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The Problems of Outer Space Pollution

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Abstract: Since the inception of the Space Age emerged an unprecedented technological, economic, military and social development for the humanity, although brought inevitable negative consequences due to the early exploration of space. A side effect of this development is pollution in space that has been increasing over the years. In general, the term pollution is used to indicate a despoiling of the natural environment. This term applies equally when it comes to space from the moment the first artificial satellite was launched into Earth's orbit, and is known as Space Debris. This article contains the concept of «space debris» and statistical data techno-genic pollution of outer space, and describes the possible methods of dealing with space debris and justifies the need for international cooperation to solve outer space pollution problem.
Keywords: Space debris, Pollutions of outer space, Space low.

1. Introduction

The Space Debris encompasses both natural micrometeoroid and artificial particles (man-made orbital debris). Meteoroids are in orbit around the sun, while most artificial debris is in orbit around the Earth. Besides the location, there is a significant difference between natural and artificial debris that is the length of time that they remain in Near-Earth space, which will depend on orbital velocity and the altitude. For natural debris, such meteoroids appear unanticipated from the deepness of space and quickly pass through Near-Earth space and most will burn up in the lower atmosphere or, in unusual cases fragments reach the surface of Earth. On the other hand, artificial Man-made Orbital Debris (MOD) are launched from Earth into orbit, and the length of time that they remain can be thousands or even millions of years which represents danger for active spacecraft and satellite vehicles.

A resent investigation shows the statistics of the total number of MODs that still remain in space and are listed by the automatic warning system for dangerous situations in near-Earth space until August 31,2015 listing a total of 17,250 objects. Of this amount 1,362 space objects are active spacecraft and satellites, while [1]. 15,888 are man-made space debris (MSD), which represents a 92% of the total number of MODs in Near-Earth space. These man-made space debris include: 2682 non-active spacecrafts, 1907 upper-stage rockets and final stage vehicles, and 11,299 fragments of spacecraft, upper-stage rockets, final stage vehicles and other elements. [2]. Other data provided by the National Aeronautics and Space Administration (NASA) shows that there are more than 20,000 pieces of debris larger than a softballs orbiting the Earth. They travel at speeds up to 17,500 mph, fast enough for a relatively small piece of orbital debris to damage a satellite or a spacecraft, and there are 500,000 pieces of debris which size of a marble or larger, as well as millions of pieces of debris that are so small they can't be tracked [3].

The location and the amount concerning man-made space debris is highly relevant considering the main danger that brings space debris, "Kessler syndrome" named after the NASA scientist who brought attention to the runaway space junk problem in 1978 [4]. This consists in a collision cascade effect that creates a chain reaction caused by an increasing number of space debris collision in Near-Earth space. This paper reviews the transition of space debris problem from being passive to aggressive and the development of technologies that contribute to the solution of this global problem.

2. Space Security and Space Debris terms

The primacy in the space sphere as dawn of the space age, and now means for state domination not only in the space, but also throughout the world. Therefore, successful participation in the exploration of outer space has a strategic importance for modern states. The result of the realization of this fact was the resumption of in the XXI century struggle for control over the pace that led to the beginning of the "second space race".

Along with the opportunities that give practical space exploration, there appeared a new problem in the sphere of global security and increasing its dependence on reliable work of space infrastructure. The cessation of

the functioning of space information systems can lead to the escalation of the conflicts. One of the main problems is the clogging outer space that creates threats not only for the existence and effective operation of space vehicles, but also affects development and security various spheres of life of the states and society, including the provision of space and, in turn, national and global security.

Today under space security understand not only the ability of one state to have military superiority in space before another, but also above all "the ability of state to control part of the cosmic space and carry out a certain activity without being subject to external pressure, threats or attack from the parties of opponents " [4]. Very important to notice that today the threat of space security no longer solely from hostile subjects and natural disturbances, but an increasing threat from pollution of outer space.

In international law there is no definition the concept of "space debris". In the legal literature there is the following definition: "This kind of pollution includes any artificial objects in orbit around Earth, which are non-functional and in respect of which one can not expect a start or the renewal of their intended functioning, which is authorized in the future, including fragments and parts thereof. Space debris Includes inactive spacecraft, used parts of missiles, material of formations as a result of planned space operations, fragments formed satellites and upper levels as a result of explosion or collision, as well as containing on board dangerous (nuclear, toxic, etc.) materials "[3, c. 119].

We suggested the following definition: "*The artificial debris (or Space Pollution) is considerate any object send by the man which no longer serves a useful function; like inactive satellites, nonfunctional spacecraft, abandoned launch vehicle stages, mission-related debris and fragmentation debris*."

In addition to the threats that space debris be directly implemented space activities, there is a danger of uncontrolled descent from orbit, incomplete combustion during the passage of the atmosphere and the fall on the surface of the Earth.

The term "space debris" is used for all artificial objects and their small fragments in outer space, which will never function again and, can serve no useful purpose, but which are a dangerous functioning spacecraft.

The problem of pollution of near-Earth space by "space debris" it theoretically appeared immediately after the launch of the first artificial earth satellites in the 50-ies of the XX century. The international level received official status only after the fact, as the Secretary-General of the United Nations, on 10 December 1993, gave a presentation on the theme "Space environmental activities ", in which he indicated the international and global he pattern of clogging of the outer space of the Earth with various wastes.

3. Statistics of Space Debris

In 2014, according to experts, near-Earth space has more than 200 thousand objects larger than 1 cm and over 330 million objects larger than 1 mm in size more than 5 000 tons. Only about 10% of them were detected, tracked and entered into catalogs with using ground-based radar and optical means. For example, in 2013, the US military command contained 16,600 objects (mostly larger than 10 cm) [3], and Russian catalog contained 15,800 objects of "space debris" in August 2014 [4]. All these objects were formed from launch in orbit Spacecrafts. Total amount of launched spacecraft and launch failure are shown in Figure1.

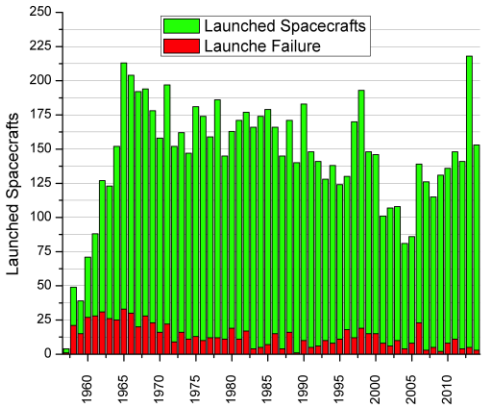

Figure 1: Total Launched Space crafts and Launch Failure (1957 - 2015)

We can see a trend of the process of launching spacecrafts to the orbit is going with high intensity. But from 1990-th to 2004-th intensity was decreasing mostly because of political situation in Soviet Union and Russian Federation. Russia still holding leading positions in space exploration: we can see it from plots on Figure 2, showing success-launched spacecraft total and by countries (Figure 2).

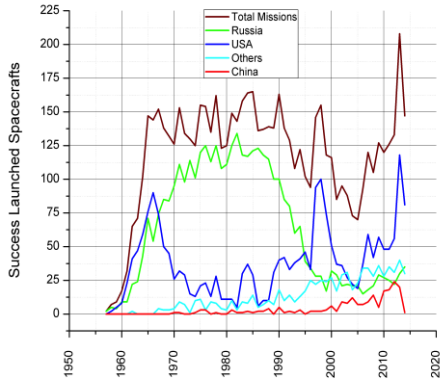

Figure 2: Success launched spacecrafts by countries (Russia, USA, Others and China) and total (1957 - 2015)

The total number of spacecraft Launched in this period is 8,593. Number of Russian spacecraft is 3,743; number of USA spacecraft – 2,022; number of other governments (Europe, Japan, China, Canada, India and others) spacecraft is 1,162. Among them, the number of Civilian Spacecraft is 4,519, and Military spacecraft – 4,074. In Civilian Programs the number of Piloted Spaceships (+35 military) is 610; number of Planetary Probes is 248; number of Communication Satellites is 1,381; and number of Meteorology Satellites is 241. Some of mentioned statistical information presented on Figure 3.

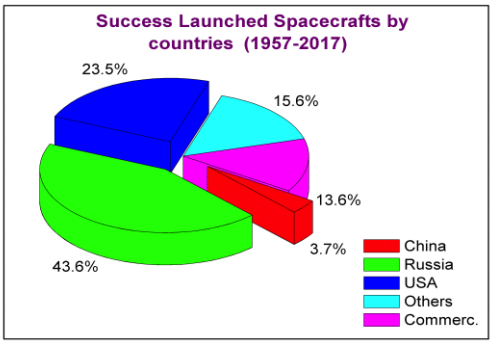

Figure 3: Success launched spacecraft by countries (Russia, USA, Others and China)

According to some estimates, the contribution to the creation of "space debris" by country is following: China - 40%; the USA - 27,5%; Russia - 25.5%; other countries - 7% [5]. According to other estimates (for 2014): Russia -39.7%; The United States - 28.9%; China - 22.8% [6].

Our estimation of contribution Russia, USA, China, and other countries to the "forming" of space pollution presented on Figure 4.

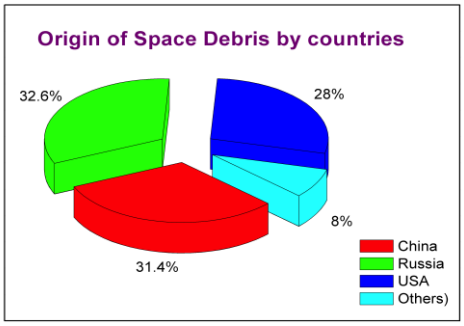

Figure 4: Origin of Space Debris by countries (Russia, USA, Others and China)

It is important to notice that when we speak about the amount of Space Debris we are dealing with approximate number, but the top three leaders are Russia, USA and China, and the growth of space junk is the most serious in the last few years.

4. Problems of anthropogenic pollution of Space

Existing intensity of investigation the space and an increase in the number of participants in space activities contribute to a significant increase quantity of Space Pollution. Explosions of waste space vehicles and an increase in the number of particles from accidental collisions of large Space objects can lead to the effect of cascading from collisions.

While increasing the rate of pollution, the use of some altitudes will be complicated or will be completely impossible. So, because of the space pollution, in the future, it will not be possible to use geostationary orbit where located space vehicles for various purposes - from communication satellites to systems of early warning of a missile attack. Also is polluting the area of low Earth circular orbits with an altitude of up to 2 thousand km, on which orbital grouping of space vehicles of various purpose and programs are being implemented for manned space flight and in the long term it is planned to organize works on the assembly of interplanetary space complexes.

In addition, increasing the probability of termination functioning of existing spacecraft and the threat to safety launching new ones. It should be noted that the damage can made by debris particles up to 1 cm large, and avoid this type of collision practically is impossible due to lack of technology tracking particles of a given size.

Thus, in 1991, in order to avoid a collision with remnants of the Soviet satellite Kosmos-955, the US Shuttle had to make a series of maneuvers. In 1996 a fragment of the third stage of the French rocket "Ariane-4" disabled French satellite "Cerise". International Space Station has repeatedly adjusted the orbit to avoid collision with Space Debris. And in 2009, the US commercial satellite collided with a non-functioning Russian military communications satellite "Cosmos-2251" [9].

Serious consequences can have cases fall of large space objects on Earth, in areas of large concentrations of people and on the territory of hazardous industrial facilities.

According to experts, in 40-50 years humanity will face the so-called "Debris rain" – unauthorized space debris, some of which because of its size can not completely burn out when passing through dense layers of the atmosphere, from orbits to the Earth.

All this affects not only the provision of interests of national security of the states, but also to ensure global security generally, and it leads humanity to understand the need to solve this problem. However, this is possible only with joint efforts of the entire world community. The realities are such that in view of many factors (scientific, technical, legal and financial) no one countrie cannot solve this problem by oneself. At the international level, work on this problem is mainly going in the two structures - Scientific and Technical Subcommittee of the Committee The United Nations Space Agency and the Inter-Agency Committee on Space Debris.

In addition, countries such as Russia, the United States, Japan, and the European Union have its near-Earth monitoring systems space for observation, cataloging and analysis of environmental conditions and prevention collisions in space. Each system uses various methods of monitoring and exchanges data with others, which allows more quickly and efficiently collision avoidance measures operating spacecraft with space debris. For example, Russia is using complex, aimed at scanning the space with the help of telescopes, and the European Space Agency for the same purpose uses radar. One of the first the United States (NASA) drew attention to the problem of anthropogenic pollution of near-Earth space and took it very seriously. The system of control of outer space in the United States provides information to government and other institutions, which allows this system to actively develop and improve, and be equipped with large optical telescopes. For example, the space observation complex on the island of Maui (Hawaii) has telescopes with mirror diameters of 1.2 and 1.6 m, with very high permeability.

Since the problem of "space debris" affects the interests of all countries involved in space exploration, its solution needs an international legal basis and close cooperation. For the adoption of agreements in this area, it is important to recognize importance of the problem by all global community.

5. Solutions of the problems anthropogenic pollution of Space

Existing tools to reduce intensity of techno-genic pollution of space can be divided into two categories:

- tools to protect from exposure space debris (avoidance of collision);
- ways to exclude the formation of space debris (de-orbitation – tools aimed to eliminate spent space devices and orbital stages of carrier rockets after completion of flight programs).

UN have repeatedly presented a number of opportunities to solve the problem of space pollution, for example,

Guidelines have been developed principles of the Committee on the Use of Space for peaceful purposes to prevent the formation of space debris [10], but they are not legally binding, and their implementation depends solely on good will of this or that state.

To continue of the earlier work in this direction within the UN and other organizations there is a system of control measures activities on this issue, which includes the following areas:

- Adoption of national standards, defining prevention requirements of space debris generation;
- Adoption of international treaty documents aimed at limiting forming space debris;
- Adoption of international standards defining requirements for space assets for the Prevention of Space debris;
- Licensing of development organizations and operators of space-rocket products based on developed international standards in space debris;
- Ousting from the international markets of the rocket-space technology manufacturers and operators that do not provide implementation requirements of international antipollution standards;
- Development and implementation of "road rules" movement in space "(rules of management a movement in space) [9].

In addition, in order to prevent intentional formation of space debris should also "prevent further testing and deployment of space weapons basing and weapons designed for use against objects from space " [11].

An example of how much testing any anti-satellite weapon systems in space can pollute it and how they can lead to the emergence of an international tensions, serve the actions of China to destroy its satellite with anti-satellite missile in 2007, as well as a response from the US to destroy his spy satellite. As a result of these actions, not only did a new tension arise in US-China relations, but and several thousand new dangerous debris [12].

Russia also pays much attention to solution of this problem in the direction prevention of space pollution. In particular, there is a first stage automated warning system about dangerous situations in the near-earth outer space [9]. In addition, the international level is going active movement to prevent militarization space, the achievement of successes in which will positive contribution to prevention pollution of near-Earth space.

In the way to treat existing Space pollution the question becomes more urgent for the certain areas of space. "Such operations may be implemented using detection technology, approach, docking and withdrawal dangerous objects from the zone of working orbits to zone of burial "[9]. But the implementation of this project due to various factors in the technical and financial, by only one state is impossible. The results on the solving the problem of space debris can only be achieved through effective international cooperation of all states.

The solution of this problem is complicated by lack of definition in international law the category of “space debris”, as well as the fact that existing international documents in the field of space exploration do not have clear legal solutions applied to the space debris, including in the part of international responsibility for the damage caused by them.

Therefore, first of all, it is necessary to develop and legally bind to the international concept of space debris, and also conclude a series of legally binding international agreements on joint work to prevent pollution and clean of near-earth space.

Priority areas of international cooperation in this area are:

- Monitoring of near-Earth space.
- Mathematical modeling of "space debris" for forecasting the debris’ flow near-Earth space.
- Development of methods for protecting space vehicles from the impact of high-speed particles of "space debris".
- Development and implementation of measures aimed at reducing the pollution of the near Earth space.

The problem of "space debris" requires states join for the international cooperation on these issues. Space debris creates a real threat to the space objects and for new launches. Obviously, these problems can be solved only through the efforts of the entire world community through the cooperation of space powers. Cosmo-space is a unique resource, and its operation must be carried out in the interests of all countries. Because of the huge financial costs, no one single state able to solve the problem of clearing outer space from anthropogenic pollution.

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