

An Analysis of the Regulations on Environmental Damage to Outer Space Caused by Space Debris

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Abstract: With the increasing frequency of human exploration and utilization of outer space, the amount of space debris has soared in recent years, which is causing environmental damage to outer space. Space debris is generated by abandoned space objects or particulate matter, mainly including obsoleted space equipment, satellites which have lost efficacy, rocket debris, and the debris caused by secondary collisions. Although an increasing number of problems resulted by space debris are gradually emerging and need to be tackled forthwith, effective measures have not been taken by related organizations so far. Improvement in outer space legislation, establishment of a unified dispute settlement organization and so forth are all imperative tasks for countries.

1. Introduction

Since the former Soviet Union successfully launched Sputnik 1, the first man-made satellite in history on October 4, 1957, mankind has been exploring outer space continuously. In the 21st century, space technology has developed unprecedentedly; the mystery of outer space has been unveiled step by step by human beings. Space activities are booming not only in number but also in form. There is no denying that myriads of outer space activities have provided abundant natural resources and huge economic benefits for the life of mankind in many aspects. However, despite substantial numbers of brilliant achievements that many countries have made, environmental damage caused by human activities in outer space exploration and utilization has become an issue that cannot be ignored and avoided.

Up till now, there have been hundreds of thousands of pieces of space debris larger than one centimeter in diameter and tens of millions of pieces larger than one millimeter in diameter, with a total mass estimated at nearly 10 million kilograms in outer space. Due to the particularity of space debris compared with other conventional waste, the damage caused by it is formidable to deal with. If countries do not place a premium on these problems or assume their responsibilities, environmental pollution in outer space will be destined to pose a real threat to the sustainable utilization of outer space.

This paper is composed of six parts including a brief introduction and conclusion. Part two will manifest the damage has occurred and will occur. Part three will cover the current deficiencies in tackling the problem of outer space environmental damage--this part will focus on the ambiguity of the existing law. Part four will discuss the possible solutions to this growing problem. Part five will

talk about the ways forward for China--Enacting Aviation Law of the People's Republic of China as soon as possible and playing an active role in establishing an international mechanism.

2. Damage Caused by Space Debris

According to the scientific calculation,a single space debris's running speed will reach 15 kilometers per second^[1].Namely,space debris larger than the cm-level is fully capable of damaging on-orbit satellites or the spacecrafts in normal operation;at the same time,fine particles of cm-level are able to break down the cloak of a man-made satellite,hit on the internal control system,and consequently undermine satellites and spacecrafts^[2].Even some small particles running at a low speed can damage the surface parts of spacecraft or space objects to some extent,forming impact pits on the surface,changing the surface performance of space objects and causing adverse effects on subsequent space activities.In addition,the collision between space debris multiplies the amount of space debris.These elements will pose a threat to the sustainability of outer space environment^[3].

2.1 Collide with Space Objects in Normal Operation

If high-speed space debris collides with normal space objects,it will cause serious damage to the latter one^[4].Space debris will make impact craters on the surface of space objects,thus affecting the performance of them,and meanwhile,tiny particles can enter the interior of a space object^[5].Tiny as these particles are,their damage to space debris is fatal.Even worse,the amount of space debris is doomed to increase as the number of space objects grow because objects that are already in orbits will continue to collide with one another in the next 200 years,creating debris which will make an area of the orbit too dense for use,or even creating a debris layer in low earth orbit which will make it difficult for space objects to enter outer space in the future.Thus,the collision between space debris and space objects will form a vicious circle^{[6][7]}.

Satellites,spacecrafts and other space objects all play a pivotal role in outer space exploration and resource exploitation.The production of satellites and spacecrafts always cost a lot of material and financial support;the achievements made through them can exert a more profound influence on all aspects of human being's daily life such as education,health care,agriculture and other important fields.Once these satellites and spacecrafts are destroyed,lots of direct and indirect impacts will be made^[8].

2.2 Pose a Threat to the Life of Astronauts

In the process of outer space exploration,it is essential as well as indispensable for astronauts to step out of the airtight space capsule and carry out extravehicular work-lunar exploration,on-orbit satellite repairment and so forth.The harsh environment of outer space is likely to put astronauts at risk at any time.Space debris travels at seven times the speed of a bullet;because of that speed,a small piece of space debris can be extremely dangerous^[9-12].Therefore,no matter how secure space suits are,once hit by high-speed space debris,the breath support device,temperature and humidity control equipment,liquid cooling equipment,gas purification device will all be out of work;namely,space suits with multiple functions,compact structures and life support system will be out of use-leading to the death of astronauts.

2.3 Exert a Bad Effect on people's Living Environment

With the impact of atmospheric resistance, the height of satellites in low earth orbits gradually decrease and finally falling from outer space will be inevitable.In this process,large satellites are

prone to have incomplete burnout debris falling to the surface of the earth. If not handled properly and promptly, these debris will easily threaten the safety of human life and even cause enormous property losses.

Worse still, with the development of science and technology, nuclear power is gradually used in outer space exploration. Some of the space debris containing unreleased nuclear power are certain to exert a bad effect on people's living environment. Space debris of this kind is also possible to affect ecological balance, which will be detrimental to the life of human beings and other creatures living on the earth for a long time.

3. Deficiency

3.1 The Definition of Space Debris is Not Clear

Generally, space debris refers to obsoleted space equipment, satellites, rockets and other space objects. However, the consensus on the legal definition of space debris has not been reached by countries all over the world.

The Moon Agreement has an explicit provision that in the process of exploring the moon and using its resources, states parties shall take measures to prevent the disruption of the existing balance of its environment, whether by introducing adverse changes in that environment, by its harmful contamination through the introduction of extra-environmental matter or otherwise. It is states' duty to take action to avoid negative affections on the environment of outer space through the introduction of extra-terrestrial matter or otherwise. However, the definition of extra-environmental matter is unclear, thus leading to the dilemma that whether space debris is included in extra-environmental matter has not been confirmed.

In addition, Article 5 of Liability Convention has an explicit stipulation. It can be summarized as when damage is caused to a space object of one launching state or to property or persons of this state, the launching state shall take the responsibility only if the damage is due to its own fault or the fault of persons for whom it is responsible. Nevertheless, this article has not made it clear whether space debris belongs to space objects. Therefore, although there exists a treaty on environmental damage liability, the uncertainty in the definition of space debris has greatly weakened the binding force of the article itself and also its role in the environmental protection of outer space^[13].

Due to these aforementioned uncertainties, what exactly is space debris that needs countries to take responsibility to clean up is unclear. And consequently, coercive power of relevant laws has reduced a great deal.

3.2 The Subject of Liability is Unclear

Firstly, according to the Outer Space Treaty, states parties have an international responsibility for their activities in outer space, whether these activities are carried on by governmental agencies or non-governmental entities. Liability Convention also explicitly stipulates that in the event of damage caused a space object of one launching state or to persons or property on board, the launching states shall be liable for compensation. However, we cannot ignore that, nowadays, based on the current level of science and technology, it is formidable to determine the country to which a vast multitude of space debris belongs. Even with the existence of Convention on Registration of Objects Launched into Outer Space, it is difficult to identify which country registered space objects belong to. In addition, the ownership transference of satellite is common in the international community; however, the transferee state is not the launching state under the Liability Convention. Therefore, according to the existing convention, transferee state is not liable for

environmental damage caused by space objects-causing the imbalance between benefit and responsibility.

Secondly, there is a tendency towards commercialization and privatization of space exploration in many countries; an increasing number of private entities and international organizations have taken part in satellite launching activities. However, there is no law to specify the party that shall bear the damage caused by private entities.

3.3 The Coordination Mechanism is Deficient

Various problems encountered in outer space exploration and utilization have indicated that the international community needs an international coordination mechanism to monitor every country's outer space activities, to deal with disputes arising from outer space exploration and to play a vital role in outer space environmental protection. At present, the lack of coordination mechanism is detrimental to the enforcement of international treaties; without supervision, it is difficult to guarantee that countries will comply with these treaties. If a country fails to conform to an international treaty, it is likely that other countries and also the international community can neither know the matter nor can they constrain its behaviors legally; thus, the legal binding force and role of international treaties have been greatly affected. As far back as the twentieth century, some distinguished space scientists have called for the establishment of such a coordination mechanism to deal with disputes brought about by outer space exploration, but these ideas have not adopted up till now. Thus, there is still no mechanism to solve these urgent issues.

3.4 Relevant Laws Are Not Perfect

It is undeniable that as for how to reduce the release of space debris and environmental damage in outer space, the UNCOPUOS (Committee on the Peaceful Uses of Outer Space) has specified several requirements in the space debris mitigation guidelines, such as: limiting the release of debris during normal operation, minimizing possible disintegration during the operational phase, limiting the possibility of accidental collision in orbit, avoiding intentional self-destruction or other harmful activities, minimizing stored energy to prevent disintegration, and trying to avoid long stays in low earth orbit after the completion of a mission. And at the same time, several eminent scholars who specialize in the research of outer space have proposed similar ideas to limit long-term interference in low earth orbit after the mission is completed, such as actively recycling space objects, pushing the obsolete spacecraft into the orbit higher than the geostationary orbit, releasing spacecraft's energy at the end of its life, thus reducing the likelihood of its explosion and so forth.

This guideline is the first international technical document on the issue of space debris, specifying national mitigation measures on space debris and providing legal norms on the formation of space debris. This guideline also explains terms such as space debris. However, these measures are only the ideas of a small number of countries and organizations. It is an international instrument without legal binding force made by members of the United Nations Committee on the Peaceful Use of Outer Space and its subgroups through adopting a series of declarations and resolutions, which lacks legal binding force and is not universal. Thus, these measures are almost impossible to be universally applied by space countries concerned.

Furthermore, Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies has been enacted since 1979. It provides a basic legal framework for peaceful exploration and utilization of the moon and other celestial bodies. The obligations of states parties in this treaty to protect the outer space environment in the exploration and utilization of outer space can provide reference for the management of space debris damage. However, since this treaty includes national interests like resource development, space

technology development and so forth, some aviation giants have not joined the treaty so far. Hence, this treaty itself is lack of binding force. It needs more countries, especially aviation giants to join.

The current five treaties on outer space law only provide framework obligations but cannot deal with the complex legal issues of space debris. The obligations of states in dealing with space debris are not clearly defined and ambiguous articles are often non-binding. The lack of enforcement rules makes it impossible to tackle complicated legal issues brought by space debris. In the past several decades, the human exploration of outer space and utilization degree have changed dramatically, but almost all of these principles and treaties enacted in the last century remain unrevised. When environmental pollution in outer space is deteriorating, the revision of treaties fall behind. Previous conventions are no longer fully applicable to the rapid development of outer space science and technology in the current era. There is a great necessity in perfecting space legislation and strengthening legislation binding.

4. Possible Solutions

4.1 Allocate the Obligations of States According to Actual Conditions

Without the supports of law and mechanism, feasibility of international cooperation is comparatively low. The mitigation of space debris requires high technical and financial support, but the strength of countries in the field of outer space exploration varies. The thorny problem facing the world is that however different the objective conditions are, both developed and developing countries always subjectively shirk their duties when undertaking their obligations to protect the environment in outer space.

Nowadays, some countries, especially developed countries have mature technology and sufficient capital in outer space exploration while others are just getting started in this field; thus, the utilization of outer space varies from country to country. Indeed, it is unfair for countries with different levels of space exploration and utilization assume equal responsibility. Countries' space technology is difficult to estimate because there exists uncertainty, but the number of satellites that have been launched by certain countries can be found out clearly through the registration system arising from Convention on Registration of Objects Launched into Outer Space in 1975. To some extent, the number of space objects launched by a country can indicate its level of damage and its liability. Therefore, one country's obligation can be allocated according to how many space objects they have launched, which is more objective, more reasonable and more scientific. Both developed countries and developing countries are supposed to assume common but differentiated responsibilities for the environmental protection of outer space, depending on their respective space technology capabilities.

4.2 Improve International Legislation

Several decades have passed since the establishment of the five conventions under the framework of the United Nations. At present, human being's ability to explore outer space has come to a new step, but these five conventions fall behind. In some situations, though there exists an explicit provision, whether it can be properly applied to matters happen nowadays need to be reconsidered.

First, from the perspective of legislative basis, the space debris mitigation guideline issued by UNCOPUOS (Committee on the Peaceful Uses of Outer Space) has laid a good foundation for future legislation though the guideline itself has no legal force. Space debris mitigation guidelines contain lots of useful contents which can make up for the ambiguity of articles in the former five

conventions. Due to its significance in improving international legislation, it should be effectively implemented to reduce the amount of space debris at source; meanwhile it can also serve as a reference to the perfection of the legislation.

Secondly, it is important to legislate on how to deal with space debris that has been generated, while it is more important to enact legislation to reduce the release and generation of space debris at source. Legislation of this kind should be taken seriously because prevention is relatively easier and more efficient than dealing with thorny problems that have already come about.

4.3 Establish a Unified Dispute Settlement Organization

In the past few decades, due to the lack of coordination mechanism, the binding force of existing international treaties cannot be guaranteed, and thus the problem of space debris has never been conquered till now. Existing organizations like International Criminal Court and International Tribunal for the Law of the Sea are international organizations dealing with related disputes. In this era when outer exploration and resource exploitation are flourishing, a variety of problems especially environmental damage caused by space debris needs to be solved imperatively. Dispute settlement organization of this kind is able to enhance the legal awareness of countries, and increase the binding force of international treaties, thus helping countries working together to deal with space debris according to explicit implementation procedures.

4.4 Enact Domestic Laws According to National Conditions

Nowadays, human being's ability in outer space exploration and utilization has improved by leaps and bounds, but both international treaties and domestic laws are defective. Based on the principles of the interests of all mankind, equality and freedom, non-appropriation, international cooperation, the peaceful use of outer space and the protection of the outer space environment, countries should develop their own domestic aviation law to effectively restrict outer space activities that are detrimental to the balance of outer space environment. Compared with international treaties made between countries, domestic aviation law is more legally binding and powerful. For example, both Swedish law on space activities and Outer space law of the United Kingdom of Great Britain and Ireland have explicit provisions that non-governmental entities must comply with when conducting outer space activities on the country's territory^[14].

5. The Ways Forward for China

China has gone through a both difficult and brilliant period in aerospace. In April, 1956, the aviation industry commission of the People's Republic of China was established to exercise unified leadership over China's aviation and rocket industries. The successful launch of China's first satellite in 1970 enabled China to become the fifth country in the world to launch a satellite independently. Nowadays, China has scored remarkable achievements in satellite, carrier rocket, space surveillance, spacecraft launching site, manned space flight and lunar exploration program. In aviation and aerospace, China still has a long way to go. At the same time, there are many problems to face, and a lot of obligations to undertake. Effectively solving the problem of space debris is also China's duty^[15].

5.1 Enact Aviation Law of the People's Republic of China as Soon as Possible

In the past five decades, China has developed into a space power from a country without the

ability to explore outer space. However, it is undeniable that among countries with mature space technology, China is the only country without aviation law. China's space rule system is now composed of administrative regulations, departmental rules and policy documents, with low legal hierarchy and vague articles. Furthermore, with the rapid development of space science and technology, commercialization of outer space activities will become an irresistible trend, thus leading to more complex legal issues. However, the responsibility that commercial space company should assume, restrictions on the scope of commercial activities, and their duty in outer space environmental protection are not regulated. All these facts indicate that space legislation in China is falling behind.

Compared with international treaties and international customs, domestic laws are more legally binding. The legislation of aviation law is an inevitable requirement for safeguarding national space security and formulating space strategy. To pursue a holistic approach to national security and resolutely safeguard China's sovereignty, security, and development interests, China needs to actively reduce the likelihood of space debris threatening satellites in orbit and damaging the ground environment, thus safeguarding homeland security, military, economic security, ecological security, resource security and social security, and improving the socialist legal system with Chinese characteristics.

At present, China's space legislation has a good research foundation, and the abundant foreign space legislation has provided a useful reference for China. Meanwhile, the legislation of national aviation law has been included in the national legislation plan. However, the time of completion and adoption has not been confirmed yet. Due to the significance of this law in the process of China's space development, the enactment of it will be destined to solve many existing and upcoming problems. This law is also expected to regulate space activities, thus reducing the generation of space debris by future space activities.

5.2 Play an Active Role in Establishing an International Mechanism

As the status of China is being promoted, China plays a vital role in the international community. China champions the development of a community with a shared future for mankind in the report of the 19th National Congress of the Communist Party of China. In the Constitution of the Communist Party of China, concepts of pursuing shared interests, defend world peace, promote human progress, work to build a community with a shared future for mankind, and advance the building of a harmonious world of lasting peace and common prosperity are also mentioned.

In outer space activities, China is also a "responsible major country". As an aviation power and one of the five permanent members of the United Nations Security Council, China has the bounden responsibility to promote the establishment of an international mechanism, to enhance international cooperation and to solve disputes; helping establishing an international mechanism to clean up space debris and prevent outer space from being further contaminated are an international obligation of China as a responsible country. In the international community, there is no so-called organization above countries.

Although in academic community, quite a few eminent scholars have called for improving space legislation, perfecting existing laws and so forth. We have no idea when these plans will be implemented and whether they can be applied to the practice. And we also have no channel of learning whether these laws can effectively solve growing problems and protect the environment of outer space after being enacted. Under such circumstances, as the biggest developing country in the world and a space-faring nation, China ought to play an active role in accelerating the establishment of an international mechanism.

6. Conclusion

The 21st century has witnessed unprecedented development in space science and technology. The mysteries of outer space have been unveiled step by step. It is undeniable that the ability of human exploration and utilization of outer space is gradually enhancing. Achievements that have been made in outer space exploration are conducive to human being's development in various fields like education, biology, physics and so forth. However, solving the problem of space debris is more difficult than solving other problems because outer space is not a region under the jurisdiction of any state and also there is no organization above the state in the international community. There is still a long way to go in how to solve the serious problems of space debris in outer space, how to strengthen international cooperation in legislation, and how to improve the existing legislation to protect outer space.

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