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A robust linear method for impact probability calculation

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ABSTRACT

We have modified and sufficiently improved the linear method for estimation of the impact probability of Near-Earth asteroids, which uses a curvilinear coordinate system [1]. The important advantage of this method is using a unique curvilinear coordinate system related to the nominal orbit of an object. One of the coordinates of this system is the mean anomaly in the osculating orbit of an asteroid. The other two coordinates of this system are Cartesian ones and their origin lies in the osculating orbit. This system allows one to take into account the fact that the distribution of possible positions of the asteroid is stretched along the nominal asteroid's orbit. This method is a linear method which means that it based on the assumption that errors of asteroid's orbital parameters at possible collision time are linearly dependent on errors at epoch of observations. We also assume that the distribution of errors of coordinates and velocities in the introduced curvilinear coordinate system is normal. The limitations of the method follow from the assumptions. Close approaches to massive bodies such as major planets can break the linear relation of errors and disturb the impact probability value. However, the method works well enough if close approaches either absent or do not have a noticeable effect on the result. The

proposed method is significantly reliable than the classical target plane method especially if the nominal position of the asteroid at time of possible collision is far from the Earth.
In the first version of this method [1] a time of a possible collision can not be determined precisely and it is being sampled in a short time range. In this modification we do not calculate the impact probability at a certain time. The probability of a collision of an asteroid with the Earth in the vicinity of a possible collision is calculated by projecting the area of possible asteroid's position, obtained in the curvilinear coordinate system, on the target plane. This also replaces calculating a three-dimensional integral with two-dimensional one.

[1] D. E. Vavilov, Yu. D. Medvedev *A fast method for estimation of the impact probability of near-Earth objects* // Monthly Notices of the Royal Astronomical Society, 2015, V. 446, 705-709.

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