

Features of the Activities of Public Entities in Space Debris Mitigation

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The article investigates the features of the activities of public entities in space debris mitigation. In order to simulate the consequences and develop adequate measures to mitigate space debris, it is necessary to create and analyze databases on space debris, and develop the systems of preventing collisions with the space debris. The commercialization of space affects the development of a system of entities dealing with mitigation of space debris, which can be divided into two groups: public and private entities. However, in our study, we pay attention to the first group of entities acting in the field of space debris mitigation, namely public entities, which can also be divided into two subgroups: international organizations and national space agencies. The further solution of the global space debris problem requires the harmonization of existing and the creation of new rules for the proper functioning of both public and private space debris mitigation actors. After all, only the joint activities of which, when carried out in a coordinated, logical and systematic way, will be able to lead to the desired results — reducing the existing and preventing the creation of new space debris in the future.

Keywords: space debris, public entities, international organizations, space agencies, mitigation, prevention, space activities, space

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Introduction

The conduct of space research and the actual development of the space age, with or without intent, leads to an increase in space debris. By its origin, space debris is divided into natural (remnants of space bodies) or artificial (orbital debris created as a result of the destruction of satellites, spacecraft, remnants of the activities of astronauts). However, both natural and artificial, space debris is located around Earth and is equally a global threat, both for further space exploration and for the life of our planet.

All countries should make every effort to jointly solve the problem of space debris. Now, some entities of international law and public entities in individual states are conducting research activities to solve the problem of space debris. However, the system of public entities of counteraction of space debris is not holistic, which does not allow for proper coordination and cooperation in this area.

That is, in order to simulate the consequences of space debris, analyze the database on space debris, create systems to counteract collisions with space debris, further solve the global problem of space debris, it is necessary to create all conditions for the proper functioning of public entities of counteraction to space debris, whose joint activities should be coordinated, logical and systematic.

Space debris is the unintended result of more than six decades of space travel, and is largely the result of disruptions, explosions or collisions of some 8,950 satellites that have been sent into orbit since 1957. Today, the European space Agency estimates that more than 900,000 objects of debris, more than 1 cm, are in orbit, which could have any impact on a functioning satellite and cause damage or a potential threat to the end of its mission [Space Debris European Space Agency, 2019]. In doing so, space debris around Earth's orbit travels at 17,500 mph, which is enough for a small piece to damage a satellite or spacecraft. The increasing amount of space debris increases the potential danger to all spacecraft, but especially to the International space station, satellites, spacecraft with people on Board [Space, 2017].

The destruction of individual satellites or the loss of specific orbits due to uncontrolled growth of debris, will have a devastating impact on the world economy in space. Today, global satellite operators spend 14 million euros annually on maneuvers to avoid debris, but over 99% are false alerts. However, in recent years, the commercialization of space has increased, which also means the mass launch of both small satellites and large satellites, carried out with new players in the private sector. This will generate several hundred thousand space debris collision warnings [Space, 2019b].

The commercialization of space also affects the development of a system of entities of counteraction to space debris, which can be divided into two groups: public and private entities. But in our study, we will pay attention to the first group of entities of counteraction to space debris, namely public ones, which can also be divided into two subgroups: international organizations and space agencies of individual states.

Organizational and legal support for the activities of international organizations to combat space debris

With regard to international organizations, the United Nations, which is by its nature global, is the largest in terms of distribution. The Committee on the Peaceful Uses of Outer Space (COPUOS) was established by the UN General Assembly in 1959. COPUOS functions to manage the exploration and use of space for the benefit of all mankind: for the sake of peace, security and development. The Committee was mandated to review international cooperation in the peaceful uses of outer space, to examine the space activities that The United Nations could carry out, to promote space research programmes, and to study the legal problems arising from space exploration. COPUOS contributed to the creation of the five treaties and the five principles of space activities. International cooperation in space exploration and the use of space technology to achieve global development goals are discussed at COPUOS annually. Due to the rapid progress of space technology, the space program is constantly changing, so the Committee provides a unique platform at the global level to monitor and discuss these events [Committee, 2019].

COPUOS has two subsidiary bodies, a Scientific and technical subcommittee and a Legal subcommittee, which focus on the prevention and minimization of space debris.

Each year, states and organizations exchange information about their research in the Scientific and technical subcommittee of COPUOS. One important outcome of these discussions was the set of space debris mitigation Guidelines that were approved by the General Assembly in 2007 [Space, 2019c].

The guidelines reflect existing practices that have been developed by a number of national and international organizations. From a technical point of view, the guidelines apply to mission planning and operation of new spacecraft and orbital stages and, if possible, to existing ones.

There is a total of seven guidelines: a) to limit debris released during nominal [spacecraft / orbital stages] operations, b) to minimize the potential for break-ups during operational phases, c) to limit the probability of accidental collision in orbit, d) to avoid intentional destruction and other harmful activities, e) to minimize the potential for postmission break-ups resulting from stored energy, and f) / g) to limit the long-term presence of spacecraft and launch vehicle orbital stages in the low-Earth orbit (LEO) region / geosynchronous Earth orbit (GEO) region after the end of their mission [Space, 2019a].

In addition to scientific research, international legal aspects of space debris mitigation measures are discussed by the Legal Subcommittee [Space, 2019c]. To help counteraction to space debris, COPUOS compiled a compendium of standards that developed legal mechanisms related to space debris mitigation measures. The purpose of the compendium is to inform states about the existing instruments and measures that have been implemented by states and international organizations in the field of counteraction to space debris [Compendium, 2019].

That is, the UN as an international global organization deals with counteraction to space debris by supporting the functioning of COPUOS, which very effectively carries out counteraction to space debris by means of coordination of international cooperation, space exploration, the creation of space research programs that focus on the destruction of space debris, as well as the formation of basic principles as for the planning of space missions to prevent the creation of space debris.

The next entity that can be attributed to the international organizations countering space debris is the European Space Agency (ESA).

Under its space safety activities, ESA aims to develop technologies to automate collision warnings, provide highly accurate orbit data and mitigate or remove debris risks, opening a valuable, new job-creating business for European industry, which will acquire a competitive advantage on the global market [Space, 2019b].

The European Space Agency has under its authority the Space Debris Office, which coordinates research activities in all major areas of space debris prevention. These include measurements, modelling, protection and mitigation of consequences from space debris. The Space Debris Office is the main coordinator of such activities with space agencies in Italy, the United Kingdom, France and Germany. Together with the European Space Agency, these national agencies form the European Network of Competences on Space Debris (SD NoC) [ESA, 2019].

The space debris administration coordinates activities on: radar and optical measurements; modeling of space debris and meteoroid environment, risk assessment models; analysis of space debris mitigation measures and their effectiveness for long-term environmental stability; assessment of the risk of collision in orbit; analysis of problems with the space debris database [ESA, 2019].

The space debris administration has developed and maintains several engineering tools for space debris analysis. These tools, which are available for use, are stand-alone and self-installed software products, including MASTER-2005 (prediction of debris and meteor showers (particles) in user-defined target orbits), PROOF-2005 (planning, modeling and observation of radar and optical debris) and DRAMA (verification of compliance of space tasks with debris mitigation guidelines) [ESA, 2019].

That is, the European Space Agency is the coordinator of research activities concerning counteraction to space debris.

International Organization for Standardization (ISO). It is an independent non-governmental international organization that, through its members, brings together experts to share knowledge and develop international standards that support innovation and offer solutions to global challenges.

ISO creates documents that provide requirements, specifications, guidelines or characteristics that can be used consistently to ensure that materials, products, processes and services are fit for their purpose. [ISO, 2019].

ISO has now ratified 15 international standards relating to space debris mitigation requirements. For example, *ISO 24113 (Document type: international standard) defines the primary space debris mitigation requirements applicable to all elements of unmanned systems launched into, or passing through, near-Earth space, including launch vehicle orbital stages, operating spacecraft and any objects released as part of normal operations. The requirements contained in ISO 24113 are intended to reduce the growth of space debris by ensuring that spacecraft and launch vehicle orbital stages are designed, operated and disposed of in a manner that prevents them from generating debris throughout their orbit lifetime. The requirements are also intended to reduce the casualty risk on ground associated with atmospheric re-entry of space objects. ISO 24113 is the top-level standard in a family of ISO standards addressing space debris mitigation* [International, 2019].

In addition to international organizations, the inter-Agency Space Debris Coordination Committee (IADC) should be mentioned, it is an international governmental forum for worldwide coordination of activities related to man-made and natural debris in space. The main objectives of the IADC are to share information on space debris activities among member

space agencies, facilitate opportunities for cooperation in space debris research, review current activities that are under way, and identify options for debris mitigation [What's IADC, 2019].

At the 17th IADC meeting in Darmstadt, Germany, the working group undertook the task of developing the first set of international consensus recommendations on space debris mitigation. The IADC space debris mitigation guidelines describe existing practices that have been identified and evaluated to limit the generation of space debris in the environment. The manuals cover the overall environmental impact of space missions, with a focus on limiting debris released during routine operations, minimizing damage from orbit breaks, clearing debris after a mission, and preventing an in-orbit collision. The IADC guidelines on space debris mitigation are not obligatory to fulfil, and therefore apply to mission planning, design and operation of spacecraft and orbital degrees to be put into earth orbit. Organizations are encouraged to use these guidelines to determine the standard they will apply when setting requirements for planned space missions [Inter-Agency, 2019].

Thus, the international mechanism for counteracting to space debris is implemented through the activities of international organizations that are part of the system of public entities of counteraction to space debris. They form the main objectives of solving problems with space debris, adopt international acts in the field of space activities, coordinate national space agencies and implement joint scientific projects aimed at reducing and destroying space debris.

Features of the organization of counteraction to space debris at the national level

The second group of the system of public entities to counter space debris, as already mentioned above, includes the space agencies of individual countries.

Of course, the United States, where the National Aeronautics and Space Administration (hereinafter — NASA) operates, has reached the greatest development in the space sphere so far. NASA is an Agency belonging to the Federal government of the United States and reporting directly to the President of the United States. It carries out the civil space program of the country, as well as scientific research of air and space and scientific and technological research in the field of aviation, Aeronautics and Astronautics [National, 2019].

NASA takes the threat of collisions with space debris seriously and has a long-standing set of guidelines on how to deal with each potential collision threat. These guidelines, part of a larger body of decision-making aids known as flight rules, specify when the expected proximity of a piece of debris increases the probability of a collision enough that evasive action or other precautions to ensure the safety of the crew are needed [Space, 2017].

NASA and the US Department of defense cooperate and share responsibility for the study of satellite debris (including orbital debris). Using special ground-based sensors and surveys of returned satellite surfaces, NASA statistically determines the extent of the population of orbital debris objects [Space, 2017].

According to the experience of other countries, in particular European countries, it is worth noting the existence of interaction between individual EU member states on counteraction to space debris.

Thus, the Italian Space Agency (ASI), the British national space centre (BNSC4), the French Space Agency (CNES), the German Aerospace Agency (DLR) and the European Space Agency (ESA) have developed and formally adopted the European Code of Conduct for Space Debris Mitigation.

The primary objectives of the European Code of Conduct for Space Debris Mitigation are:

- *prevention of on-orbit break-ups and collisions,*
- *removal and subsequent disposal of spacecraft and orbital stages that have reached the end of mission operations from the useful densely populated orbit regions,*
- *limitation of objects released during normal operations* [European, 2004].

To achieve these objectives, the Code defines the main measures to be followed in the design and operation of space systems to prevent or minimize the formation of space debris. These measures are grouped into: — management activities; — project activities; — operational measures; — protection measures. It does not cover security measures at the launch stage [European, 2019].

The German anti-space debris policy, which is implemented by the Space administration of the German aerospace center, is that each contractor involved in a particular space mission applies product safety requirements, including reducing the size of space debris throughout all phases of the project. The legal framework for countering space debris is the Space Activities Act of 22 August 1998 and the Telecommunications Act of 22 June 2004. For space projects in Germany, space debris mitigation requirements are mandatory [Germany, 2019].

In the UK, the outer space Act 1986 is the legal framework for regulating activities in outer space (including the launch and operation of space objects) carried out by persons associated with the United Kingdom. The act grants licensing and other powers to the Secretary of State, who acts through the UK Space Agency. The act provides for the fulfilment of the UK's obligations under international conventions relating to the use of outer space. Under the law, the Secretary of State does not grant a licence unless he is satisfied that the activity being licensed does not endanger public health or the safety of people or property, would be in conformity with international obligations, and would not harm the national security of the United Kingdom. In addition, the legislation requires the licensee to conduct its operations in such a way as to prevent pollution of outer space or adverse changes in Earth's environment [United, 2019].

Discussions are going on in Italy with the aim of developing national legislation related to outer space, including provisions on measures to reduce space debris. Until the adoption of the national space law, the implementation of activities related to the reduction of space debris is still limited to the provisions of the treaties signed by the Italian Space Agency, which has the institutional task of defining, coordinating and managing national space programmes [Italy, 2019].

That is, the activities of space agencies, which are part of the second subgroup of public entities to counteract space debris, differ in their structure and powers. Although, the legal framework of each country, adopted on the basis of international conventions governing space activities, has some peculiarities. In some countries, such as Italy, legislation on space activities is just being formed, herewith most countries cooperate to form a common policy to reduce space debris around Earth.

Conclusion

The modern system of public entities of counteraction to space debris consists of international organizations (the UN Committee on the peaceful uses of outer space, European Space Agency, the International organization for standardization; the Intergovernmental Coordinating Committee on space debris; International telecommunication Union) and the

space agencies of individual states (currently the most active in the field of counteracting space debris is the USA, Italy, the UK, Germany, France).

Public entities of counteraction to space debris should coordinate international measures to counteract space debris, because it is a global problem for humanity. At the same time, their activities should have strong political support, which will allow to economically support and develop new programs to counteract space debris. In addition, it is necessary to create new programs, involve educational and scientific institutions, invest in international scientific projects to create a more effective counteraction to space debris.

The peculiarity of the activities of public entities to counteract space debris is the formation of a regulatory framework, standards that are aimed at reducing space debris, however, at present these standards are advisory in nature, respectively, do not require mandatory actions on the part of space entities. It is now necessary to harmonize the national legislation of individual states with existing international principles for the reduction of space debris, taking into account the commercialization of space activities and the creation of rules for private sector players.

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