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DEVELOPMENT OF ORBITAL AND INTERORBITAL UAV WITH NUCLEAR CHARGE

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Abstract. *The subject of this study is orbital and interorbital unmanned aerial vehicles (UAVs) and their design peculiarities. The work aims to find universal multipurpose UAV configurations for orbital defensive, environmental, and research purposes. The results of an analysis and comparison of various design layouts for orbital and interorbital UAVs are presented. Various design peculiarities and layouts are considered. Based on the existing UAV layout with a shrapnel-trinitrotoluene ordnance, a layout with a nuclear ordnance is proposed. It is noted that the launch of such an orbital and interorbital UAV is accomplished through the use of the Falcon Heavy launch vehicle. The scientific novelty lies in the developed layout of combat UAVs (UCAVs) with a nuclear ordnance, which allows for kinetic strikes from both sides of an asteroid's deepest central craters.*
Keywords: *UAV, nuclear, UCAV, asteroid, launch vehicle, satellite, environmental safety*

Introduction

Today, the World's most technologically advanced countries are constantly creating new universal space transport technologies and improving the existing ones in order to protect Earth from comets, asteroids and other Near-Earth Objects (NEO), which, when falling on our planet, can cause a series of huge tsunamis, a shift of tectonic plates, fire tornadoes the size of a continent, an impact winter or even several such apocalyptic events at once [1] – so it may be resulted not only in environmental damage and destruction of properties, but also in mass human deaths. According to previous studies by NASA scientists, a collision of an asteroid of 10 kilometers in size with the Earth will cause irreparable damage to the biosphere, which in turn will lead to Human extinction [2]. The least threat of that kind comes from comets - not due to their sizes, but to their low density [3]. Thus, the results of NASA studies of the NEO size showed that the fall of an object with a diameter of less than a kilometer will be resulted in significant local or regional damage, but does not cause a global catastrophe. At the moment, a wide and unique knowledge has already been accumulated on the detection, tracking, cataloguing and description of near-Earth asteroids and comets in order to prevent their collision with Earth [4]. Humanity possess the technologies as to sending the artificial satellites into deep space to influence comets and asteroids movement, to change their flight trajectories, and to crash into or land on the surface of those space giants. However, it yet not solved a problem of creating the universal orbital space technology that can be used to prevent collisions of detected near-Earth objects with our planet (by an explosion resulted in a complete or partial destruction of an asteroid, or in a change of its trajectory) - that is why research is so relevant.

Purpose and objectives of the study

The purpose of this study is to develop a design layout of an orbital and interorbital unmanned aerial vehicle (UAV) with a nuclear ordnance for the destruction of asteroids with a diameter of more than one kilometer. To achieve this purposes, the following objectives were formulated:

- ✓ analysis of existing deign-and-technological solutions (DTS) and the peculiarities of orbital UAVs and analysis of features and DTS of orbital UAVs with ordnance of shrapnel-trinitrotoluene type;
- ✓ development of combat UAVs (UCAVs) with ordnance of nuclear type.

Literature review and state of the art

In [5], it is presented a UAV with the wings made of a flame-resistant carbon fiber composite material based on a cyanate ester resin matrix that has high thermal and radiation resistance. However, such technologies are too expensive for test launches and studies. In [6], a technology of reusing the first stage and side boosters of the Falcon Heavy launch vehicle is proposed to reduce the cost of a UAV launch mission. It should be noted that such a design-and-technological solution (DTS) has not sufficient practical experience yet, therefore it cannot be unequivocally accepted and should be further studied. To protect the UAV electronics, a titanium protective module is widely used, due to its ability to withstand high levels of radiation – similar one is used in NASA Juno [7]. In [8], the insulation protection of the UAV is achieved using multilayer insulation (MLI), consisting of MLI blankets (MLIB) made of metallized polyimide film (Kapton/Aluminized Mylar). All subsystems used on the UAV are resistant to the radiation environment in low Earth orbit (LEO) and are controlled via a low-latency satellite network, such as Starlink or TDRSS [9]. The DART project [10] showed the world the experience of the failure of a kinetic impact, where the probe has crashed into the 160-meter-diameter asteroid Dimorph and did not destroy or split it, but changed its flight trajectory and reduced the flight speed of Dimorph by 0.4 mm/s instead, and also formed a crater on the surface of the asteroid.

In [11], there are proposed the UKROP unmanned missile complex and a method of orbital and interorbital UAVs launching that is carried out by the reusable Falcon Heavy rocket, which bring two UAVs into the planet orbit. The rocket consists of some structural components, at the first it is an interstage compartment, a beam-truss structure made of polymer composite materials (PCM) – carbon fiber and aluminum foam. In the middle of the rocket main block it is installed a beam-truss structure for hanging the junction unit that holds two UAVs. The main fairings of the rocket second stage are moveable and as they opened the UAVs with folded interchangeable swept wings takes off and deploys its wings, which carry in-built solar panels, radio antennas and batteries to use their additional backup power for photo and video equipment. It should be noted that the DART project [10] is more expensive and more complex compared to the presented UKROP project [11], due to the use of a satellite that launches a probe for a "space ram". The project is extremely ineffective as it's not able to destroy the asteroid completely or radically change its flight trajectory due to the warhead absence and a lack of place for its location. Therefore, the data of the considered works may be used as the basis for creating an "ideal" orbital and interorbital UAV that able to destroy potential asteroid threats, which can harm the Earth and humanity as a whole. In addition, such a UAV may also be used to solve the environmental problem of cleaning the Earth's orbit.

Taking into account the experience gained in the development and operation of orbital and interorbital UAVs, there is a need to improve the DTS of such UAVs by using new non-standard layouts of placing the multifunctional equipment, which provides new opportunities for the further development of missile-unmanned applications for the purpose of asteroid threats destroying.

Analysis of orbital and interorbital UAV with ordnance of shrapnel-trinitrotoluene type

To eliminate potential asteroid threats that could harm the Earth and all of humanity, the authors, based on the analysis of open sources, propose to use the layout of the combat UAV “UKROP” published in [11]. Such a UAV is proposed to be used for strikes with destroying or changing the flight trajectory of medium and small asteroids (up to one kilometer in diameter) heading towards Earth’s orbit. Figure 1 shows the main layout and its DTS.

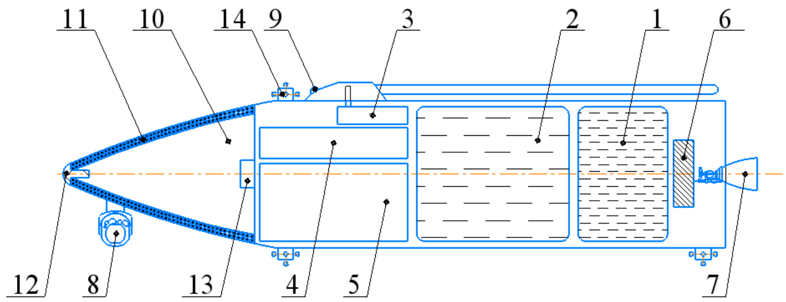

Figure 1 – Layout of combat UAV with ordnance of shrapnel-trinitrotoluene type [12]

A peculiarity of this layout is a shrapnel-trinitrotoluene charge 10 and 11 with a contact detonator 12 in the UAV nose for accurate and complete destruction of the space object. For standby detonation, a radio electric detonator 13 is installed, which will detonate the warhead by radio signal from the Earth or a satellite located at the closest distance to the UAV. It should be noted that system will be individually fitted for each asteroid, so to strike into the deepest central crater of the asteroid. The UAV fuselage has two cylindrical fuel tanks (kerosene 1 and liquid oxygen 2), which are connected by fuel lines to the electric pump 6. The electric pump 6 mixes the liquids according to the stoichiometry of 1 kg of kerosene to 2.56 kg of oxidizer and feeds them into the combustion chambers of the UAV jet engines 7 (Vacuum Merlin 1D), which allows for 451 seconds of continuous operation of three engines – to increase flight speed and perform jet impulse yaw manoeuvres.

The UAV has seven gas rudders 14 with five jet liquid oxygen nozzles on each, which in turn provide excellent opportunities for maneuvering along all the axes of the UAV flight. The on-board computer 4 allows to control, process, receive and transmit commands to all electrical devices of the UAV to create favorable conditions for performing various functions, such as changing the wing sweep by means of two electric motors 3, which are connected by cables, like all other UAV systems, to the on-board computer 4, which in turn is connected to a lithium-ion battery 5 to power all systems and devices of the UAV. Cameras 8 and 9 that connected by cables to the on-board computer are used for visual inspection and operator guidance of the UAV to the deepest craters of the asteroid. The UAV with shrapnel-trinitrotoluene ordnance type (Fig. 1) has a simple, cheap, technologically effective and lightweight layout compared to the UAV in work [11], where it was promised to split the asteroid into small fragments. Among the disadvantages, it can be noted the small force of the explosion, which does not allow the use of such UAVs for splitting/fragmenting the large asteroids of greater than 1 km in diameter.

Orbital and interorbital UAV with ordnance of nuclear type

To solve the problem of splitting/fragmenting an asteroid larger than one kilometer in diameter, the authors propose to use a combat UAV with a nuclear type of ordnance. When comparing nuclear and trinitrotoluene (TNT) ordnance by their damage output, it was found that the scale of destruction of the nuclear one ranges from kilometers to tens of kilometers, while the TNT ranges from meters to hundreds of meters, depending on the size of the charge. That is, the smallest nuclear charge is the orders of magnitude more powerful than the largest conventional bomb. This fact is a key while solving the problem of splitting/fragmenting an asteroid larger than 1 kilometer in diameter. The authors propose to use a DTS of combat UAV with a nuclear charge instead of a shrapnel-trinitrotoluene one. This approach is based on the hypothesis that broken asteroid fragments up to 20 meters in diameter are not a threat to our planet as they burn up completely in the dense layers the Earth's atmosphere – it's confirmed by the results of work [10]. The general layout and DTS of a combat UAV with ordnance of nuclear type are shown in Figure 2.

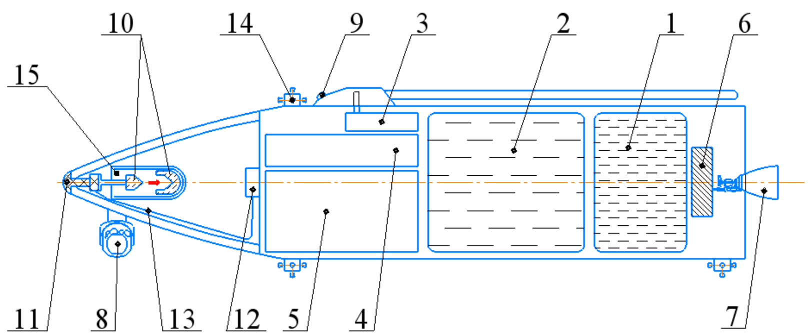

Figure 2 – Layout of combat UAV with ordnance of nuclear type

The charge explosion is carried out by the radio electric detonator 12, which receives a command either from a ground station (radio transmitter), or satellite, or on-board computer 4 and transmits an electric discharge via cable 13 to the detonator 11. The detonator accelerates the first uranium fragment 10 with a charge and crashes into the next uranium fragment of the same type, which resulted in a supercritical mass creation and starts a nuclear fission chain reaction with the enormous energy release in microseconds.

The on-board computer 4 allows to control, process, receive and transmit commands to all electrical devices of the UAV to create favorable conditions for performing the various functions, such as changing the wing sweep by means of two electric motors 3, which are connected by cables, like all other UAV systems, to the on-board computer 4, which in turn is connected to a lithium-ion battery 5 to power all systems and devices of the UAV. Cameras 8 and 9 that connected by cables to the on-board computer are used for visual inspection and operator guidance of the UAV to the deepest craters of the asteroid. The working liquids from two cylindrical fuel tanks (kerosene 1 and liquid oxygen 2), which are connected by fuel lines to the electric pump 6, are mixed according to the stoichiometry of 1 kg of kerosene to 2.56 kg of oxidizer and feeds them into the combustion chambers of the UAV jet engines 7 (Rutherford), which allows for 320 seconds of continuous operation of three engines – to increase flight speed and perform jet impulse yaw manoeuvres. The UAV has seven gas rudders 14 with five jet liquid oxygen nozzles on each, which in turn provide excellent opportunities for maneuvering along all the axes of the UAV flight.

The scheme (Figure 2) allows for the following masses: the first uranium fragment is 26 kg, the second fragment is 38 kg, the detonator is 40 kg, the metal cannon structure 15 for accelerating the uranium fragment is 600 kg. Then the energy of the uranium charge explosion should be 15 kt. Peculiarity of the layout of the combat UAV with a nuclear ordnance of the cannon type is in using the classic uranium bomb with two uranium fragments of uranium-235. The prototype of this ordnance is the uranium bomb "Little Boy", which was used in Hiroshima in 1945 [12].

The disadvantages of this DTS include the fact that such a UCAV layout is very radiation-hazardous, requiring the use of complex high-tech robotic equipment and a large number of experienced specialists in nuclear physics. However, there is an advantage in using the nuclear-charged UCAVs – it is possible to use in them “old” nuclear weapon, which on the Earth must either be kept away from people safely or, as a priority, completely disposed of. That is, the use of such UCAVs will solve the problem of destroying the asteroids that large in diameter (more than one kilometer, but less than 10 km), on one hand, with certain benefits from the disposing of nuclear charges, which shouldn’t be used by humanity on the Earth, on another hand – thus providing protection from an environmental disaster. The further research may be in improving the DTS of nuclear-charged UCAVs, as well as in developing the appropriate technical documentation for its manufacture.

Summary and Conclusions

An analysis of existing DTSs was performed and peculiarities of the orbital UAVs were identified. The general DTS of UCAV with shrapnel-trinitrotoluene ordnance was presented. A structural layout of orbital and interorbital UCAVs with a nuclear type of ordnance, which based on the existing UCAV with shrapnel-trinitrotoluene charge, was proposed. The disadvantages and advantages of such UCAVs were indicated. It was found that the use of UCAVs with a nuclear ordnance allows not only the disposal of asteroids larger than one kilometer in diameter, but also to utilise the nuclear materials, instead of their storaging as garbage on the Earth, thereby ensuring environmental safety for humanity and the planet as a whole.

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FLAT HOT-PRESSING TECHNOLOGY FOR THE PRODUCTION OF WOOD PLASTIC COMPOSITE

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Abstract. *Wood plastic composites (WPCs) are advanced and promising materials that combine the advantageous properties of both wood and polymers. They are characterized by excellent performance, including high mechanical strength, dimensional stability, resistance to moisture and biological degradation, and improved durability under variable environmental conditions. The possibility of utilizing recycled raw materials such as wood waste and thermoplastic polymers in WPCs is also considered an environmentally sustainable alternative to conventional wood-based panels. WPCs can be manufactured using a variety of processes, including extrusion, injection molding, and compression molding, depending on the intended geometry and application of the final product. WPCs are usually made by extrusion. This method allows for the production of products with unlimited length and a small cross-section. However, it is unsuitable for the manufacturing of large flat composite boards. Flat pressing is a promising method for making WPC boards. However, this method is still underdeveloped in WPCs production and requires further research.*

Key words: *wood plastic composites, flat pressing, polymer, wood particles.*

Introduction

In view of the global awareness of environmental challenges and the need to reduce waste accumulation as well as harmful emissions, the wood-based composite materials industry is increasingly implementing more environmentally friendly and sustainable alternatives. One effective approach of addressing these issues is the production of wood plastic materials (WPCs) based on the utilization of recycled polymers and wood residues, which complies with the principles of the circular economy and is regarded as an environmentally safe technology [1-3]. Flat hot pressing is one of the most efficient methods for manufacturing WPCs. The main advantages of this method include the possibility of using wood fillers of various particle size fractions, which enables optimization of the internal structure and