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SPACE DEBRIS AND THE MAINTENANCE OF SECURITY IN THE ORBITAL SPACE

Abstract. The paper presents the problems of human made space waste and discusses the threats they generate. The major hazards of this group of waste are collisions and the emission of chemical pollutants from radioisotope systems used to power artificial satellites and space missions. Activities that enhance the level of security in the Earth's orbital space and the legal aspects of space development are also analyzed.
Keywords: space debris, radioisotope power systems, space law

ANTROPOGENICZNE ODPADY KOSMICZNE A ZACHOWANIE BEZPIECZEŃSTWA W PRZESTRZENI ORBITALNEJ

Streszczenie: W pracy przedstawiono problematykę odpadów kosmicznych wytworzonych przez człowieka oraz omówiono generowane przez nie zagrożenia. Do głównych niebezpieczeństw ze strony tej grupy odpadów zalicza się kolizje oraz emisję zanieczyszczeń chemicznych pochodzących z systemów radioizotopowych wykorzystywanych do zasilania sztucznych satelitów i misji kosmicznych. Przeanalizowane zostały także działania wzmacniające poziom bezpieczeństwa w przestrzeni orbitalnej Ziemi oraz aspekty prawne związane z zagospodarowaniem przestrzeni kosmicznej.
Słowa kluczowe: odpady kosmiczne, radioizotopowe systemy zasilania, prawo kosmiczne.

Introduction

Exploration of orbital space was the result of technical progress and the result of the space race associated with political rivalry. The United States of America and the former Soviet Union are the most important states in the initial phase of space conquest. You can list some spectacular events in the history of gaining advantage in the near Earth space. They include the launch of the artificial satellite Sputnik 1 in 1957, the human space flight aboard the spacecraft Vostok 1 in 1961, or the landing of the Apollo 11 mission on the Moon in 1969. Scientific progress and the use of modern technologies have contributed to the speedier development of space. Analyzing the last decade, it can be noticed the success of space development in many countries. They invest in projects involving the use of orbital space, using modern artificial satellites (telecommunication, telephone, television, meteorological, remote sensing[1]) or conducting advanced research in the International Space Station (ISS). Recent years also abound in progressive missions to explore further space and celestial bodies (Juno Mission to Jupiter, Cassini Mission at Saturn, Mars Science Mission (Mars Science Laboratory – the official name of the Curiosity rover).

The use of space is associated with various dangers. Types of dangers in space can be divided into several categories. The presence of man in space due to conditions different from the Earth is a threat to his life and health. The danger may be associated with use of outer space for a variety of purposes (e. g. research, economic, or military). However, more problems appears in connection with pollution of outer space waste. In the further part of this work will be analyzed the risks and dangers associated with the problem of an increasing quantities of waste of anthropogenic origin in orbital space, and the activties taken in order to reduce these threats.

Types of waste in space and the hazards associated with them

Orbital waste of natural origin

Orbital waste have different sources. Some of them are natural objects, while the others are artificial made by man. Wastes of natural origin are called meteroids. As defined by NASA, the meteroid is a small piece of rock or iron moving in Space [1].

[1] Remote sensing means observation for remote testing of the Earth and its surrounding, using a device located in artificial satellites. Source: A. Górbiel, *Międzynarodowe prawo kosmiczne*, PWN Warszawa 1985, p. 63.

Spectacular phenomenon observed by us from the Earth, giving the effect of „shooting stars", is a phenomenon of meteors. The speed of the meteor relative to an observer on the ground is made up of the orbital speed of the meteor and Earth. The Earth moves on the orbit at a speed of 30 km/s. Meteor moving on the parabolic orbit near Earth reaches speed of 42 km/s. Lump of such material getting into the atmosphere suffers great pressure of shock wave of air, even hundreds of kg/cm^2, with the result that easily falls apart and evaporates. In the case of large lumps their weight may not dry off and during reducing the speed, the rest of the lump can fall to the ground. The lumps of such matter are called meteorites [2].

The fall of the meteorite on Earth is associated with a shockwave of air and is a big danger for humans and other life forms. There are many examples of the falls of meteorites in different parts of the Earth, leaving depressions and craters of various depths and causing the surrounding destructions.

The chemical composition of meteorites is not a danger to the health and life of humans and the natural environment. It is similar to the composition of the Earth's crust. On the waste of natural origin we have little effect, besides their monitoring.

Space waste generated by human

Much more problematic are the waste of artificial origin, made by man from his business and activity in space. In International naming this type of waste is specified as: „space debris" or „space junk". According to NASA it is circling Earth. It is pieces from spacecraft and launched objects. These objects either land or burn up in the atmosphere. But many of the objects sent into space are still in orbit around the Earth [3].

The weight of space debris is from a few grams to several tons, and their size from a few millimeters to tens of meters. These wastes are from about 100 to more than 36 000 km above the Earth's surface [4]. Part of this waste burns up in the atmosphere or falls to the ground – most often to the water of the seas and oceans. However, many of them remains in orbit. Danger primarily is concerned with space debris collisions with other objects moving in orbits, such as for example: active satellites, or the International Space Station (ISS).

In addition, there are known collisions of space debris from each other. This causes their disintegration into smaller pieces and increases the number of collisions. This phenomenon is called the Kessler syndrome. The name comes from the name of a scientist who was dealing with the problem of space debris during the 1970s (the 20th century) working for NASA.

Increase waste in space (produced by man) is disturbing. Currently in the year 2017 according to data catalog'ed and published by NASA (as of 4 April 2017), in the orbital space is 18347 objects. It includes 4434 objects put in or-

bits named payloads – having the status of active objects. Remaining number 13913 includes space rocket bodies and debris [5]. The catalogued space waste have size at least 10 cm.

Comparing the number of cataloged objects put in orbits in 1997 (as of 1 January 1997) you will see a significant difference. There were the 2302 objects placed in orbits. Cataloged space waste and rocket parts were 6205 pieces. A total of 1997 was 8507 all objects cataloged by the U. S. Space Command [6]. Between 1997 – 2017 came 9840 objects (in total) in orbits. The number of cataloged objects (in total) increased in this period by 116%. While the space waste in 2017 compared with 1997 increased by 7708, that is 124%.

The number of space debris will grow in the coming years, but the problem is finding the right methods of their minimization. So far has not yet implemented any optimal methods of safe deorbitation including greater amount of space waste.

The use of radioisotope power systems in space and the dangers associated with them

Besides the collision in space and waste decay into the next smaller fragments, posing threats, the danger is also a nuclear power comes from them. Objects with equipment for space exploration need sources of energy. In outer space can be used two sources of energy. These include solar and thermal energy of nuclear transformation.

Some of the missions are using only solar power, to some however, nuclear energy is need. The radioisotope technology electrical systems was used in the initial phase of space exploration. The isotopes are varieties of the same chemical element with a different number of neutrons. Isotopes have the same chemical properties (small derogations from this regularity show hydrogen isotopes) however, they differ slightly in their physical properties [7]. Radioisotopes are radioactive isotopes of elements whose nuclei are spontaneously transformed [8]. This technology involves converting heat during decay of isotopes.

Radioisotope Power Systems have been used for space research for more than 50 years. Their use has enabled many missions, discoveries and reaching distant places in our solar system. Thanks to these systems was managed to conduct Moon research, observe geysers and volcanoes on Saturn's moons, and conduct many long missions conducted by NASA [9].

There are many positive aspects of using this kind of energy from the Radioisotope Thermoelectric Generator (RTG) both on Earth and in space. But on the other hand there are also dangers associated with its use. Energy acquisition that is the drive for artificial space objects is possible through the use of the radioactive element – the platoon. Because of the radioactivity it is dangerous for the health and life of organisms. Its salts are strong poisons. They cause

damage the bone marrow, liver and lymph nodes. The metal is also used to build nuclear weapons and is used in nuclear reactors as a source of energy [8].

Another element that is used to generate energy in reactors of satellites and research probes is radioactive uranium. Inactive satellites pointing in the direction to the Earth are constructed in such a way to get rid of radioactive substances to a higher orbit, so as not to cause the terrestrial environment contamination. This is one of the easiest ways of taking care of the cleanliness of the orbital space. However, there are examples of uncontrolled space waste collisions with the Earth and radioactive outlets derived from these objects (the failure of the satellite Cosmos 954 and irradiation of the space above Canada, waste from the satellite Kosmos 1402 and 1220, the Mission of Apollo 13). For the detection of radioactive contamination are used an American aircraft type WC – 135 Constant Phoenix.

NASA pays great attention to preserve the highest level of safety in the areas of use radioisotopes. Safety is taken into account at the stage design, as well as research, production and operation of nuclear systems. Security features that minimize the risk of dispersion of nuclear material during the collision are also analyzed and implemented.

Monitoring of space debris

To increase the level of security in space, it is important to monitor the waste in orbital space. By defining the position of the object of the group of the space waste, the calculation its speed and distance, it is possible to do maneuvers. This allows you to reduce the risk of collision. Radar techniques are commonly used for this type of action. The European system of detecting and tracking objects in space has been approved by the European Union as the EU SST (Space Surveillance and Tracking Framework Support, Decision of 16 April 2014, No 541\/2014\/EU of the European Parliament and of the Council). Because it is an European programme – it concerns the protection of European Union's objects in space. In particular, is to prevent collisions between satellites with space waste and other objects.

In turn, cataloging of orbiting objects is handled by the US Satellite Catalog (USSC). This catalogue takes into account all artificial satellites and other objects of anthropogenic origin, including those that have returned to Earth's atmosphere, or have visited the celestial bodies since 1957.

The selected astronautic organizations and legal regulations on the use of outer space and the preservation its safety

In the world are governmental and non – governmental organizations which carry out research in space, ensure safety in this area, cooperate in Astronautical development, implement space programs, and carry out the missions.

One of the oldest organization is International Astronautical Federation – IAF. It was established in 1952 at the 3 rd International Congress of Aerospace in Stuttgart. In its assumptions an organization strives to development and application of astronautics, deals with the promotion of issues related to the peaceful use of outer space and technical knowledge through the organization of symposia and scientific conferences.

The organization brings together 48 member countries and 200 astronautical organizations (including the Polish Astronautical Association), institutions and companies in the field of astronautics (including aerospace companies). In 1960 IAF established the International Academy of Astronautics (IAA) and the International Institute of Space Law (IISL), which was one of the first space regulatory initiatives[10].

The International Academy of Astronautics is an International organization working in the International Astronautical Federation. This organization also conducts space research and undertakes activities for their development. Among the research areas is the space economics research, its application and the problem of security in space.

Another rapidly growing International organization is the European Space Agency (ESA) the idea of the creation of the Agency was the signing of two conventions:

- Convention on the establishment of The European Space Research Organisation on 14 June 1962
- Convention on the establishment of The European Organization for the Development and Construction of Space Vehicle Launchers on March 29, 1962

The aim of the European Space Agency is the realization of a joint European research programme and use of outer space. The Agency also supports the development of a modern and competitive industry in the Member States. According to data from ESA in 2017 members of this organization are following Member States: Austria, Belgium, Czech Republic, Denmark, Estonia, Finland, France, Greece, Spain, Ireland, Luxembourg, the Netherlands, Germany, Norway, Poland (November 2012), Portugal, Romania, Switzerland, Sweden, United Kingdom, Hungary and Italy. On the basis of a separate agreement, Canada is also involved in the work of the ESA. European Space Agency branches are

located in different Member States and each of them deals with the actions at different levels:

- The European Astronaut Centre (EAC) in Cologne, Germany;
- The European Space Astronomy (ESAC) in Villanueva de la Canada, Madrid, Spain;
- The European Space Operations Centre (ESOC) in Darmstadt, Germany;
- The ESA Centre for Earth Observation (ESRIN) in Frascati, Italy;
- The European Space Research and Technology Centre (ESTEC) in Noordwijk, the Netherlands;
- The European Centre for Space Applications and Telecommunications (ECSAT) in Harwell, Oxfordshire in the United Kingdom [11]

In Poland from 2012 works branch of the European Space Agency named Polish Space Agency. In addition, in Poland operates Aerospace Employers Association (ZPSK) from October 31, 2012. It is an Association of more than 45 Polish enterprises as well as research institutions operating in the space sector.

Committee on the Peaceful Uses of Outer Space deals with legal aspects. It was founded in 1959 by The Resolution 1472 (XIV) of the Assembly of the United Nations of 12 December [12].

The basis of legal regulations in the area of outer space is The Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space including the Moon and other Celestial Bodies, opened for signature on 27 January 1967, also known as the Treaty on Outer Space. It was established in the framework of the negotiations of the United Nations and signed by the representatives of the Governments of the United States, Great Britain and the former Soviet Union. The Treaty became final on October 10, 1967.

On the issue of responsibility the key is the article VI of the Treaty. It specifies the international responsibility for the activities in outer space. It is not important whether this activity is carried by the governmental or non – governmental organizations. One of the most important issues raised and sanctioned in the Treaty is the freedom of access to space outside the atmosphere and within the celestial bodies. In addition, freedom applies to both: the research and use of outer space [13].

However, the use of the space can be used peaceful purposes only and it is prohibited to place in orbit any objects with nuclear or any other kind of weapons of mass destruction, it is prohibited to install such weapons on celestial bodies or placing such weapons in outer space in any other manner. Says about this Article IV of The Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space including the Moon and other Celestial Bodies, signed on 27 January 1967.

The liability for the damage caused by space objects sent into space has already been discussed in the mentioned Treaty. In article VII is a mention of

the international liability for damage caused by the object or its part to another State in airspace, space and on the ground.

International agreements also regulate Space law. Regulations which are the key importance include:

- United Nations Declaration on International Cooperation in the Exploration and Use of Outer Space for the Benefit and in the Interest of All States, Taking into Particular Account the Needs of Developing Countries, United Nations Resolution 51/122 of 13 December 1996;
- Agreement Governing the Activities of States on the Moon and Other Celestial Bodies, United Nations Resolution 34/68 of 18 December 1979;
- The Convention on registration of objects launched into outer space of January 14, 1975 Dz.U. 1979 nr 5 poz. 22;
- The Convention on International Liability for Damage Caused by Space Objects of 29 March 1972, Dz.U. 1973 nr 27 poz. 154;
- Declaration of Legal Principles Governing the Activities of States in the Exploration and Use of Outer Space, United Nations Resolution 1962 (XVIII) of 13 December 1963.

Conclusions

In connection with space exploration started in the 50s of the 20th century, space was increasingly political and economic important. The most attractive was the geostationary orbit, on which were placed the astronaut equipment, fulfilling useful functions (telecommunication, telephone, TV, weather, remote sensing). As time goes by, on the orbits the artificial satellites still arrive and their operation is limited. This causes continuous enlargement of space debris population, which are the sources of variety of threats. These threats are connected with the risk of collisions with other objects, the risk of falling on Earth, and emissions from radioisotope systems. Therefore preventive measures are needed to minimize hazards. Since space has become increasingly important for human activity, appropriate institutions have been created and also legal regulations on the use of space and celestial bodies have been introduced. The facilitating systems for precise tracking of objects to prevent possible collisions, have also been created. However, the major problem in the near future will be the increasing number of space waste of anthropogenic origin and the search for effective methods of their deorbitation.

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