GUIDED ASTEROIDS AGAINST HAZARDOUS ASTEROIDS

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ABSTRACT

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: the criteria for selecting projectile-asteroids which reduce the 3D targeting strategy to 2D targeting strategy; the use of distributed integrated navigation systems which elements are located on projectile-asteroids, target-asteroids, and on the Earth and in space [3, 4].

These two innovations allow solving the problem of deflecting dangerous asteroids using existing modern space facilities. The criteria for selecting projectile-asteroids and the structural scheme of a distributed integrated navigation system of the pair “target-asteroid”-“projectile-asteroid” are presented [5]. The structural scheme of a multilevel system for planetary defense against hazardous asteroids with additional Russian innovations is also presented [5].

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

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GUIDED ASTEROIDS AGAINST HAZARDOUS ASTEROIDS: INNOVATIONS FROM RUSSIA

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Keywords: *planetary defense, asteroid hazard, target-asteroids, projectile-asteroids, distributed integrated navigation systems*

This paper develops the Russian idea of using guided projectile-asteroids to deflect dangerous asteroids. The development of this idea is based on two innovations: 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 and the structural scheme 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. For the purposes of international cooperation in the field of planetary defense we present the possibilities of the Kuznetsov Research Institute for Applied Mechanics regarding the development, manufacture and supply of inertial command tools for placement on asteroids and opportunities of the Center for Operation of Space Ground-Based Infrastructure regarding launching payloads from Russian cosmodromes.

GUIDED ASTEROIDS AGAINST DANGEROUS ASTEROIDS: INNOVATIONS FROM RUSSIA

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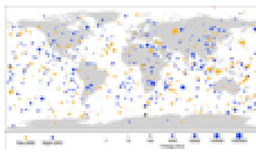
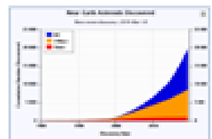
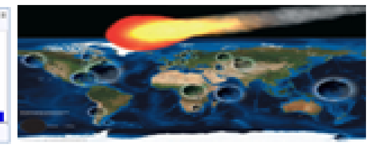
Abstract

This paper develops the Russian idea of using guided projectile-asteroids to deflect dangerous asteroids. The development of this idea is based on two innovations: 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 and the structural scheme 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. For the purpose of international cooperation in the field of planetary defense we present the possibilities of the Kuznetsov Research Institute for Applied Mechanics regarding the development, manufacture and supply of inertial command tools for placement on asteroids and opportunities of the Center for Operation of Space Ground-Based Infrastructure regarding launching payloads from Russian cosmodromes.

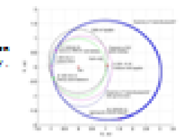
Asteroids of the Solar system



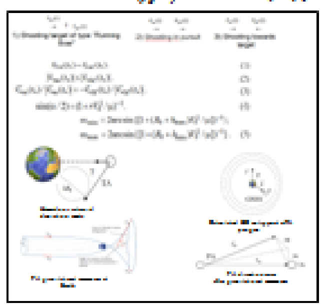
An example of successful Russian-American cooperation in the field of planetary defense [17, 18]

A relatively new idea is to use an asteroid as a projectile to change the trajectory of a hazardous asteroid was first introduced in paper [1] at Malta Symposium on Hazardous Near Earth Asteroids, 2009 and published a year later [2]. The idea consists of transferring a PA into a trajectory intercepting the target asteroid (TA). Naturally, this requires to provide PA with propulsion with the needed amount of fuel and use a gravitational maneuver, for example, around the Earth.

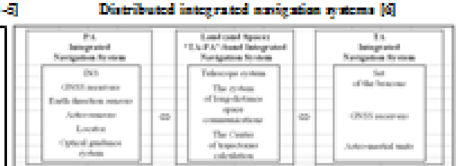


"Space billiards" and features of national (Russian) hunting for asteroids [3-5]

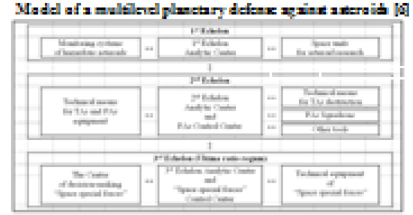
Criteria for choosing projectile asteroid (PA) [3-5]



Distributed integrated navigation systems [6]

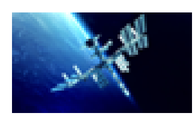


Model of a multilevel planetary defense against asteroids [6]



Kuznetsov Research Institute for Applied Mechanics

Center for Operation of Space Ground-Based Infrastructure (TsENKI)

CONCLUSION

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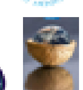

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PLANETARY PROTECTION AGAINST ASTEROIDS: A VIEW FROM RUSSIA

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Abstract

This paper develops the 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 structural scheme of a distributed integrated navigation system of the pair "target asteroid" (TA) - "projectile asteroid" (PA) are presented [5]. The structural scheme of a multilevel system for planetary defense against hazardous asteroids with additional Russian innovations is also presented [5]. For the purposes of international cooperation in the field of planetary defense we present the possibilities of the Kuznetsov Research Institute for Applied Mechanics regarding the development, manufacture and supply of inertial command tools for placement on asteroids and opportunities of the Center for Operation of Space Ground-Based Infrastructure regarding launching payloads from Russian cosmodromes.

Introduction

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.

Chelyabinsk event of February 15, 2013 has demonstrated the inability of our civilization not only to prevent, but even to predict and warn the citizens of the impeding threat. Russian Deputy Prime Minister Dmitriy Rogozin (now General Director of the Roscosmos State Corporation) offered to the world community collaboration in the area of asteroid defense, 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.

The main objectives of this paper are the following:

1) The development of known idea [1, 2] of using guided projectile-asteroids to deflect dangerous asteroids 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;
2) Presentation of structural scheme of a multilevel system for planetary defense against hazardous asteroids with some additional Russian innovations [5];
3) The propositions from the Russia side for international cooperation in the field of planetary defense in part of the possibilities of the Kuznetsov Research Institute for Applied Mechanics regarding the development, manufacture and supply of inertial command tools for placement on asteroids and in part of the opportunities of the Center for Operation of Space Ground Based Infrastructure regarding launching payloads from Russian cosmodromes.

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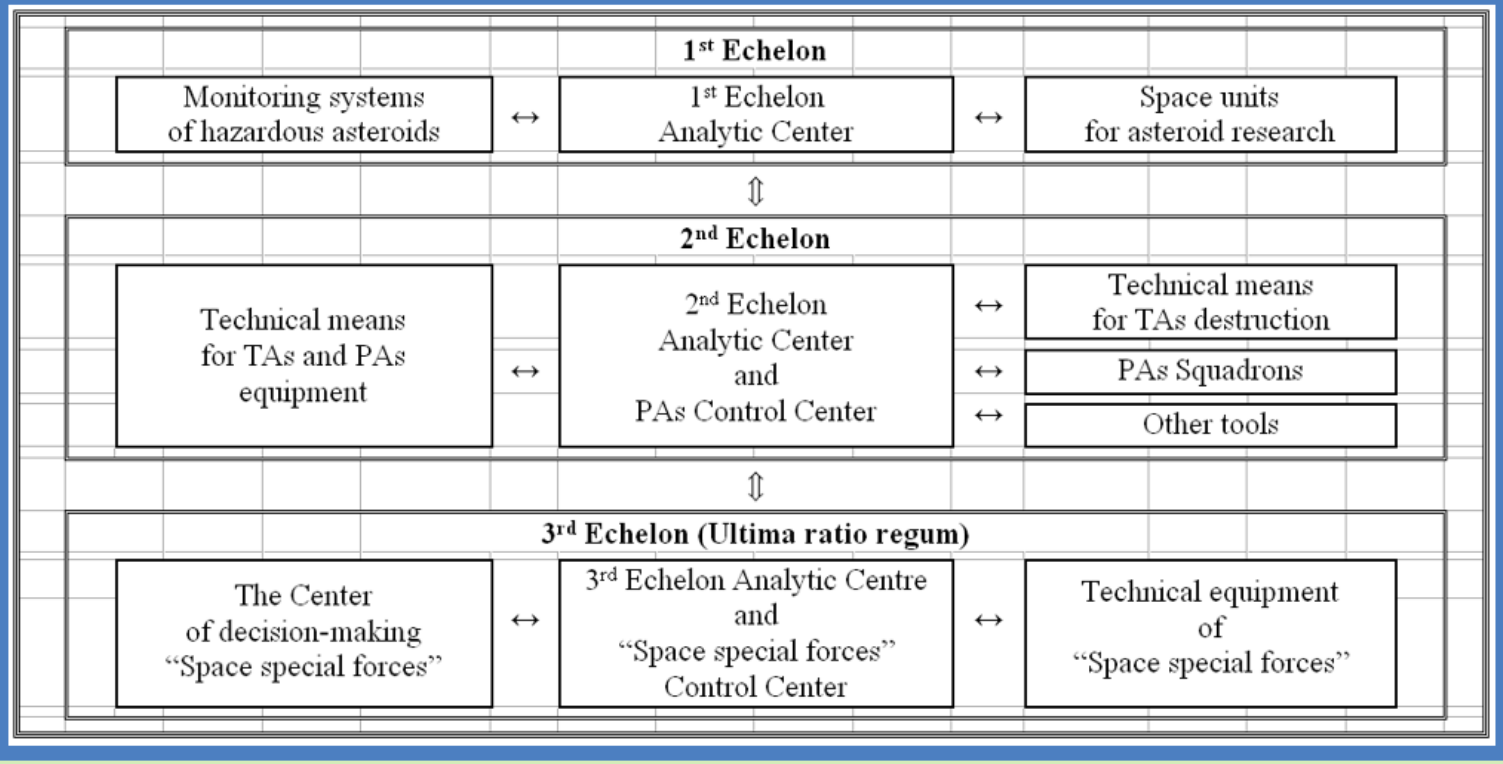
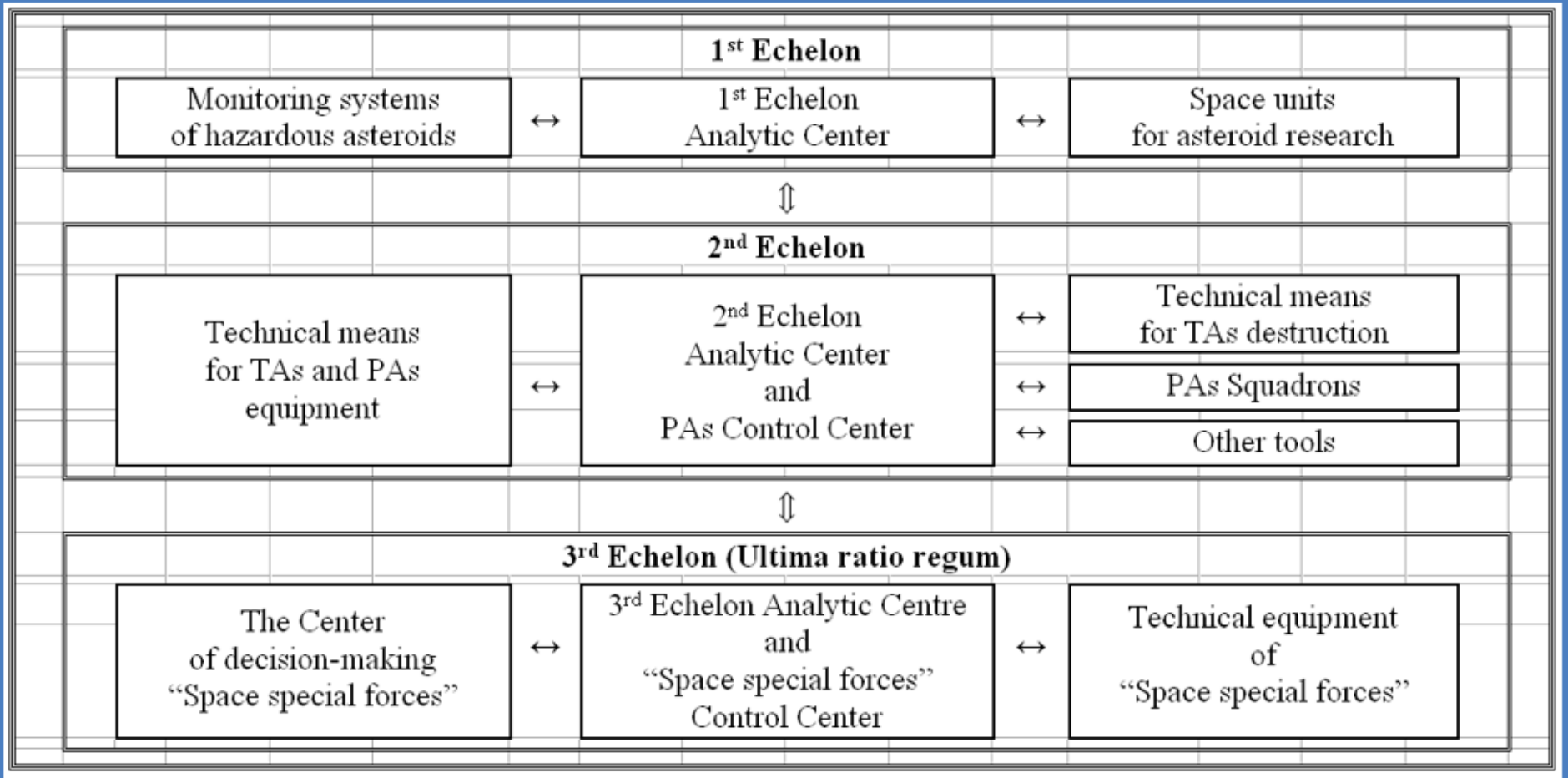
Structural scheme of a multilevel system for planetary defense against hazardous asteroids [5]



Structural scheme of planetary defense multilevel system

Structural scheme of a multilevel system for planetary defense against hazardous asteroids [5]



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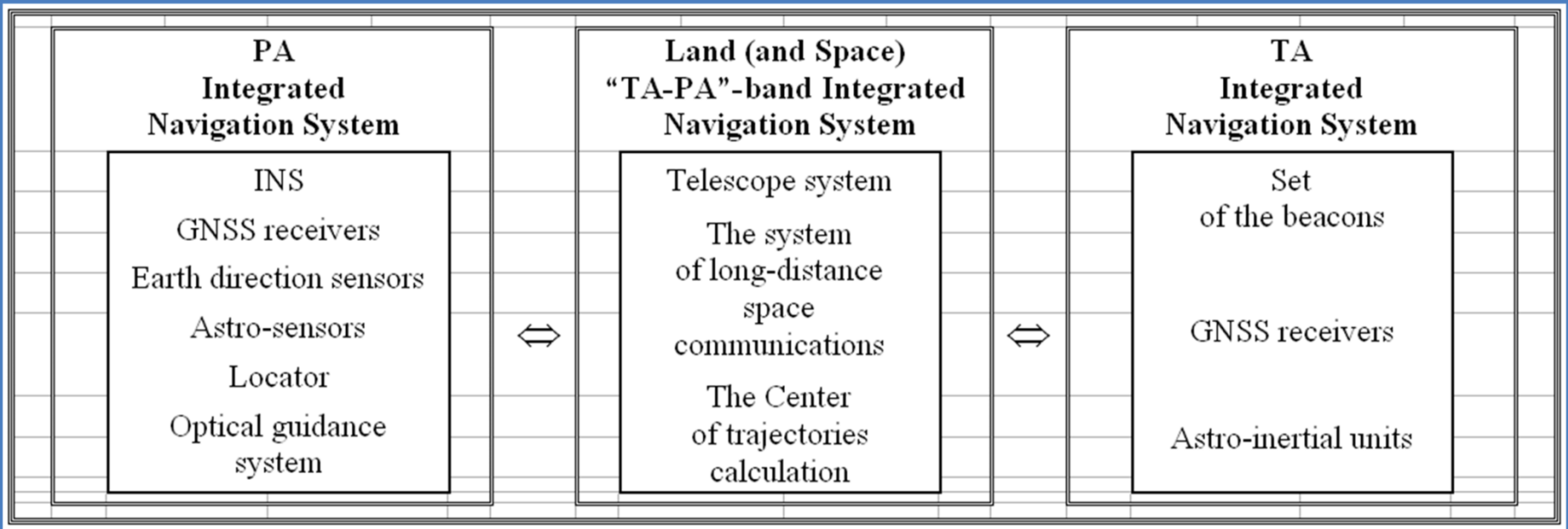
Structural schemes of distributed integrated navigation systems of the pair “TA-PA” [5]



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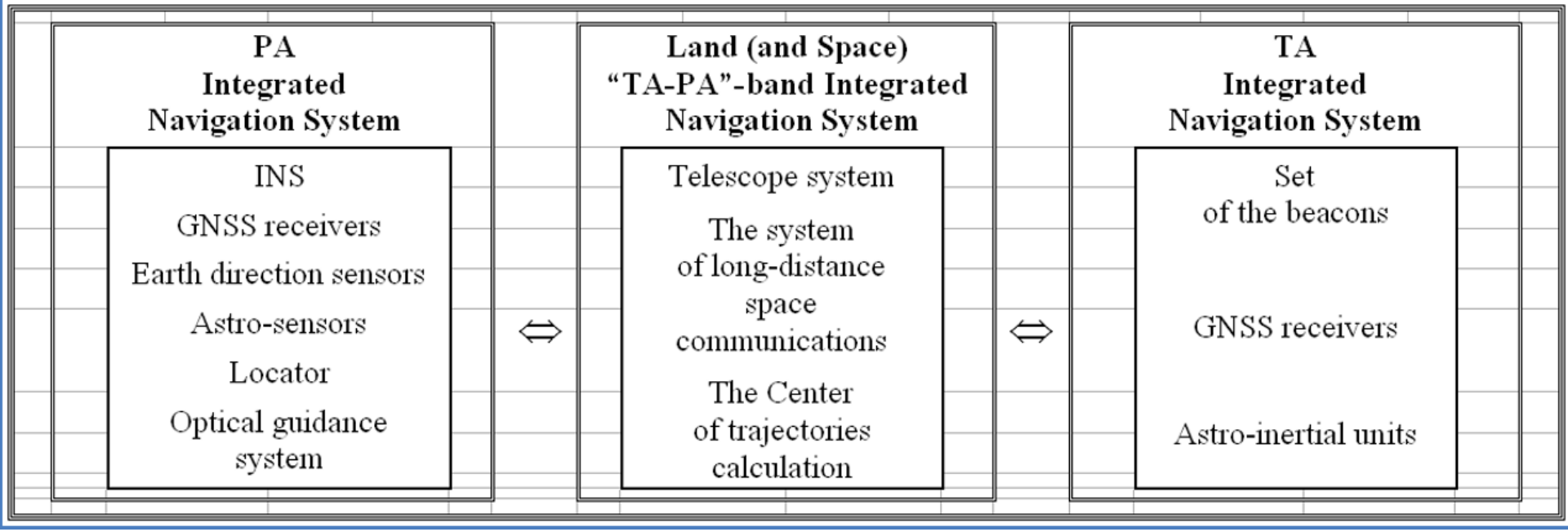

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Scientific Research Institute for Applied Mechanics

The Scientific Research Institute for Applied Mechanics (SRIAM) was founded in 1955.

The SRIAM was the first enterprise in Russia whose task was to create gyroscopic command instruments for rocket and space technology. Since 1994, the SRIAM is named after Academician V.I. Kuznetsov. Since 2006, the SRIAM has been a part of the Federal State Unitary Enterprise "Center for Operation of Space Ground Based Infrastructure".

The SRIAM is the leading enterprise in Russia for the creation of precision command instruments for rockets and space vehicles.

On October 4th, 1957, the first artificial earth satellite created in the USSR was launched, which announced the beginning of the space age in the history of mankind. In this project, gyroscopic instruments created by a team of developers led by V.I. Kuznetsov were used. For the next years, the SRIAM had been developing high-precision gyroscopes, accelerometers, gyrostabilized platforms and strapdown inertial systems for ballistic missiles, launch vehicles (Vostok, Voskhod, Molniya, Soyuz, Progress, Energiya), returnable manned spacecrafts, satellites for various purposes (Spectrum, Araks, Sesat, Express, Glonass, Yamal, Monitor-E, Kazsat, etc.) and orbital stations (Salyut, Almaz, Mir, International Space Station), as well as for control systems of spacecraft for the investigation of the Moon, Mars, Venus and Halley's comet surfaces.

The instruments of the SRIAM provided the launching of the first satellite of Earth, the flight of Yuri Gagarin, the docking in space of ships under the Soyuz-Apollo program, the fly-around and photographing of the reverse side of the Moon, the delivery of lunar soil to the Earth, the operation of orbital stations.

The devices developed in SRIAM have high accuracy and reliability: up to 150000 hours of continuous operation and more than 25 years of operation. Today, the instruments of SRIAM provide the implementation of programs of the Russian space industry in developed and implemented gyroscopic systems for a new generation of space vehicles.

Center for Operation of Space Ground Based Infrastructure (TSeNKI)

Center for operation of space ground-based infrastructure ("TsENKI") was established as a division of Federal State Agency in 1994 in accordance with the Government ordinance (August 24, 1994) on Russian-Kazakh Baikonur cosmodrome operation agreement (March 28, 1994). In accordance with this ordinance the Russian Ministry of Defense started transferring Baikonur cosmodrome to Federal State Agency in order to execute Russian federal space program.

In 2000, "TsENKI" became federal state unitary enterprise (FSUE) (Government ordinance № 770-r of June 5, 2000). In 2005, "TsENKI" merged with Kuznetsov Scientific Research Institute for Applied Mechanics (Presidential decree № 1442 of December 12, 2005; Government ordinance № 823 of December 28, 2005). "TsENKI" merged with Barmin research institute of launch complexes, "Motor" Design Bureau, "Vympel" Design Bureau and "Baikonur" federal space center (Presidential decree № 1784 of December 16, 2008; Government ordinance № 54-r of January 27, 2009). The merger with these companies boosted scientific and technological potential of the Russian space industry; maximized intellectual and financial resources efficiency in order to develop space- and ground-based systems to improve the quality of Baikonur cosmodrome facilities operation and spacecraft launches. At that time "TsENKI" main objective was project cooperation between the enterprises for the space industry and the Ministry of Defense in order to operate Baikonur cosmodrome in accordance with lease terms of the space complex. "TsENKI" was commissioned by Roscosmos to design space complex's operation system (including the system's implementation), to develop legal and technological framework for spacecraft launches.

"TsENKI" is the leading Roscosmos department to prepare and perform spacecraft launches.

SRIAM and TSeNKI

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Conclusion

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 TAs using controlled PAs. It may seem that the task of hitting TA with a PA with accuracy of ~ 1 m cannot be achieved. However, the results of simulations demonstrate feasibility of solving this task with modern technical means. 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 [6] are not required). Firstly, the NS should be integrated, comprising INS, star trackers, Earth direction sensors, GNSS receivers, radars, beacons, and optical guidance systems. Secondly, the NS should be distributed with the elements installed on PA, TA, and on the Earth and in space. Finally, criteria for selection of PAs and their use scenarios for deflecting TAs 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 TA, 2) squadrons of PAs and 3) other means. Technical means of destruction of TA are "stone-crushing devices". Options of use PA (and squadrons of PAs for massive TA) are presented. The block diagram of the distributed integrated NS of the pair "TA-PA" is given. 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 from asteroids, we propose to use the capabilities of SRIAM and "TsENKI".

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Conclusion & References

Published: 17 August 2016

Distributed integrated navigation systems for planetary defense against asteroids

N. I. Krobka, S. A. Aksenov, S. A. Bober, E. V. Efremova, I. V. Logashina, A. V. Tukmakov, Yu. V. Fedorenko & E. N. Chumachenko

Gyroscopy and Navigation **7**, 296–310(2016) | Cite this article

Abstract

The main objectives of this paper are to give an interdisciplinary overview of the current status of the research on planetary defense against asteroids, which is a real challenge, and consider technical proposals on the development of a multilevel planetary defense system based on modern space technologies, providing for the application of projectile asteroids to deflect target asteroids' trajectories and distributed integrated navigation systems, the navigation equipment of which is supposed to be installed on many different objects. The composition of such navigation systems and their accuracies are discussed. This work is based on the results obtained by the international Research Laboratory of Space Research, Technologies, Systems and Processes [1], founded at Moscow Institute of Electronics and Mathematics (MIEM), Branch of Higher School of Economics (HSE) in 2011. The project was supported by the grant of the Government of the Russian Federation (2011–2013) [2, 3]. We have also used pioneering ideas from the course of lectures *Models of planetary defense* [4], prepared at the Department of Mechanics and Mathematical Modeling, MIEM NRU HSE in 2014 [4].

Conclusion

The world must be protected from space threats in a collective manner.

The authors study ecologically clean Russian methods [1-7] for deflecting hazardous target-asteroids (TAs) using controlled projectile-asteroids (PAs).

It may seem that the task of hitting TA with a PA with accuracy of ~ 1 m cannot be achieved. However, the results of simulations demonstrate feasibility of solving this task with modern technical means. The analysis of deflections scenarios has shown [3, 4] the required composition and accuracy of the navigation system (NS). Super-high-precision gyroscopes and navigational equipment [8, 9] are not required.

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

Secondly, the NS should be distributed with the elements installed on PA, TA, and on the Earth and in space.

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Nowadays, the creation of the 1st echelon [5-7] 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 [5-7] of planetary protection are completely absent so far.

In the interests of collective defense of the planet against dangerous asteroids, we propose to use the capabilities of Scientific Research Institute for Applied Mechanics named after Academician V.I. Kuznetsov and TsENKI.

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