

Global Security: Ukrainian HOPSIS Program and Space Mission to Destroy Asteroids

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The article highlights the actual problems of ensuring the Global Security of the World and Ukraine. The results of studying the experience of the Geneva Center for Security Policy and the legal provision of security are presented. The article presents the results of the Ukrainian experience of participating in the mission of the Geneva Center for Security Policy in terms of ensuring Space Security. The problem of Asteroid Hazard is singled out, and the possibility of its elimination using the Science & Space LLC launch vehicle as a carrier of kinetic weapons is described. The legal basis for the use of weapons in outer space and the inevitability of liability for their use are considered – even in the kinetic missile version, which is not a weapon of mass destruction. The world experience in the topic of Global and Space Security under study is considered.

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Introduction

The globalization of the world today has also identified the problems of Global security. There is a particular need for reconstruction to improve the security and resilience of the state. This includes reducing Ukraine's strategic vulnerabilities (trade routes, energy dependency). It does not diminish the pertinence of human security but calls for a balanced and multi-pronged approach to reconstruction. In democratic societies, human security and state security are interconnected components that complement each other. Only when people are adequately protected against the wide range of threats that they face can society become truly resilient. Human security can therefore be a vital piece of the reconstruction (Greminger & Lunding, 2023).

The authors studied the experience of the work of the world center for ensuring global security, created in Europe: Geneva Centre for Security Policy (Geneva, 2023). The activities of this Center are multifaceted and comprehensive. It is based on the international law and international security programs.

The work also analyzes the Space Security Program of Ukraine: Open World – Ukraine: Orbital Prosperity of Humanity Through Safe and Industrial Space (HOP SIS). In addition to the above, the authors consider the use of kinetic weapons as part of specialized Asteroid Defense (AD) to destroy an asteroid in outer space or in the Earth's atmosphere and the possibility of creating a non-nuclear, non-explosive analog of asteroid damage even before they hit the Earth's surface.

Geneva Centre for Security Policy

The Geneva Centre for Security Policy (GCSP) has its roots in the Geneva Summit of 1985: the first meeting between US President Ronald Reagan and Soviet General Secretary Mikhail Gorbachev to discuss international diplomatic relations and the arms race in the midst of the Cold War.

In 1995, Mr. Adolf Ogi, Swiss President and Federal Counsellor in charge of the Federal Department (Ministry) of Defence, initiated the establishment of an international Foundation in Geneva to expand the reach and impact of the course and serve as a contribution of the Government of Switzerland to peace in Europe. 11 States accepted to nominate a representative to serve on the Foundation Council (board of trustees).

The Geneva Centre for Security Policy's (GCSP) mission is to advance peace, security and international cooperation by providing the knowledge, skills and network for effective and inclusive decision-making through executive education, diplomatic dialogue, research and policy advice. GCSP can successfully achieve these goals by constantly and timely focusing on the Medium Term Strategy for 2023-2027 are able to successfully achieve these goals by our continued and timely focus on our Medium-Term Strategy 2023-2027 (MTS). The GCSP's mission was strengthened, when in 1996, Switzerland joined the Partnership for

Peace (PfP), an initiative led by the North Atlantic Treaty Organisation (NATO) to enhance transatlantic security cooperation. GCSP was a Swiss contribution to the PfP and is now recognized as a Partnership Training and Education Centre (PTEC). GCSP has created an inclusive environment for a global community of 184 countries and sectors to come together to exchange ideas and develop sustainable solutions for a more peaceful future.

The governing body of the GCSP is the Foundation Council, which consists of representatives of 52 Member States and the Canton of Geneva, incl. and the State of Ukraine, which joined the GCSP in 1995.

In 2019 GCSP analyzed the OCSE mission in Ukraine with the aim of preventing conflict and achieving peace (Lessons, 2019). This conference was attended by Mr. Alexander Hug, former Dep Chief Monitor OSCE Mission to Ukraine (Vienna). There is no information about the participation of Ukrainian state representatives in the conference, as well as there is no information about the participation of the state of Ukraine in the work of the GCSP in general since 1995. It is only known that diplomat Maxim Kononenko, Ambassador Extraordinary and Plenipotentiary of Ukraine to the Republic of Estonia, completed a training course at GCSP: Executive Program on the Legal Aspects of the Current and Future Use of Force, Geneva Centre for Security Policy (GCSP) (Geneva, Switzerland), October 2017. Other Ukrainian specialists also received personal training at GCSP.

But this does not mean that no one from Ukraine is participating in GCSP missions.

On March 17, 2022, a discussion of the issue of Ukraine took place at a meeting of diplomats, “Breakfast Debrief on the War in Ukraine, with Club Diplomatique de Genève” (Breakfast, 2022). Diplomats of Ukraine did not take part in the meeting. On April 13, 2022, a discussion of the topic took place, “The War in Ukraine: Repercussions in the World and in the Middle East” (Chalyi, 2023). Ukrainian government officials did not participate in the meeting. On September 5, 2022, a debate was held at GCSP on the topic “Impact of the War in Ukraine on Multilateralism and the World Order – A Geneva Security Debate” (Impact, 2022). Ukrainian representatives did not participate in the debate. On February 24, 2023, a debate was held at GCSP, “The Humanitarian Response – Marking the One-Year Anniversary of the War in Ukraine – A Geneva Security Debate” (Humanitarian, 2023), without the participation of Ukrainian representatives. On July 7, 2023, in GCSP was discussed topic “Ensuring Long-Term Peace in Ukraine: What Solutions?” (Ensuring, 2023).

The discussion was attended by Mr. Andrej N. Lushnycky, President of the Ukrainian Society in Switzerland and honorary consul of Ukraine in Switzerland.

GCSP is registered in Geneva as a non-profit Fund, but, in addition, responds to modern challenges: the GCSP is ISO 9001:2015 certified. ISO 9001:2015 is an international quality label that specifies the requirements for a quality management system within an organisation.

Among the activities of GCSP is Space Security (The Future of Outer Space Security), which is the focus of this study.

Outer space must be kept secure as a global commons for all of humanity. This involves proactively dealing with issues such as space debris and the weaponization of space. At the same time, this must be reconciled with the reality that the security of a state's space interests is vital to its national interests. In recent years, space weaponization has escalated and caused tensions to flare between some countries.

It includes sessions led by international experts on the following topics: Cybersecurity and space security, Space debris, Space weaponization, New space (industrial development of outer space), Space power and policy, Space governance.

Open World – Ukraine: Humankind Orbital Prosperity by Safe and Industrial Space (HOPSIS)

It should be noted that in Geneva, the GCSP pays a lot of attention to the problems of security and peace in Ukraine, as a component of global security. Research Institute of Space Industrialization (ISI) (Research, 2023), the office of which is located in Ukraine, unites specialists and scientists of various fields of activity from different countries who have a good understanding of what security is and, in particular, Space Security. ISI supports the activities of an international organization in Geneva and participates in the GCSP program Prize for Innovation in Global Security.

The Institute, together with the National Space Facilities Control and Test Center (State Space Agency of Ukraine), is implementing the Open World – Ukraine: Humankind Orbital Prosperity by Safe and Industrial Space (HOPSIS) (2013-2023), a program aimed at monitoring near-Earth space and the introduction of new rocket and space technology that does not pollute space with debris.

The program aims to ensure space security and control of near-Earth space in the global security policy (Open, 2023). The program considers threats in ensuring space security: space debris; militarization of the Cosmos; natural impact on the Earth from space.

Technogenic and military manifestations in space can be eliminated in four ways: exclusion of man-made junk by replacing disposable space technique on returning to the Earth reusable Spacecrafts (Orbiters) (Levenko et al., 2016) and return to the Earth and elements of Launch Vehicles (reusable LV) (Levenko et al., 2014): asteroid impact avoidance; observation and control of space objects; space monitoring and analysis system.

Prevention of technogenic (man-made) of space debris (2013-2023)

The non-used satellites, the rocket stages and the space boosters flying in near-Earth space, in the 21st century, accumulated in such quantities that they are dangerous for flights in space now. After the operation, such objects were not originally planned to be returned to Earth. They gradually lose altitude and burn in the Earth atmosphere. However, this process is stretched for decades. And the pace of satellite launches is such that previously launched objects do not have time to descend from their orbits. As a result, the problem of “space junk” (space debris) has appeared. Research Institute of Space Industrialization (ISI) offers an engineering (technical) decision: only the returned spacecrafts (Orbiters) need launched into Space; launch vehicles and rocket stages return from orbits to Earth.

Any modern satellite can be maneuvered on Earth’s orbits to avoid collisions with other objects, and it can be returned to Earth – it’s Orbiter.

Research Institute of Space Industrialization has analyzed and developed three models of Orbiters: weight up to 50 kg, Orbiter USC-50-X; weighing up to 500 kg, Orbiter USC-500-X; weighing up to 1000 kg, Orbiter USC-1000-X (Directions, 2023).

According to the authors: until the launches of disposable spacecraft into high orbits stop, the problem of “space debris” will not be solved.

ISI offers engineering solutions: only returning satellites and ships should be launched into space (Orbiters); launch vehicles and rocket stages must return from orbits to the Earth.

This can be done technically. However, administrative measures need to be taken to ensure the implementation of technical solutions in a legal framework (Space governance – as

interpreted by the GCSP, based on UN decisions, international agreements, in particular, the Outer Space Treaty (OST), 1967: on the peaceful use of space).

Asteroid impact avoidance (2020 – 2023)

According to current forecasts, asteroids 50-70 m in size can fall to the Earth in the period of up to 90 years and cause significant damage to the Earth's surface. To ensure space (asteroid) safety, planetary duty can be organized to detect, intercept and destroy approaching asteroids of this size. On duty, there may be an interceptor missile (launch vehicle) with a 200-500 kg metal kinetic interceptor (payload of a space apparatus).

According to the calculations, the asteroid may be destroyed at an altitude of about 80-140 km (Space, 2023).

As early as 1995, the United Nations Office for Outer Space Affairs (UNOOSA) organized the United Nations International Conference on Near-Earth Objects (Cowing, 2013). UN Scientific and Technical Subcommittee at the 50th session on February 22, 2013, in Vienna, endorsed the report of its Working Group on Near-Earth Objects (NEOs) that recommended the establishment of an international asteroid warning network (IAWN). A Space mission planning advisory group (SMPAG) should be established by those Member States of the United Nations that have space agencies. This means that the State Space Agency of Ukraine should take the initiative.

The group was created in 2014, under the name Space Mission Planning Advisory Group (SMPAG). In 2016, the SMPAG set up an ad hoc working group to address legal issues related to its planetary defense methods, in particular, those related to the use of «weapons» (Barug et al., 2020).

A State would potentially incur international liability through the use of impulsive methods such as conventional explosives or nuclear explosive weapons (in accordance with the Outer Space Treaty (OST) requirements), Partial Test Ban Treaty, Treaty on the Prohibition of Nuclear Weapons (TNPW). Weapons for the destruction of asteroids should not be analogous to weapons of mass destruction – according to the authors, it should be a kinetic precision weapon.

Nevertheless, when creating a kinetic weapon, liability may still arise in the event of an accident or a change in the asteroid's flight path, which will entail a blow to the territory of a state that did not use weapons against the asteroid: constructive measures must be taken to prevent such a situation. Absolute liability would mean that even if the State that launches the weapon takes all measures to avoid the error, but the error still occurs, it would be held liable. This risk could severely limit any planetary defense initiative by some States.

The need for additional rules on planetary defense is indisputable, but the form and scope of such rules remain unclear (Barug et al., 2020).

An asteroid hazard exists, although this event may not occur within the lifetime of one person. However, the impact of the Earth by an asteroid can lead to global consequences, which has already happened in the distant geological past of the planet. According to the European Space Agency: as of April 2019, 20 000 asteroids whose orbit brings them near Earth have been found. At the current rate of roughly 150 new discoveries every month (The day, 2019).

As recognized in the world, the main problem of anti-asteroid defense lies in the plane of international law (Koplow, 2019). NASA and its partner space agencies in other countries, as well as space explorers, have already made efforts to survey dangerous near-Earth objects

(including flights to asteroids in the United States and Japan), and some methods have been developed that could be used to deflect a dangerous asteroid.

The most promising route considered by the panel for addressing both these legal issues is to exercise the powers of the United Nations Security Council. Under Chapter VII of the U.N. Charter, the Security Council holds a unique law-making ability and possesses the authority to supersede the provisions of other treaties. If prompted by a genuine emergency, the Security Council could therefore authorize states to exert their best efforts for planetary defense.

Such a solution to the legal problem allows Ukrainian specialists to offer their own version of anti-asteroid protection: a space mission to use an anti-asteroid kinetic launch vehicle.

Control on orbits. Observatio of Near-Earth Space

To control the launches of Launch Vehicles, Orbiter space flights, and the landing of Spacecrafts, use the opportunity of the National Space Facilities Control and Test Center (NSFCTC) State Space Agency of Ukraine. Within the framework of the proposed program Open World – Ukraine: HOPSIS NSFCTC can provide information without restrictions. Experience of such work is available: NSFCTC maintains a catalog of celestial objects with the definition of the flight orbits and monitors the trajectories of re-entry Spacecrafts to Earth. Currently, the NSFCTC is exchanging information within the framework of the space programs of the European Union: Copernicus, Proba-V, MetOp, and navigation support systems the EGNOS.

Technical capabilities of NSFCTC can solve the problem of the space militarization: due the control of space objects in the interests of the security of space and the whole of mankind. As of April 2020, 2713 space objects and 12593 space debris objects are controlled. By 2023, the number of objects launched into orbit has more than doubled.

The program Open World – Ukraine: HOPSIS, with its components, eliminates man-made and military manifestations in space. In addition, the Open World – Ukraine: HOPSIS project can provide ground control of global security.

NSFCTC has monitoring and observing equipment:

- a) Nature seismic manifestations (earthquakes, information on the site <http://nkau.gov.ua/nsau/nkau.nsf/Main1E/indexE?opendocument>);
- b) Technogenic seismic manifestations (nuclear, thermonuclear and other explosions, launches of heavy Launch Vehicles);
- c) Fall of space objects to the Earth (for example, the fall of the Chelyabinsk meteorite).
Re-entry of space objects into Earth atmosphere.

The complex of orbital support, control, and management, as well as global terrestrial monitoring, allows eliminating a number of the problems of ensuring the security policy of mankind, first of all, in space security.

The program is implemented in the legal field of Ukraine, considering international agreements.

2020 – space monitoring and analysis system

The Space Monitoring Center of the SMAS (NSFCTC) ensures the collection of information on space objects, administering the Main Catalog and the Catalog of priority space objects;

operational estimation of the orbital constellation and the state of ground facilities; planning of the application of the means of Space monitoring and analysis; formation of messages on space situation and bringing them to consumers of information.

The National Center is working on involving to the SMAS both national and foreign facilities of space objects monitoring (On Space, 1996).

Space mission to destroy asteroids (Ukrainian HOPSIS+AD program)

The energy of meteorite and asteroid impact

The authors conducted a study of the processes of asteroids falling to the Earth and evaluated the consequences of this process. The shock wave in the Earth's crust during the fall of an asteroid of a sufficiently large size is catastrophic: the atmosphere will not be able to extinguish its huge flight speed. For example, the flight speed of the asteroid 99942 Apophis (diameter 325 ± 15 m) is 30.728 km/s. With a mass of this asteroid of 6.1×10^{10} kg, its kinetic energy of falling to the Earth can be $\approx 2.4 \times 10^{19}$ J. This will be an impact that will cause destruction, an earthquake, volcanic eruptions with atmospheric emissions, and a tsunami.

The results of similar falls of asteroids remained on the surface of the Earth. Одним из наиболее крупных астероидным образованием является Попигаи impact structure – crater (Siberia, Krasnoyarsk Krai of the Russian Federation): диаметр 100 км, глубина 200 м, возраст 35,7 млн лет.

Chicxulub crater has a diameter of 180 km, is located on the Yucatan Peninsula in Mexico, partly in the waters of the Gulf of Mexico, and is 66.5 million years old. Scientists estimate that the crater was created by the fall of a ten-kilometer asteroid. The impact energy is estimated at 5×10^{23} J (which is 2 million times more powerful than the explosion of the most powerful thermonuclear bomb: the explosion power of the “Tsar bomb” AN602 on October 30, 1961, was 2.4×10^{17} J). The formation of the crater is attributed to a planetary catastrophe in which dinosaurs became extinct, and the Cretaceous period ended on Earth.

When an asteroid collides with the Earth, the kinetic energy of motion is transformed into impact and thermal energy. All aspects of such a possible catastrophe have already been studied.

An assessment was made of the destruction caused by the fall on the land of the most massive and most probable asteroids and meteorites 10-300 m in size (Shuvalov et al., 2013).

As a result of the analysis, it was determined that destruction on the Earth's surface is inevitable when the size of the asteroid is more than 30 m in diameter. This applies to massively distributed stone asteroids.

It was determined that because of the destruction of an asteroid by an explosion, the falling debris should be less than 20-30 m. This circumstance was taken into account when choosing a method for destroying a dangerous celestial body before it hits the Earth.

Over the past decades, the asteroid-comet hazard has been studied in the world. Potentially dangerous space objects have been identified (Near-Earth Objects, NEOs). Most of the known asteroids are able to cross the Earth's orbit (Earth-crossing asteroids, ECAs) – there are about 800 of them. In addition, long-period comets can enter a potentially dangerous Earth impact orbit as little as two months before they are discovered (Kozelkov, 2014).

This means that anti-astroid weapons must be constantly on “combat” duty: from known technical means, launch vehicles with long-term storage fuel are suitable for this within the “space alert announcement” time.

The most dangerous are local catastrophes from falling asteroids with a diameter of 50 m (the area of destructive impact is 1900 km²) – the frequency of their probable fall is less than 100 years. Global catastrophes can be caused by asteroids with a diameter of 2 to 10 km: the frequency of their appearance is likely once every 1 to 70 million years. The death of a civilization is probable when an asteroid with a diameter of 100 km falls to Earth (the probability of such an asteroid falling once every several billion years).

To break an asteroid with a diameter of 50-70 m into fragments that will burn in the atmosphere is the main task of protecting the Earth from asteroids, according to the authors.

The LONEOS (Lowell Observatory Near-Earth Object Search) system is operating in the United States to search for asteroids and comets dangerous for the Earth. Under the Near-Earth Asteroid Tracking (NEAT) program, observation stations operate on Maui and at the Palomar Observatory. Monitoring of near-Earth objects is carried out according to the Australian-American project CSS and the project of the European Union countries Asiago-DLR Asteroid Survey (ADAS). The control of outer space is also carried out by the Ukrainian National Space Facilities Control and Test Center, as well as the National Academy of Sciences of Ukraine, its Main Astronomical Observatory (Main, 2023).

An engineering problem that the authors solved: the release of energy from the collision of a mass, for example, a metal block, in a collision with a cosmic body (asteroid). From studies of different years, it is known that even when a bullet is flying at a speed of more than 4 km/s, the thermal energy of the impact turns the target into plasma and has a stopping power. And it is also known that the energy released during the explosion of 1 ton of trinitrotoluene (TNT equivalent) is equal to 4.184·10⁹ J.

Studies on the possibility of using kinetic weapons to change the flight path of the asteroid Dimorphos (diameter ≈160 m) have already been carried out in deep space, DART mission, USA, 2022: at the time of the impact on the asteroid, the spacecraft weighed 550 kg, the impact energy was 1×10⁹ J (Tavernier, 2022).

Kinetic launch vehicle

The authors consider the use of kinetic weapons as part of a specialized Asteroid Defense (AD) to destroy an asteroid in outer space or in the Earth’s atmosphere. The authors analyzed the possibility of creating a non-nuclear, non-explosive analog of hitting asteroids before they hit the Earth’s surface.

It is taken into account that during the collision of moving bodies with a speed of more than three km/s, the kinetic energy of the impact significantly exceeds the energy release of conventional explosives. The use of an asteroid destruction element made of steel as a launch vehicle payload is considered.

The final calculations are presented in the Technical proposal for the creation of a kinetic launch vehicle XXX-1. The calculations took into account the effect of a collision with an asteroid, only the payload of a rocket with a mass of 200 kg (the total final mass of the payload and rocket structure can reach 1000 kg – the payload does not separate from the launch vehicle).

A technical proposal for the implementation of the HOPIS + AD program with a kinetic launch vehicle XXX-1 is presented by the Ukrainian Science & Space LLC.

If necessary (decision by the UN Security Council), a single-stage launch vehicle XXX-1, using a transitional Hohmann trajectory with repeated switching on of a GS-10 liquid rocket engine, is launched into a circular near-Earth orbit to an altitude of 500 km. After determining the time of impact on the asteroid from this orbit, the launch vehicle with the engine turned on moves towards the asteroid and hits it.

Without taking into account the speed of the asteroid on the opposite course, the speed of the launch vehicle, according to the calculations performed, is 7.8 km/s. The energy released during the collision of the payload of a 200 kg launch vehicle with the surface of a stationary asteroid will be $E_{200} = 1.2 \times 10^{10}$ J (the energy is an order of magnitude greater than in the explosion of one ton of TNT). When performing a mission on the opposite course of the asteroid at a speed at least equal to the speed of the kinetic fighter XXX-1 (taking into account that, depending on the definition of energy, the speed is squared), the impact energy can be $E_{\Sigma} \approx 5 \cdot 10^{10}$ J or 12.4 tons of TNT equivalent. Data on the results of the explosion of 5 tons of trinitrotoluene are known (Adushkin & Khristoforov, 2004): crater diameter 110 m, depth 21.4 m.

With the ratio of the asteroid diameter to the funnel depth of 2:1 for the complete destruction of the asteroid, the obtained parameters correspond to the destroyed asteroid with a diameter of 42.4 m. And with the equivalent of 12.4 tons of TNT, the parameters can reach, presumably, there are no open data on such ground-based explosions, calculation by the extrapolation method: crater diameter 178 m, crater depth not less than 34.5 m: this is enough to completely destroy an asteroid with a diameter of ≈ 70 m.

Consequently, the task of destroying an asteroid with a diameter of 50^{+20} m can be performed.

When designing a launch vehicle, modern trends were taken into account: rocket low-budget (one small-sized stage 12 m long and 1.1 m in diameter, liquid fuel is supplied to the engine without a turbopump unit by gas pressure); the rocket is environmentally friendly and can be stored in a filled form for a year (propellant components: highly concentrated hydrogen peroxide and ethanol), after which the rocket can be refueled. Schematic diagram of XXX-1 corresponds to the launch vehicle GreenSpace company Science & Space LLC.

The main thing: a kinetic missile is not a weapon of mass destruction (with a TNT or nuclear charge), and is not a weapon for destroying spacecraft in Earth's orbit (the likelihood of space militarization), since it can only be used by decision of the UN.

Conclusions

Participation of Ukraine in the work of the Geneva Center for Security Policy to maintain global security in the world is the most important condition for security for Ukraine itself.

An element of such participation is currently the Ukrainian Space Security Program: Open World – Ukraine: Humankind Orbital Prosperity by Safe and Industrial Space (HOPSIS). The program consists of four sections, three of which are being successfully implemented.

Until recently, the task of providing anti-asteroid protection (AD) remained a problem. This problem has been solved and presented by Science & Space LLC in the form of a Technical Proposal for the creation of a kinetic launch vehicle XXX-1 (for the destruction of the most numerous asteroids when they approach the Earth). The kinetic missile is not a weapon of mass destruction.

It is necessary to continue research to form a clear legal framework for the use of weapons to prevent the asteroid threat: this problem can be solved by making an operational decision at

a meeting of the UN Security Council.

The ongoing HOPSIS program is only a part of global security, incl. Ukraine. Ukraine's problems are constantly considered in the Geneva Center for Security Policy, as they are related to global security in the world. But, as a rule, this happens without the participation of representatives of Ukrainian state organizations.

Unlike most other sites of recent international reconstruction projects, Ukraine will be recovering not from intrastate but interstate conflict. The HOPSIS + AD program will provide Human security in Ukraine as a component of the global security of mankind.

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