites of Hot Bird type (b) for 4 days in March 1999 (Uzhgorod). Circles-initial satellites positions, squares-final positions, figures-satellites numbers

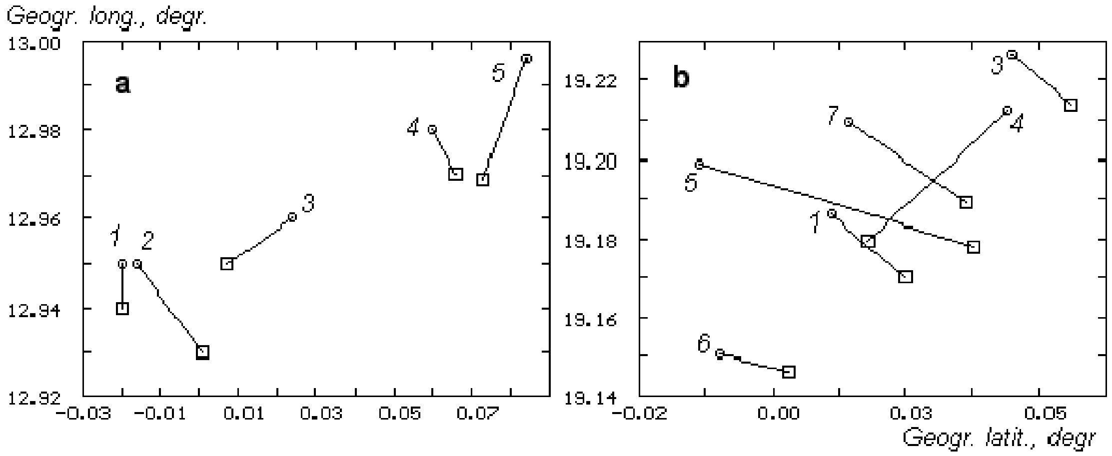

Figure 3: Geosynchronous satellites movements using the results of MAO (Kyiv) observations in January 1999 in two "collocation" zones: (a) for 1.1 day; (b) for 0.12 day

For investigation of the collisions risk the determinancy-probability method was used [5]. The probability p of two objects collision is determined as a product $p = p_{\varphi\lambda}\, p\,(\Delta h < R + r)$, where $p_{\varphi\lambda}$ is the probability of the collision under condition that the objects have the same height h upon the Earth, $p\,(\Delta h < R + r)$ is the probability that the difference distances of two satellites centres from the Earth Δh less than $R + r$, where R and r are the satellites radii.

It may be presented as:

$$p\,(\Delta h < R + r) = \int p\,(h) \left(\int\limits_{h-(R+r)}^{h+(R+r)} p\,(x) dt \right) dh,$$

where $p\,(h)$ is the probability density of the objects distribution by the height.

The objects distribution by the height has a small difference from such one by the declination $p(\delta)$. The function $p(\delta)$ was obtained from 2982 observations at SRL for three years (Fig. 4), where δ – in km ($1°$ corresponds to 750 km).

The observations at SRL and MAO are completed now for experimental determination of satellites distribution in the geostationary orbit.

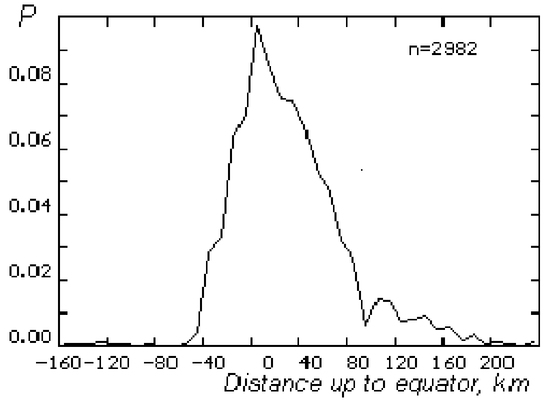

Figure 4: Density of distribution probability of the satellites equatorial distances

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