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GUIDED ASTEROIDS AGAINST HAZARDOUS ASTEROIDS

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This paper develops the Russian idea of using guided projectile-asteroids to deflect dangerous asteroids [1, 2].

The development of this idea is based on two innovations [3, 4]: the criteria for selecting projectile-asteroids which reduce the 3D targeting strategy to 2D targeting strategy; the use of so called distributed integrated navigation systems which elements are located on projectile-asteroids, target-asteroids, and on the Earth and in space.

These two innovations allow solving the problem of deflecting dangerous asteroids using existing modern space facilities.

The criteria for selecting projectile-asteroids [3, 4] and the structural scheme [5] of a distributed integrated navigation system of the pair "target-asteroid"-"projectile-asteroid" are presented.

The structural scheme of a multilevel system for planetary defense against hazardous asteroids with additional Russian innovations is also presented [5].

The problem of protecting the Earth against dangerous asteroids is well known. Work on the creation of planetary defense systems is underway in many countries.

Russian Prime Minister Dmitry Rogozin (now General Director of the Roscosmos State Corporation) has offered other countries cooperation in the field of protection against asteroids, since neither Russia nor other countries have the means to destroy asteroids that are dangerous to the planet, and urged the leading states of the world to pay attention to this important problem.

For the purposes of international cooperation for the reliable planetary defense we present [6, 7]:
1) Opportunities of the Center for Operation of Ground-based Space Infrastructure Facilities (TsENKI) regarding launching payloads from Russian cosmodromes (http://en.russian.space);
2) Possibilities of the Scientific Research Institute for Applied Mechanics named after Academician V.I. Kuznetsov (SRIAM) regarding the development, manufacture and supply of inertial command devices (http://en.russian.space/250/) for placement in open space on asteroids.

The SRIAM is the leading enterprise in Russia for creating precise command tools for rockets and spacecrafts. Its command tools allowed the launch of the first satellite of the Earth, provided Yuri Gagarin's flight, docking of the USSR and US spacecraft in space as part of the Soyuz-Apollo program, circling and photographing the far side of the Moon, delivering lunar soil to Earth.

The SRIAM has developed high-precision gyroscopes, accelerometers, gyrostabilized platforms and strapdown inertial systems for ballistic missiles, launch vehicles (Vostok, Voskhod, Molniya, Soyuz, Progress, Energiya), for returned manned spacecraft, satellites (Spectrum, Araks, Sesat, Express, Glonass, Yamal, Monitor-E, Kazsat, Resurs-DK, etc.), and orbital stations (Salyut, Almaz, Mir, International Space Station), as well as for the Moon, Mars, Venus and the Halley's Comet exploration spacecraft control systems.

Devices developed at the SRIAM have high accuracy and reliability: up to 150,000 hours of continuous operation and more than 25 years of lifetime (http://www.russian.space/250/).

The world must be protected from space threats in a collective manner. Whether the politicians will succeed in coordinating an international program for planetary defense against asteroids – time will tell. Meanwhile, the authors study ecologically clean methods for deflecting hazardous target-asteroids using controlled projectile-asteroids.

It may seem that the task of hitting target-asteroids with a projectile-asteroids with accuracy of ~ 1 m cannot be achieved [3, 4]. However, the results of simulations demonstrate feasibility of solving this task with modern technical means [3, 4].

The analysis of deflections scenarios has shown for the first time the required composition and accuracy of the navigation system (super-high-precision gyroscopes and navigational equipment [8, 9] are not required).

Firstly, the navigation systems should be integrated, comprising inertial navigation systems, star trackers, Earth direction sensors, GNSS receivers, radars, beacons, and optical guidance systems.

Secondly, the navigation systems should be distributed with the elements installed on projectile-asteroids, target asteroids, and on the Earth and in space.

Finally, criteria for selection of projectile-asteroids and their use scenarios for deflecting target asteroids were determined.

Nowadays, the creation of the 1st echelon of a complex of planetary protection against dangerous asteroids goes "in a natural way".

Systems of land-based and space-based monitoring of dangerous asteroids and the Centers of planetary protection are being created in many countries, including those within the international cooperation.

Space units for asteroid research begin to be created according to many programs of research (in the future – development) asteroids.

But the 2nd and 3rd echelons of planetary protection are completely absent so far.

In the 2nd echelon there are three environmentally friendly options of protection:

1) technical means of destruction of target-asteroids;

2) squadrons of projectile-asteroids;

3) other means.

Technical means of destruction of target asteroids are "stone-crushing devices" [3, 4]. Options of use projectile-asteroid (and squadrons of projectile-asteroids for massive target asteroids [5]) are presented.

The block diagram of the distributed integrated navigation system of the pair "target-asteroid - projectile-asteroid" is given [5].

By other means we mean all other essentially possible, but less effective, from the authors' point of view, options of eliminating threats of dangerous asteroids.

Realization of the 3rd echelon of a complex of planetary protection demands detailed study not only of technical, but also legal issues and the international coordination.

In the interests of collective defense of the planet against asteroids, we propose to use the capabilities of SRIAM and TsENKI.

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