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COMMITTEE ON THE PEACEFUL USES OF
OUTER SPACE
Scientific and Technical Subcommittee
Forty-third session
Vienna, 20 February – 3 March 2006
Agenda item 11
New-Earth objects

Information on research in the field of near-Earth objects carried out by Member States, international organizations and other entities

In accordance with the agreement reached at the forty-second session of the Scientific and Technical Subcommittee (see A/AC.105/848, annex I, para. 20) and endorsed by the Committee on the Peaceful Uses of Outer Space at its forty-eighth session,[1] the Secretariat invited Member States and international organizations to report on their near-Earth object activities, including missions, search and follow-up, as well as plans for future activities for consideration by the Subcommittee.

The present document contains reports received from the Russian Federation and the United Kingdom of Great Britain and Northern Ireland.[2] Reports received by 9 December 2005 are available in all official languages of the United Nations and have been distributed as document A/AC.105/863.

[1] Official Records of the General Assembly, Sixtieth Session, Supplement No. 20 and corrigendum (A/60/20 and Corr.1), para. 151.

[2] The reports have not been formally edited. They will be edited, translated into all official languages of the United Nations and distributed as document A/AC.105/863/Add.1 after the forty-third session of the Scientific and Technical Subcommittee.

V.06-51272

Russian Federation

PLANETARY DEFENSE CENTER

Survey of the Planetary Defense Center activities

Essential scientific and technology experience has been accumulated in Russia and CIS countries in the area of prevention the asteroid-cometary danger. The experience could be used for creation of the Planetary Defense System (PDS). The System is intended to defense our planet against the asteroid-cometary danger [1-7]. As a basis for this we take a fact, that back in previous days in Soviet Union alone there were developed and undergone all ground-testing programs almost all main components of PDS or prototypes of such. As example of such one can mention many samples of space-rocket techniques, nuclear weapons, communication, navigation and operation means, etc. Some of these do not have any analogy anywhere in the world. And today there is a unique opportunity to use these means, many of which were developed for military use, not for destruction, but for protection of humanity in a whole.

However activities in the area are performed separately and to a great extent, as initiative. In this connection to join efforts of the entities and expert of various areas for the necessary work and establishment of PDS the Planetary Defense Center (PDC) was established by some Russian and Ukrainian enterprises in 2002 year in the form of non-profit partnership.

The main areas of PDC activity are the following:

- development of the Planetary Defense System concept for defense against asteroid-cometary danger;
- development of possible space hazard scenarios and also methods and facilities of its prevention;
- participation in preparing and performing of the imitation and demonstrative experiments on development the PDS components;
- the popularization, information and other activities.

The base of PDC activities is the Conceptual project of the “Citadel” PDS, approved by organizations-members of the PDC [4,5].

Planetary Defense System “Citadel”

System “Citadel” shall include global control space-and-ground system and regional segments of instant interception.

PDS project foresees creation of short-notice PDS reaction echelon, which shall be in a fully prepared mode. It shall be used for protection from relatively small (10 to some hundred meters) asteroids and nuclei of burned comets, which often enough collide with Earth and might be detected only some twenty-four hours, weeks, or months before collision.

Basis of interception service shall be made of space-rocket, nuclear, and other means of Russia (CIS), USA, European and other states. It shall include reconnaissance and interceptor spacecrafts (S/C)

Possible scheme of the echelon of PDS short-term reaction components and functioning of its components are given on figure 1.

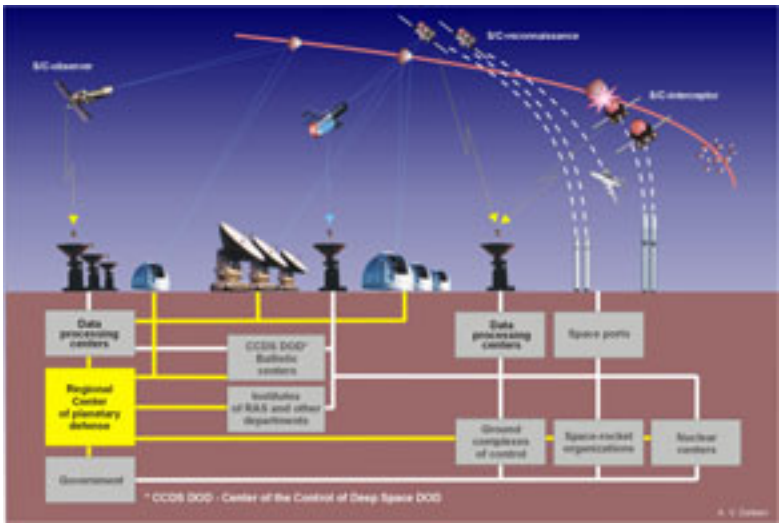

Fig.1. The functional design and schematic of interaction of components of the echelon of short-term reaction of the PDS.

S/C-reconnaissance

S/C-reconnaissance are the main PDS components.

A major task when developing a S/C-reconnaissance is to make as small as possible all on-board operation systems and other units of S/C. This is also true for on-board scientific equipment. In line with energy consumption properties of Launch Vehicle (LV) and diminishing the time necessary for launch preparation, shall provide for a maximum time interval between the launch of S/C-reconnaissance and the approach of S/C-interceptor towards a dangerous object.

The spacecraft design is developed by the PDC in cooperation with Lavochkin Association on base of some small spacecraft [6].

It is foreseen to include two panchromatic cameras of high and medium (with larger field of view) resolution, tree multispectrum cameras of visible, ultraviolet, and infrared ranges, video spectrometer, laser distance measuring device, gravity measuring tool, on-board radio system for downloading of scientific data are planned to be part of S/C-reconnaissance scientific equipment.

Mass of S/C-reconnaissance is 233 kg, energy consumption – 300 Watt.

Outer appearances of S/C-reconnaissance in operational mode and the mounting of scientific equipment is given in figure 2

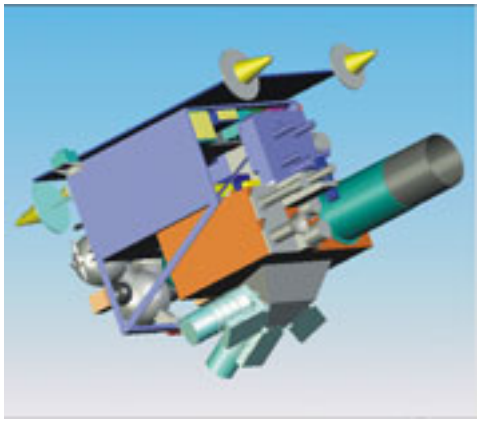

Fig.2. Outer appearances of S/C-reconnaissance

Missions with usage of S/C-reconnaissance

"Space patrol" project [7] foresees development and launch of a spacecraft towards asteroids passing close to Earth as well as towards objects moving in meteorite flow. The following projects may be carried out: "Flight", "Strike", "Diffusion" and "Interception".

In frame of "Flight" project methods and means of distant examining of dangerous celestial objects shall be tested, and well as studies of asteroid properties from fly-by trajectories, testing of S/C-reconnaissance and other components of PDS.

In frame of "Strike" and "Diffusion" projects properties of space objects at high-velocity strike (up to 70-90 km/s) will be studied. For penetration into the surface of asteroids special penetrators might be used.

In frame of "Interception" project it is foreseen to perform interception of an asteroid. Some types of missions in some cases might be combined (for example "Flight" +" Strike" and so on).

Development of a spacecraft for the mentioned above missions shall take from 2 to 5 years.

Organizational and legal aspects

The PDS development and operation will put for the mankind a multitude of extremely not only non-ordinary scientific/technological problems, but also the organizational, politic, ethic, juridical, legal, ecological, etc ones.

PDC also is engaged in the decision of these questions. Results of the activities were presented in scientific conferences and workshops.

We invite for cooperation all partners, wishing to participate in the PDS "Citadel" creation.

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ЦЕНТР ПЛАНЕТАРНОЙ ЗАЩИТЫ

Обзор деятельности Центра планетарной защиты

В России и странах СНГ накоплен значительный научный и технологический потенциал, который может быть использован для разработки Системы планетарной защиты (СПЗ) нашей планеты от астероидно-кометной опасности [1-7]. Основанием для этого является, в частности, то, что в свое время в одном только Советском Союзе были созданы и прошли натурную отработку практически все базовые компоненты СПЗ или их прототипы. К ним относятся многие образцы ракетно-космической техники, ядерного оружия, средств связи, навигации, управления и т.п. Причем ряд из них не имеют аналогов в мире. И сейчас представляется уникальная возможность применения этих средств, многие из которых разрабатывались в военных целях, не для уничтожения, а для защиты всего человечества.

Однако работы в этом направлении ведутся разрозненно и, в значительной степени, в инициативном порядке. В связи с этим, для объединения усилий организаций и специалистов из различных отраслей для проведения работ в обеспечение создания СПЗ, в 2002 году рядом организаций России и Украины учрежден Центр планетарной защиты (ЦПЗ) в форме некоммерческого партнерства.

Основными направлениями деятельности ЦПЗ являются:

- формирование концепции построения Системы планетарной защиты от астероидно-кометной опасности;
- разработка возможных сценариев космической угрозы, а также методов и средств ее предотвращения;
- участие в подготовке и проведении имитационных и демонстрационных экспериментов по отработке компонентов Системы планетарной защиты;
- проведение разъяснительной, информационной и другой деятельности.

Основой для деятельности ЦПЗ является Концептуальный проект Системы планетарной защиты "Цитадель", одобренный организациями - членами ЦПЗ [4,5].

Система планетарной защиты "Цитадель"

Система «Цитадель» будет включать в себя наземно-космическую службу глобального контроля космического пространства и региональные сегменты службы оперативного перехвата.

Проект СПЗ предусматривает создание, в первую очередь, эшелона краткосрочного (оперативного) реагирования СПЗ, который будет находиться в постоянной готовности. Он предназначен для защиты от относительно небольших (от десятков до сотен метров) астероидов и ядер потухших комет, которые достаточно часто сталкиваются с Землей и могут быть обнаружены всего лишь за несколько суток, недель или месяцев до столкновения.

Основу службы перехвата будут составлять ракетно-космические, ядерные и другие средства России (СНГ), США, Европейских и других государств. В ее состав будут входить космические аппараты (КА) разведчики и перехватчики.

Возможная схема построения эшелона краткосрочного реагирования СПЗ и схема взаимодействия его компонентов представлена на рис. 1.

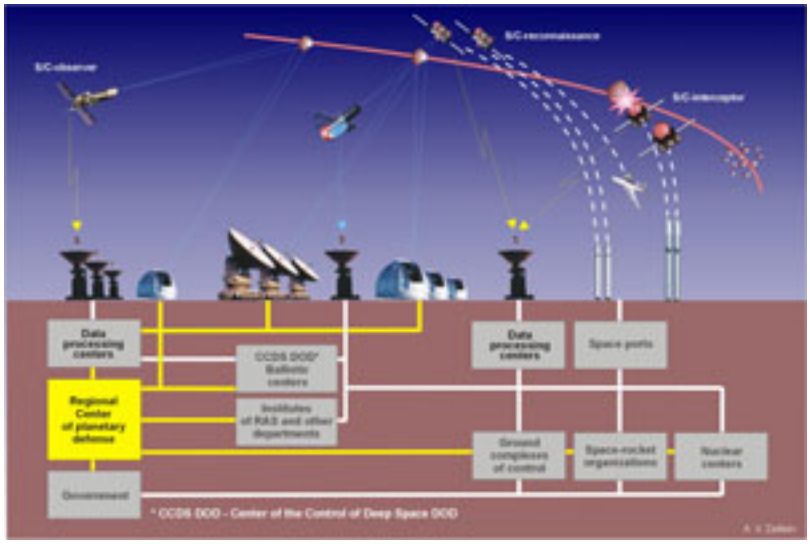

Рис. 1. Схема построения эшелона краткосрочного реагирования СПЗ

КА-разведчики

Одним из главных компонентом СПЗ являются КА-разведчики.

Важнейшей задачей при создании КА-разведчиков является миниатюризация бортовых служебных систем и агрегатов КА, а также, бортовой исследовательской аппаратуры. Это, наряду с энергетическими характеристиками РН и сокращением времени их подготовки к запуску, обеспечит максимальный интервал времени между пролетом КА-разведчика и подлетом КА-перехватчика к опасному объекту

Проект такого КА разработан Центром совместно с НПО им. С.А. Лавочкина на базе одного из проектируемых малых КА [6].

В состав исследовательской аппаратуры КА-разведчика предполагается включить две панхроматические камеры высокого и среднего (с большим полем обзора) разрешения, три мультиспектральные камеры видимого, ближних ультрафиолетового и инфракрасного диапазонов, видеоспектрометр, лазерный дальномер, гравигрдиентометр, бортовой радиокомплекс для передачи научной информации.

Масса КА-разведчика составит 230 кг, энергопотребление – 300 Вт.

Внешний вид КА-разведчика в рабочем положении и размещение бортовой исследовательской аппаратуры приведены на рис.2.

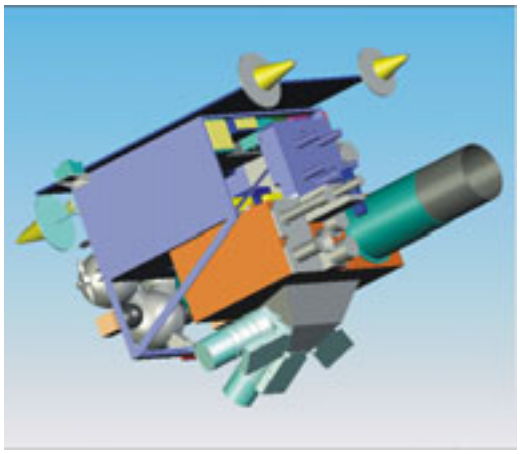

Рис. 2. Общий вид КА-разведчика

Экспедиции с использованием КА-разведчиков

Проектом “Космический патруль” [7] предусматривается создание и запуск КА к пролетающим вблизи Земли астероидам, и, в частности, к объектам, движущимся в метеорных потоках. При этом могут быть реализованы экспедиции: типа "Пролет", "Удар", "Внедрение"' и "Перехват".

В ходе экспедиции "Пролет" будет проводиться отработка методов и средств дистанционного изучения ОНТ, исследование характеристик астероидов с пролетных траекторий, отработка КА-разведчиков и других компонентов СПЗ.

В экспедициях "Удар" и "Внедрение" будут изучаться характеристики небесных тел и физические процессы при высокоскоростном (до 70-90 км/с) ударе. Для внедрение в грунт астероидов могут использоваться специальные зонды-пенетраторы.

При выполнении экспедиции "Перехват" предполагается осуществить перехват астероида. Некоторые типы экспедиций в ряде случаев могут быть совмещены (например, экспедиция "Пролет"+"Удар" и т. п.).

На создание КА для осуществления указанных экспедиций потребуется от 2-х до 5 лет.

Организационно-правовые аспекты

Создание и эксплуатация СПЗ поставит перед человечеством множество весьма неординарных проблем, причем не только научно-технических, но и организационных, политических, этических, юридических, правовых, экологических и т. п.

Решением этих вопросов также занимается ЦПЗ. Результаты этих и других работ представлялись на научных конференциях и рабочих совещаниях.

Мы приглашаем к сотрудничеству всех, желающих принять участие в разработке проблем создания Системы планетарной защиты «Цитадель».

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United Kingdom of Great Britain and Northern Ireland

Report on Near Earth Object Activities with a UK interest

This short report gives a brief introduction to some of the NEO related activities taking place in the UK as well as those where the UK has an interest. Further information can be found in the BNSC annual report which will be circulated at the COPUOS S&T Subcommittee in February 2006.

The United Kingdom is home to two Centres providing information on Near Earth Objects.

The first is the Spaceguard Centre, located at the former Powys Observatory, near Knighton in mid-Wales. It represents the Spaceguard Foundation as the International Spaceguard Information Centre. It has set up the nationwide Comet & Asteroid Information Network (CAIN) and has a well established outreach programme. It currently liaises with Spaceguard organisations in 17 countries around the world and encourages the establishment of new ones (the latest being Spaceguard South America, Spaceguard Israel and the recently constituted Spaceguard India).

The Centre acts as the Primary Science Advisor for the Faulkes Telescope NEO project and has acquired private funding to set up a pair of 0.3m robotic telescopes for astrometric follow-up. The project is known as the Spaceguard NEO Astrometry Project (SNAP). One system will be located at the Spaceguard Centre (SNAP N), and the other will be located in Namibia (SNAP S). The status of the programme is that the equipment for SNAP N has been procured, and the robotic system is under development. It is anticipated that SNAP N will be fully operational in April 06. Once commissioning is complete, SNAP S will be installed, thus representing a significant increase in the UK contribution to the global follow-up process.

The second is the UK Near Earth Object Information Centre (NEOIC) which was established in response to Recommendations 13 and 14 of the UK government's Task Force Report on NEOs. The NEOIC is operated by a consortium led by the National Space Centre, under contract to BNSC. The main centre is based at the National Space Centre in Leicester which houses a NEO exhibition and provides a primary contact point for public and media enquiries. A network of seven academic institutions active in the field of NEOs advise the Centre, these are: Queens University Belfast, UKATC Edinburgh, Natural History Museum London, Queen Mary University London, Imperial College London, and the University of Leicester. In addition there are three regional Centres with linked exhibits and access to the NEOIC facilities. These are based in W5 Belfast, he Natural History Museum, London and the Royal Observatory, Edinburgh. The NEOIC's website is hosted at www.neareathobjects.co.uk and provides a virtual exhibition, a resources section (education/media) and latest NEO news, including FAQs. The site also allows access to the Report of the UK Task Force on Potentially Hazardous NEOs.

The Open University(OU) has just commenced an undergraduate course that includes NEOs as one of the seven topics covered, including not just the science but the related themes of communication, risk, ethical issues and policy/decision-making. A study

text has also been produced to accompany the course: Ball, A. J., Kelley, S. P. and Peiser, B., Near-Earth Objects and the Impact Hazard. S250 Science In Context Topic 2, The Open University, 2005. ISBN: 0749214341. The Open University runs an active programme of post-graduate/PhD studies, recent PhD examination titles included "Thermal Infrared and Optical Observations of Near-Earth Asteroids" and "Penetrometry of NEOs and Other Solar system Bodies"

In addition to theoretical studies a number of experimental programmes are under way, amongst them the development of a penetrometry rig, to simulate a high mass, low speed impact of a penetrometer fixed to a landing spacecraft. Penetrometers will be key to enabling in situ measurements on an NEO surface, which are likely to be delicate in nature, to give structural and mechanical information on the body, key for successful mitigation/negation of the body. The Open University has an interest more broadly in instrumentation for the in situ physical and geochemical investigation of NEOs.

The OU anticipates partnering with industry for ESA's DQ Phase A mission study, providing input across a range of scientific and engineering-related fields. The Open University is also engaged in the CNES-led assessment study for a rendezvous and landing mission to a primitive binary NEO. ASI and DLR are also part of the study team. The study, ending in March, is in competition with other missions in the CNES system to proceed to a Phase A study. Open University staff have also continued their ongoing membership of ESA's NEOMAP Committee.

QinetiQ continues to promote its SIMONE (Smallsat Intercept Missions to Objects Near Earth) concept. The goal of SIMONE is to send micro-spacecraft, each to a different type of Earth crossing NEO. This would allow physical and compositional characterisation observations to be made, in support of possible mitigation strategies. The concept arose as a response to the UK NEO Task Force Report. SIMONE was one of 6 studies commissioned by ESA for a possible NEO mission. SIMONE was a collaborative study between QinetiQ and the Open University's PSSRI. Although SIMONE was highly regarded by ESA, of the 6 studies completed, only the Don Quijote mission was selected to go forward to Phase A, as it was assessed to be more strongly directed towards a mitigation experiment. However ESA remain very interested in the SIMONE concept, and it is anticipated that elements of SIMONE will almost certainly be taken forward in some form. The SIMONE mission concept is based around a small (120 kg) spacecraft equipped with gridded-ion electric propulsion (QinetiQ T5), powered from an ultra-lightweight solar array. The spacecraft would carry a suite (13 kg) of miniaturised instruments to make the observations. The original concept envisaged 5 identical spacecraft each of which would rendezvous with a different object. The multiple build would be extremely cost effective, and the 5 spacecraft could be launched to Earth orbit simultaneously using the ARIANE-5 ASAP. The electric propulsion enables great flexibility on launch window and Earth orbit escape.

Research is underway at the University of Southampton to assess the global threat to Earth posed by small, sub-kilometre diameter, Near Earth Objects (NEOs). The many impact-generated effects resulting from a NEO impact each have an effect on the Earth’s ecosystem and serious consequences for the human population. The primary challenge in the research is accounting for each impact-generated effect and

developing an adequate model to simulate it. To this end a computer simulation tool is under development with the capability of modelling small NEO impacts. This tool tackles the hazard on both a local and global scale, tracking the consequences of an impact on the human population. Each of the impact-generated effects will affect the human population and infrastructure to varying degrees. Therefore the analysis of mortally rates and infrastructure cost is the key feature of the simulation. Overall hazard assessment of a NEO impact event will be rated by the casualty figure and level of infrastructure damage.

The computer simulation tool first tracks the object as it enters the Earth's gravitational sphere of influence. Its path is then simulated through the atmosphere as it experiences ablation and aerodynamic forces. The object's energy is either fully spent in the atmosphere, resulting in an airburst, or it reaches a ground impact. The impact event is modelled using algorithms based on the current literature. Land impacts include the effects from seismic activity, shock waves, radiation generated by the developing fireball, and ejecta distribution. Ocean impacts require a tsunami wave to be modelled which will then inundate coastlines across the globe.

The simulation output analyse how each impact-generated effect affects human populations world wide. Casualty figure estimates will be complemented by an indication of the economic cost due to infrastructure lost. These two indicators will enable assessment of the NEO hazard on a global and country-by-country basis. Investigations can be carried out into the involvement of individual countries in any known NEO events. Furthermore, numerical modelling techniques will provide analysis of the threat, leading to a global understanding of each individual's risk due to potential NEO impact events.

The objective of work conducted by the University of Glasgow is to develop fundamental optimal control theory and apply it to the interception of hazardous NEOs. Different parameters, time, mass, orbital corrections, maximum deviation, etc. will be optimised. A study of the robustness of the methods will also be performed to take into account the uncertainties on both the NEO dynamics and boundary conditions. A variety of propulsion methods, ranging from solar sails to nuclear propulsion will be considered and the advantages and disadvantages of each assessed. Numerical simulations in a realistic scenario will be developed in order to investigate the performance of such methods and, to evaluate the optimal trajectories and deviation methodologies, the simulation data will be animated. This is a three year programme funded by the Engineering and Physical Sciences Research Council.

During November 2005, the Royal Aeronautical Society hosted a Workshop in London on NEOs to assess the current status of research into NEO characterization, detection and orbit determination, mitigation and policy. The meeting was sponsored by United Nations Office for Outer Space Affairs, the European Space Agency, the British National Space Centre, and the Rutherford Appleton Laboratory. Leading scientists from Europe engaged in NEO activities met to review how Europe could best contribute to, and complement the existing activities around the world. The Association of Space Explorers (ASE) contributed a valuable insight to how policy might develop to address issues that arise should a hazardous NEO be identified.