COPUOS
Scientific and Technical Subcommittee
47th Session
February 16, 2010

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European Representation
in Brussels

YUZHNOYE
design office

GLOBAL PROJECT ON THE ANTI-ASTEROID PROTECTION OF THE EARTH

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1. Global Challenges-Global Solutions: Space Approach

- Today Humanity is confronted with a number of challenges having a global nature, both ones of on-the-Earth origin and ones related to the space environment.
- It is evident that due to the very global nature of the problems, a search for global solutions is an imperative.
- Space Technologies, even with their current level of development, could help in some important cases.
- The space community can come up with proposals vital for saving our civilization and thus finally start – in the eyes of average citizens - to pick up the tab.

2. Examples of the Global Projects
(Yuzhnoye proposal)

- **SOLAR KEY: SPACE SOLAR ENERGY SYSTEM**
- **ANTI-ASTEROID PROTECTION OF THE EARTH**
- **REMOVAL OF IN-ORBIT SPACE WASTE**
- **SPACE DISPOSAL OF HAZARDOUS WASTE**
- **IONOSAT: SPACE SYSTEM FOR NATURAL AND MAN-CAUSED DISASTERS MONITORING**
- **SPACE PATROL: GLOBAL SATELLITE SYSTEM OF CRISIS SITUATIONS MONITORING AND CONTROL WITH IMMEDIATE RESPONSE**

3. Yuzhnoye in brief

Yuzhnoye State Design Office named after M.K.Yangel was founded in 1954 to initiate development of strategic-purpose missile-weapon complexes.

More than 50 years of collaboration with PA Yuzhny Machine-Building Plant, academic, science and research, manufacturing enterprises of former Soviet Union resulted in the development and production of four generations of strategic missiles, represented by 13 modifications which formed the basis of strategic missile forces. There were also produced 7 types of world-class launch vehicles (Kosmos, Interkosmos, Cyclone-2, Cyclone-3, Zenit-2, Zenit-3SL, Dnepr).

LOCATION: Dniepropetrovsk – industrial, business and scientific capital of Ukraine; aerospace and metallurgical centre of Ukrainian industry

YEAR OF ESTABLISHMENT:1954

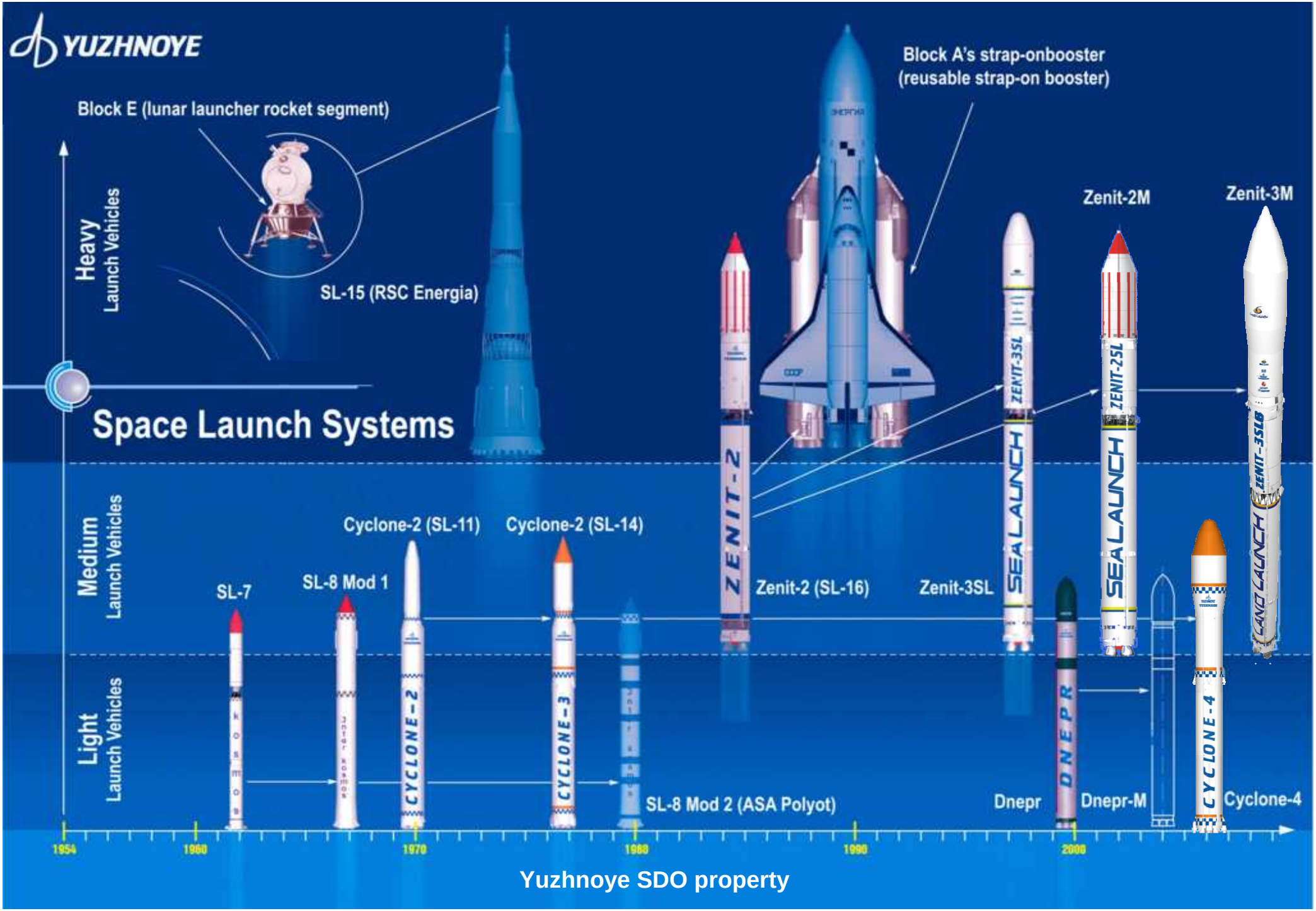
NUMBER OF EMPLOYEES:4500

MANAGEMENT: Dr. Stanislav Konyukhov, General Designer – General Director

MAIN DIRECTIONS OF ACTIVITY: Development of innovative aerospace technologies such as launch vehicles, Earth remote sensing satellites, propulsion systems for launch vehicles, advanced composites materials for space application and etc.

REPRESENTATIVE OFFICES: Brussels (Belgium), Long Beach (USA), Kiev (Ukraine)

JOINT VENTURES: Sea Launch (Ukraine, USA, Russia, Norway), Kosmotras (Ukraine, Russia), Space International Services (Ukraine, Russia), Alcantara Cyclone Space (Ukraine, Brazil)



Yuzhnoye SDO property

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4. Anti-asteroid Protection: Problem Statement, Existing Approaches

- According to the experts' estimations, between 500 and 1,000 massive – with a diameter of 150 kilometres or more - asteroids cross the Earth's path regularly and any one of them could cause a global catastrophe. But this is just a fraction of some 6,000 cosmic objects circulating around the planet and currently known. Probably, the most famous of them is asteroid Apophis which is to pass close to the Earth in 2036, with a one in 45,000 chance of a collision. An impact by Apophis would generate the equivalent of a 500-megaton blast and inflict enormous damage.
- There is a common understanding by astrophysicists that the best method for avoiding a catastrophic collision would be to change the path of the asteroid heading toward our planet. Non-nuclear techniques are considered to be effective for the asteroids having small size (up to 100 m), while for big ones, reaching in size 1 km and more, nuclear is the only option. It is also clear that the cardinal way of preventing the collision – head-on impact on the asteroid – may create many equally dangerous smaller asteroids. This problem is already in the focus of, so far few, scientists in the world researching the structure and composition of asteroids.

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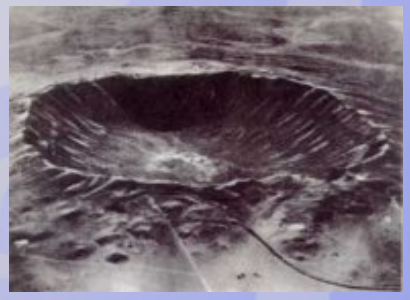
4. Anti-asteroid Protection: Problem Statement, Existing Approaches (cont.)

- Some other, “non-destructive” options were proposed – such as use of 10-tonne "gravity tractor", the device which would rely on the force of gravity to deflect any orbiting rocks years before any potential collision could happen; it is being developed by Stevenage space company EADS Astrium. However, the idea is still in its early stages and the company says a prototype is some way off from being built.
- Another approach - to attach a long tether with a weight at the end to deflect the asteroid’s orbit, is also only an idea.

5. Yuzhnoye proposal

Yuzhnoye offers an effective and safe system of anti-asteroid protection that allows to eliminate or significantly reduce a hazard of the Earth impact by large asteroids.

This system is designed to deflect an asteroid from a motion trajectory dangerous to the Earth . It can be applied at a distance of about 10 000 000 - 100 000 000 km from the Earth. The technical essence of the project consists in injection into interception trajectories of special modules flying at head-on courses. The specific feature of the proposed anti-asteroid modules is that they do not utilize the components of an atomic fuse applied in hydrogen bombs, and, therefore, no radioactive elements are present in the products of explosion. In the proposed system, initiation of the explosion reaction of hydrogen synthesis is provided at a meeting point of cumulative jets that are formed during collision with an asteroid at relative velocity of about 100 km/s. The anti-asteroid space-rocketry complexes, which realize the above described principle, can be developed already with the current level of technological evolution. The particular advantage of this system consists in the fact that it cannot be used for military applications within Earth environment, in particular by terrorists, which is especially important in today's world.



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5. Yuzhnoye proposal (cont.)

To impact an asteroid, creation of a *multi-echelon system* is proposed. For each echelon, options for the asteroid impact module (IM) and orbital stage (OS) are being developed.

Briefly, possible sequence of operations to impact a dangerous asteroid assumes the following:

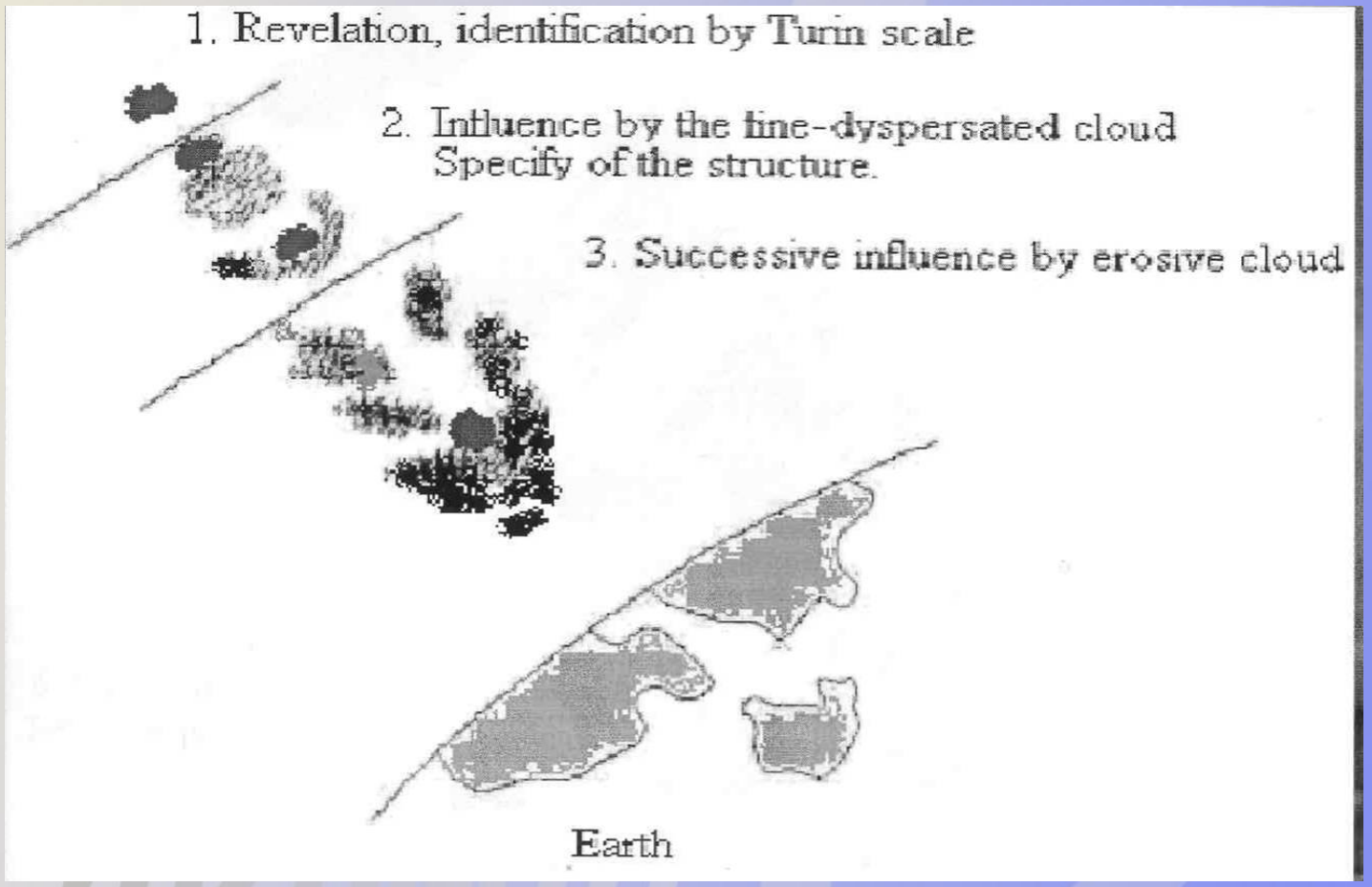
- **Impact by the fine cloud (to clarify the asteroid's structure);**
- **Serial impact by erosion clouds;**
- **Kinetic impact by means of a rocket module's collision with the asteroid;**
- **Impact on the asteroid by a laser beam (from the rocket module's board).**

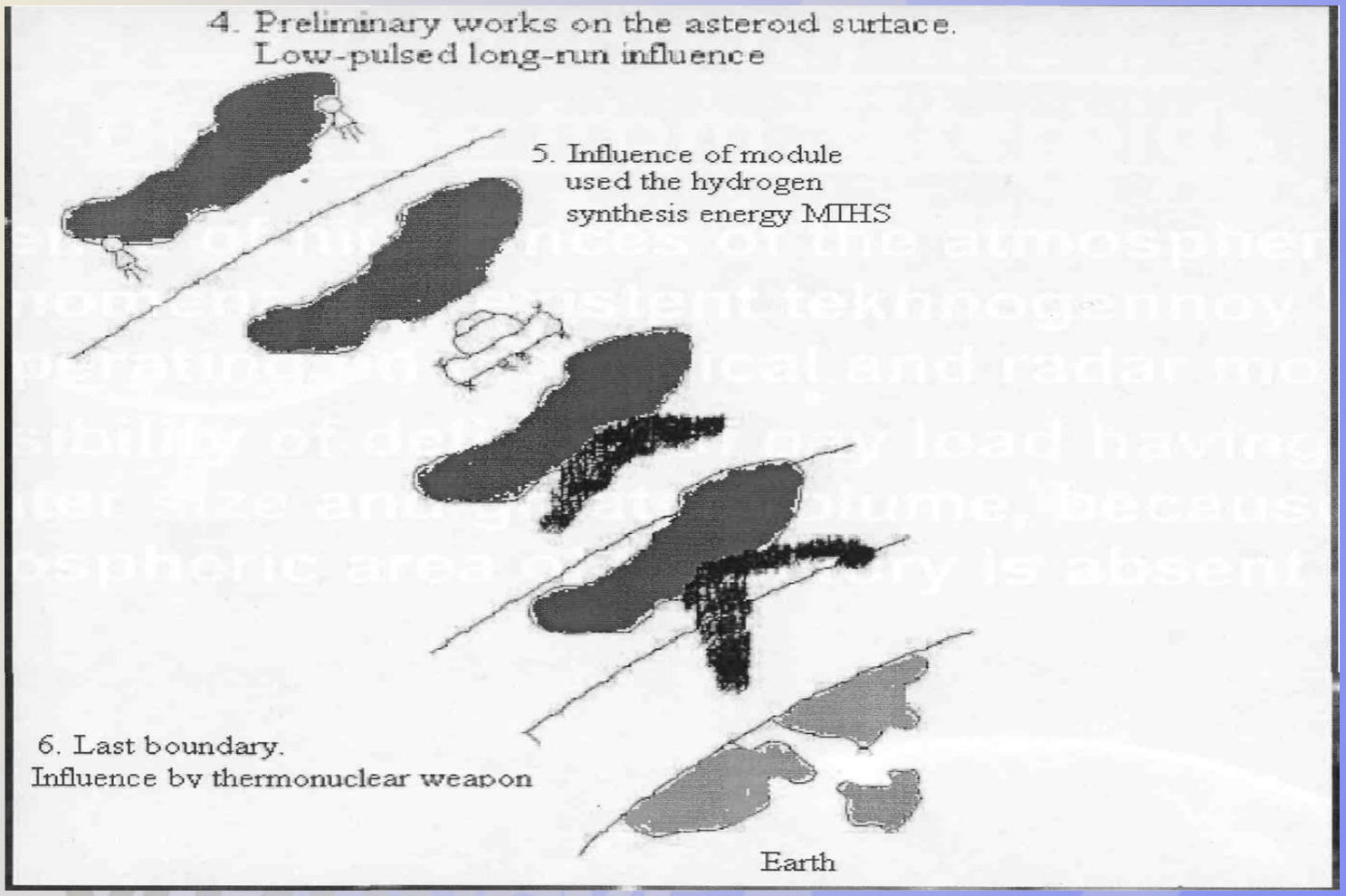
In case the asteroid overcomes all the echelons of non-nuclear impact, than the last frontier means can be used – rocket complexes with nuclear weapons.

Picture: dancewithshadows.com

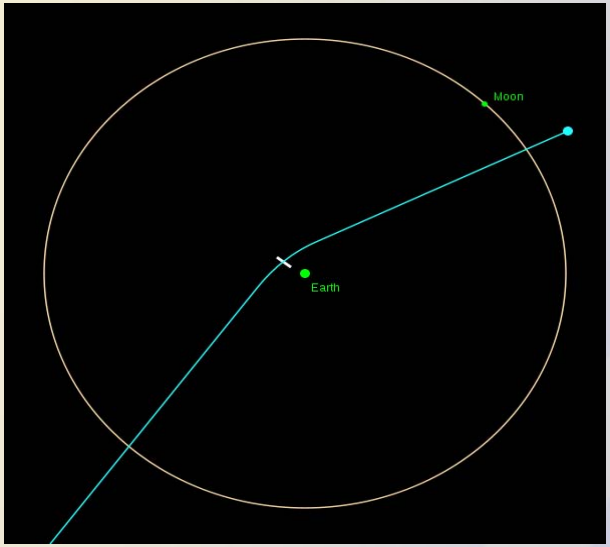
5. Yuzhnoye proposal (cont.)

Sequence of operations on prevention of collision of an asteroid with Earth





6. The Case of Apophis



The close approach of Apophis to the Earth and Moon on 13 April 2029 (Wikipedia)

Apophis asteroid: first dangerous proximity to the Earth in 2029, the most dangerous – in 2036.

***Peculiarity* - head-on impact by the rocket module (while being comparatively minor) may lead to the negative result – raising probability of the asteroid's collision with the Earth. To avoid this, the kinetic impact should be performed on the rocket module trajectories whose velocity vector at the moment of collision has an acute angle with the asteroid's velocity vector.**

In order for the asteroid to avoid getting into the gravitational trap, it is sufficient to correct its trajectory in advance just for 1÷2 km. Such a task could be implemented by using the existing rocket-space technology. Two variants of the kinetic impact are considered:

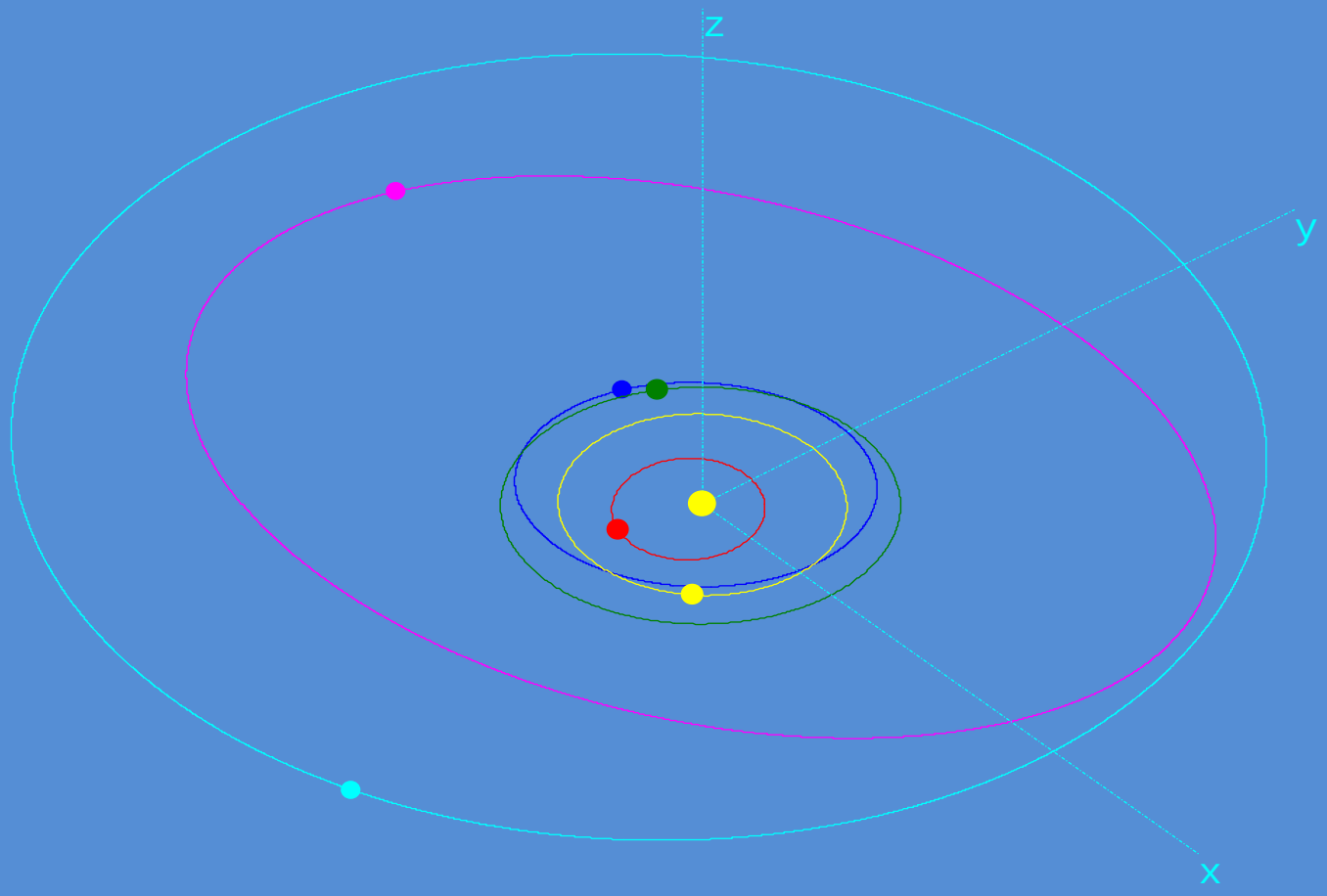
- **mild impact, which aims at guaranteed avoidance of the gravitational "keyhole" by Apophis;**
- **medium impact, which aims at making a distance between Apophis and Earth bigger at the moment of rapprochment in 2036.**

To implement the scenarios, one can use kinetic impact modules which can be delivered to the collision trajectory by the Zenit family launchers.

T = 2029 2 22.0

Major planets:

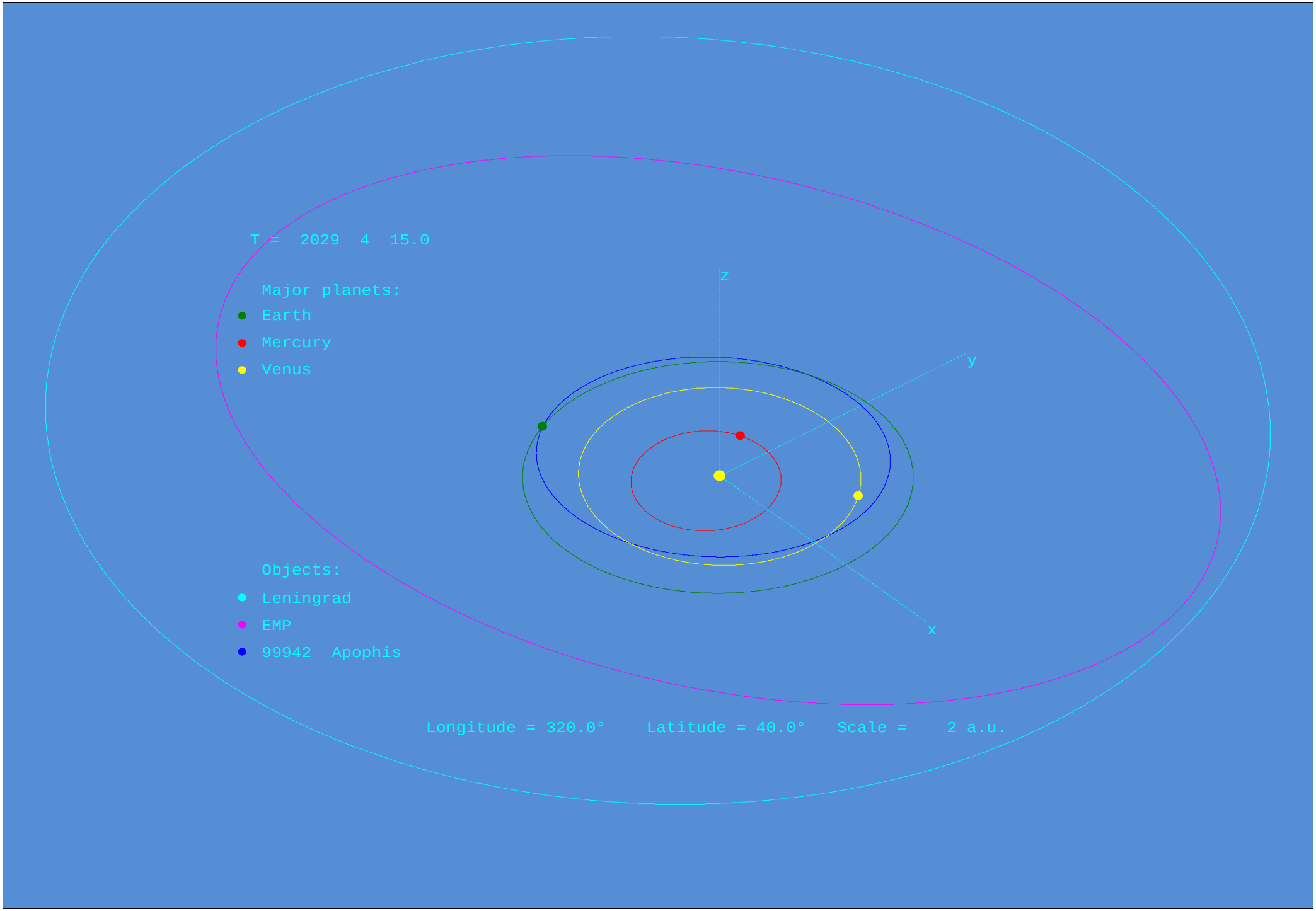
- Earth
- Mercury
- Venus



Objects:

- Leningrad
- EMP
- Apophis

Longitude = 320.0° Latitude = 40.0° Scale = 4 a.u.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Major planets:
Earth
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Objects:
Leningrad
EMP
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Major planets:

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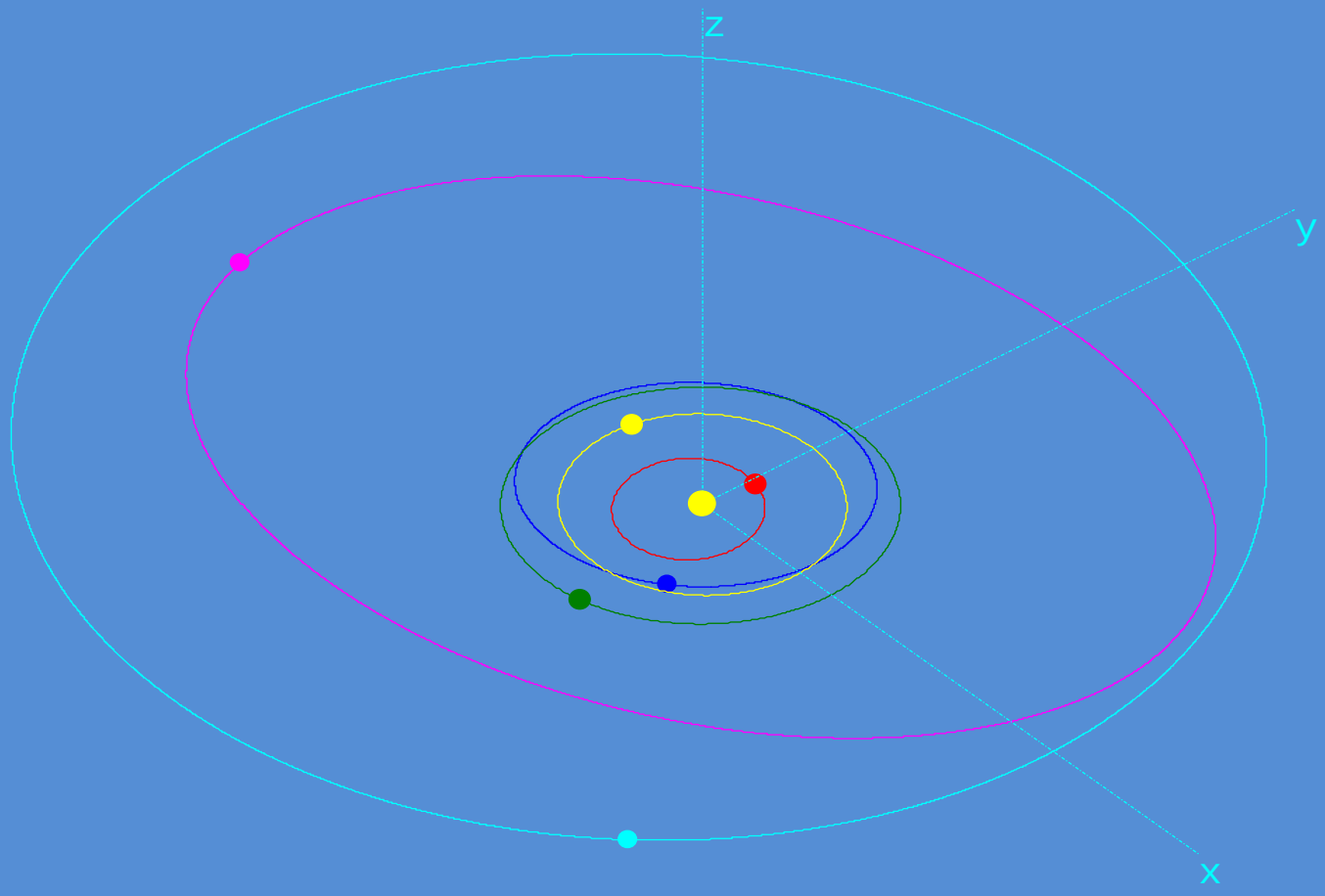

Objects:

- Leningrad
- EMP
- Apophis

Longitude = 320.0° Latitude = 40.0° Scale = 4 a.u.

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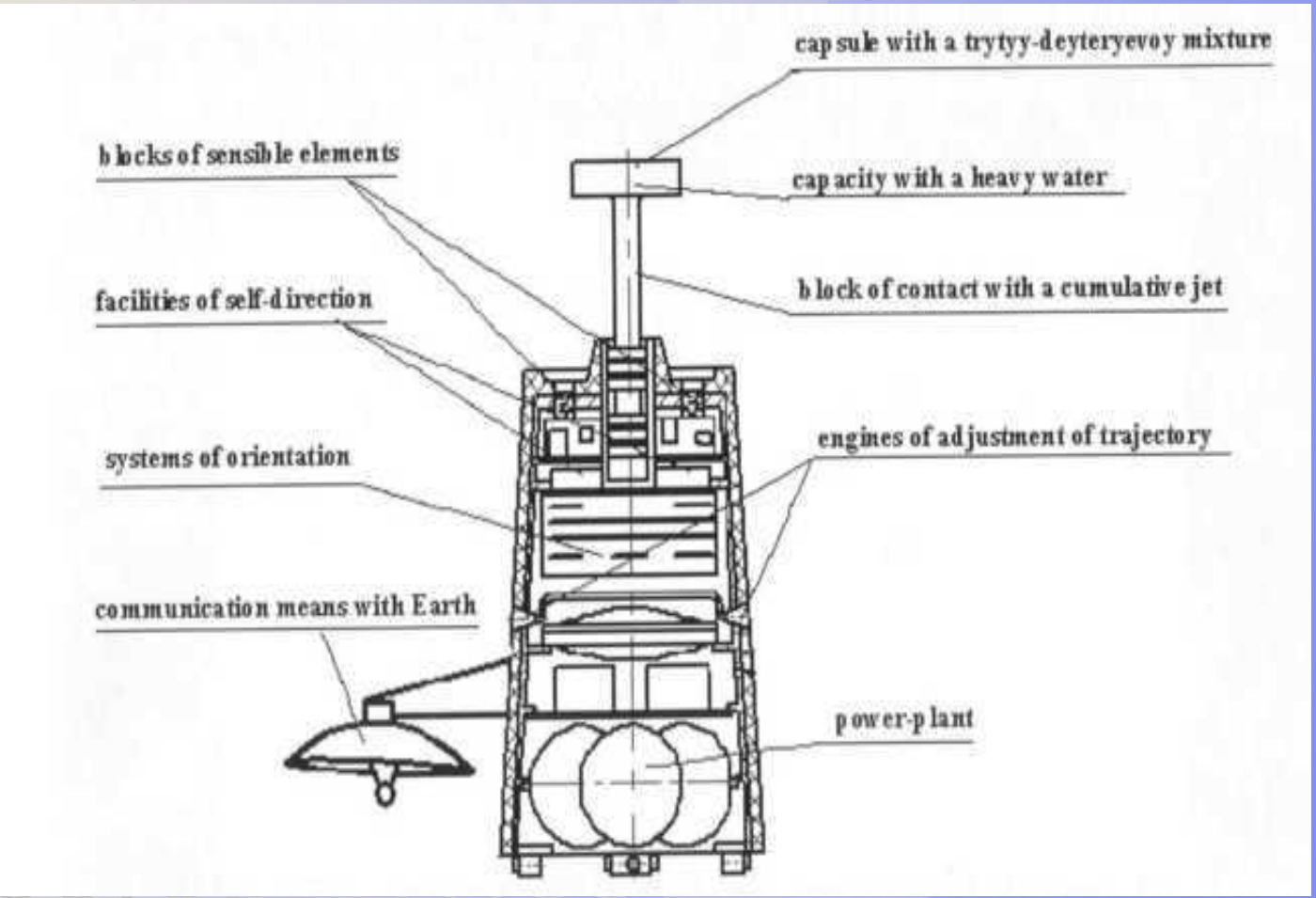
Zenit-2SLB

A two-stage ILV based on the first two stages of the Sea Launch Zenit-3SL, is designed for delivering payloads to inclined low Earth circular and elliptical orbits.

ILV type	Monoblock, Liquid-Propelled, Two-Stage
Propellants Fuel Oxidant	 Kerosene Liquid Oxygen
Payload Mass Injected into the orbit (Hcirc = 200 km, i=90º), kg	12370
Injection Accuracy Altitude, km Inclination, degree	 ± 4,7 ± 0,054
Mission Reliability	0,992

6. The Case of Apophis (cont.)

The general sketch of the impact module



7. On the Global Projects Implementation

There are several steps to be undertaken on the way towards all the mentioned projects' realization:

- development and refining of technical concept
- selection of interested partners-customers and preparation of agreements with them
- selection of the partners-experts in concrete technical domains
- search for the sources of finance
- getting permissions from state and local authorities, as well as from regulators
- making the environmental impact assessment and legal due diligence
- studying of factors and creation of conditions facilitating introduction of the proposed innovative concepts, etc.

7. On the Global Projects Implementation (cont.)

- The leading space International bodies - IAF, IAA, IISL – could play an extremely important role. The IAF can create under its roof a special structure tasked with development of the strategy and action plans for each global project, selection of appropriate partners, consolidation and leading them for the project success. The Federation and the newly created structure can be an interface in relations with UN, governmental and inter-governmental organizations, potential sponsors, investors; organize global thematic fora; be in charge of educating people and awareness-raising on different aspects of the global projects.
- The IAA can make a very important input by conducting studies and preparing reports on the respective topics and presenting the outcomes to the target audiences; providing top-level expertise on the key projects issues; organizing stand-alone International conferences and symposia on technical, social and policy aspects of the projects.
- The IISL can provide a legal due diligence and juridical assistance which are crucial for every global project.
- In general, with respect to the global projects, the motto "Viribus Unitis" is applicable to the International space cooperation more than ever before.

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8.CONCLUSIONS

Modern space technologies are mature enough to help in solving some global problems of Humankind.

Yuzhnoye Design Office of Ukraine has developed proposals of six Global Projects, implementation of which using space technologies already available or being developed throughout the world will make the Earth citizens' life more safe, secure and comfortable.

Presented is Yuzhnoye proposal on creation of effective and safe system of anti-asteroid protection. The described approach towards particular case of the Apophis asteroid could be considered as a testbed. *Viribus Unitis* should be a motto of this and any other global project.

The current global economic and financial crisis does not help to implement this kind of the projects. Yet, it also presents an opportunity.

The leading space International bodies - IAF, IAA, IISL – could play an extremely important role.

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