

SPACE TRAFFIC MANAGEMENT FOR THE MOON AND THE DEVELOPMENT OF SPACE LAW

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ABSTRACT

Several legal issues are becoming more and more pressing for outer space activities, amongst them the need for space traffic management. The amount of space debris and the number of space missions planned are the main reasons why a space traffic management regime should be adopted in the coming years. However space traffic management is usually studied merely with respect to Earth orbit. Although most current space activities take place in Earth orbit, new endeavors to explore and exploit the Moon call for broadening of the concept of space traffic management. Considering current political conditions, the time now seems strategic for the adoption of more detailed laws and regulations concerning the status of outer space and celestial bodies, including space traffic management. Momentum and political urgency are very important aspects in the adoption of outer space legislation, as was witnessed forty years ago when the very strict Outer Space Treaty was adopted. In this respect, space traffic management should be one of the issues specifically looked upon in the coming years, during which space law will hopefully know many fruitful developments. The issue of space traffic management for the Moon should be addressed specifically as some of the requirements will differ from space traffic control around the Earth.

1. INTRODUCTION

Space traffic management is a very broad concept that has been discussed for a few years in the space community. The concept appeared when it was realized that, like air space, outer space was beginning to be crowded, but that no traffic control was in place, unlike in air space. Despite the recent discussions about space traffic management no definition is yet internationally agreed upon and the concept is still under refinement. José Monserrat Filho defines space traffic management as “knowing exactly at any given moment where each spacecraft is, in the air or in outer space, where it has come from and where it is going and how it is working. It also involves assuring the safety of space activities by preventing collisions and harmful interference, as well as protecting outer space and Earth’s environment.”[1] A comprehensive definition seems to comprise all the phases of space activities, from pre-launch, to de-orbiting, whilst taking into account everything that might interfere with other space activities, be it on Earth or in outer space, both physically and through radiofrequency. Main concepts that need to be introduced in space activities seem then to be transparency, agreements and pre-notifications.

Considering the growing number of space objects in space and the increasing number of significant space actors, these concepts

seem essential to promote safe space activities in the long-term. Even though space might still be considered a hazardous, dangerous and expensive activity, the space age celebrates its 50th anniversary this year and the testing period is over. Space becomes accessible to more and more States and private actors, directly and indirectly and this creates a need for more and more satellites and capabilities. However the limited lifetime of satellites and the difficulty of servicing, de-orbiting or recycling of space objects, makes this constant need a considerable problem in the long-term, leading us towards a time when near-space might become a very dangerous trash bin. During the summer 2007 at the International Space University, a team of thirty students from seventeen countries worked on the topic of space traffic management, identifying some of the key issues at hand, and proposing effective management measures. [2] The number of space objects bigger than 10cm in diameter orbiting the Earth is at an all-time high of approximately 12,000 and increasing by the day. This increases significantly the probability of highly damaging collisions between space objects, although the occurrence still remains rare today. Only one damaging collision has been reported so far, between the French Cerise satellite and an upper stage of an Ariane rocket.

For the moment, it is still a technical challenge to remove or destroy space debris, and until then, it is important to combine this research with the implementation of an effective space traffic management regime. In the attempts of defining space traffic management, the notion is generally defined in a very broad sense as the management of all space traffic, whether it is taking place around the Earth or elsewhere. This is fully justified and essential in order not to exclude any space activities from the control that

might take place. Moreover it should not be overseen that space traffic management does not only take place in Space but also on Earth, as launches and re-entry play a big part in an efficient regulation. However most activities in space are confined to Earth's orbit and that is where regulation is most urgently needed. Therefore the discussions on space traffic management have so far been focused on regulating activities in Earth's orbit. An example can be found in the IAA Cosmic Study on Space Traffic Management [3] where the three phases considered are the launch phase, the in-orbit phase and the re-entry phase. The second phase implies that only Earth's orbit has been taken into account in the study.

However the renewed interest of several States for the Moon, its exploration and use, calls for a broadening of the debate on space traffic management that could include space traffic management around the Moon. It is only fair that it has not been discussed yet, for two main reasons. First, the Moon has not been in the focus of space activities for a long time and has only recently regained the full attention of the space community. It is also seen as a stepping-stone for future Mars exploration. Second, a space traffic management regime for the Moon might differ in many ways to the one for Earth's orbit. While the launch phase will bear many similarities, the in-orbit and re-entry phases will take place around and on the Moon, and as such will raise many different technical issues as well as legal and policy questions. It might seem premature to talk about such a regime for the Moon considering that even a regime for the Earth is still not agreed upon. However there are several reasons why it would be sensible to start thinking about such a regime today.

The new United States Vision of Space Exploration [4] calls for a human return to

the Moon by 2020 and the possibilities of further exploring and using the Moon as a permanent base are strongly envisaged. Indeed, the U.S. announced on December 4th 2006 the ambition of installing a lunar base with a permanent human settlement on the Moon by 2020. In parallel to this, the Chinese, Russian, Indian and Japanese space agencies have formed more and more ambitious and dynamic intentions for future Moon exploration, setting the same time frame of 2020. This all seems to point at the Moon as being the new international destination for space exploration, both manned and unmanned. If human missions are being envisaged in several countries and on a big scale as was just pointed out, this might still seem far fetched. However these manned missions will be prepared by robotic missions that are currently already being designed. Another point that should not be overlooked is the search for new materials and new sources of energy coming from space. This quest will most probably also be the source of an increased space traffic towards the Moon. All these new endeavors will certainly have consequences on space traffic to, around and from the Moon.

The time seems appropriate to raise the issue, as a space traffic management regime for Earth orbit is now in the process of being created with several studies taking place at the international governmental, non-governmental and academic level.

2. A STRATEGIC TIME

The Moon has already been explored a number of times by different American missions. After the Apollo program ended in 1972, the missions to the Moon suddenly came to an end as the US space policy and the American public slowly lost interest and started focusing on a space program with more tangible benefits. A number of

scientific missions have continued to be carried out since the Apollo times, increasing our knowledge of the lunar environment and our technological capabilities but raising a lot less public interest. Although the Moon has always been the subject of investigation and dreams, it was not until recently that concrete lunar projects have been incorporated in national space policies. And this time, not only in the US and Russia but also in emerging Space powers, like India, China and Japan, which are countries that have never shown a strong interest in space exploration and settlement and are traditionally mainly focused on Earth applications and the direct benefits of space for development, like Earth observations and telecommunications. Even though Europe has still not shown a clear interest in manned missions to the Moon, the European Space Agency recently experienced strong media coverage with the controlled crash on the Moon of the European scientific mission SMART-1, that completed its observation activities, showing its renewed interest in robotic missions. Europe has also been developing the AURORA exploration program since 2001 and is focusing more on the Moon since 2004 as a response to the United States' policy.

All these new projects will increase space traffic to the Moon and might thus represent a threat to the lunar environment and to the sustainability of the activities carried out on the lunar surface. However, plans for the Moon already include international cooperation, which might help a space traffic management regime and might show us the way to go. On May 31, 2007 14 space agencies issued a "Global Exploration Strategy" that proclaimed that "This Global Exploration Strategy will bring significant social, intellectual and economic benefits to people on Earth. (...) This new era of space

exploration will strengthen international partnerships through the sharing of challenging and peaceful goals. It will inspire people everywhere, particularly youth.”[5] This global strategy will serve as a starting point for future collaboration among the main stakeholders. Its purpose is to have an international discussion on the objectives of lunar exploration, and eventually Mars and other destinations will be taken into account as well. It will help to maximize what can be accomplished and avoid useless redundancies, like several missions carrying out the same geology experiment. In December 2006 the Lunar Exploration Objectives document was released and it should be noted that traffic management is pointed out as an essential part of the transportation category. It writes: “Establish a lunar base traffic management system. Define landing zones for cargo and crew landers and establish safe traverse routes in the immediate vicinity of surface infrastructure elements”. [6] This exclusively considers traffic on the surface of the Moon, whereas a comprehensive space traffic management regime would comprise much more than that, but it is an encouraging start.

The US report of 2004 and this global exploration initiative envisions an active future for the Moon and makes the need for an agreed upon legal status of the Moon urgent. Arguably, the current legal texts relating to Outer Space and Celestial Bodies are not detailed enough for the activities prospected to be carried out on the Moon. The Outer Space Treaty adopted in 1967 provides for a general non-appropriation principle and guarantees freedom of access, use and exploration of Outer Space, the Moon and other Celestial Bodies. In order to detail the status of the Moon and give it the title of Common Heritage of Mankind, the Moon Agreement was adopted in 1975. This

agreement was however widely criticized and none of the major space faring nations ratified it. The agreement is thus binding only on a very limited number of States that have no ambition of going to the Moon any time soon. [7] Although there is room for interpretation, this agreement is not detailed enough to regulate permanent, extensive and perhaps commercial activities on the Moon. However, for lunar activities to flourish and attract private companies and thus private funds, a certain legal certainty will be needed. This seems hard to achieve as many conflicting interests are at stake. There are several means of achieving an agreed upon legal framework. Until now it is by means of international public law that the status of outer space has been defined, but the latest attempt for the Moon has not been very successful. Apart from the long and tedious process of adopting a treaty, it might be possible to form customary international law by international and uniform practice. This would take some time as well but would avoid the formal negotiations. In the context of the global exploration strategy, such a uniform practice might be feasible. The disadvantage of this is that it will possibly undermine the interests of the countries that are not yet capable of going to the Moon and are not part of the global initiative. Therefore it is strongly recommended that global partnerships, technological and political, should be formed between the agencies involved and developing countries so that they can have a say in the development of the legal status. This would also respect the requirement of the Outer Space Treaty that exploration should be carried out for the benefit of all mankind.

This issue can be seen in a positive way both for the adoption of an international legal status for the Moon, and for an effective space traffic control around it. As stated, it is most probable that a legal regime for the

Moon needs to be clarified before any extended lunar activities take place. At the same time, the need for a space traffic management regime for the Earth is becoming more urgent. If both these needs are answered by concrete actions, the momentum should be used to define an effective space traffic management regime for the Moon. This strategic moment in time should be used to clarify a lot of the legal and regulatory issues concerning Outer Space and particularly the Moon. As it seems and despite the Global Exploration Strategy, the US and China, in cooperation with Russia, might engage in a modern space race to the Moon, to show their technological superiority and capabilities to investigate the lunar environment with robotic means in order to prepare future human missions and perhaps a permanent lunar settlement. A competitive environment has proven to be a very positive incentive in the space sector for States to come to an agreement on sensitive topics. In the 60s and 70s the Outer Space Treaty and the Liability Convention were agreed upon between the two major space faring nations at the time, although they provided for a very strict regime. This was a strategic interest and a trade-off, as first they did not know who would win the race and, second, they wished to accommodate third countries to be free to test their unsecured space technologies. Although the treaties are sometimes questioned they put in place the principles of outer space law that are still abided by today, forty years later. Maybe this anniversary and its political context is the opportunity to start a new round of space law creation, although not necessarily in the same way, as mentioned earlier. There are enough issues in space law that need to be resolved for the benefit of all countries' space activities. It seems to be time for all major space faring nations to realize this as most of the issues at hand are critical for a

long-term and sustainable development of space activities.

These are the reasons why it is not too soon to talk about a space traffic management regime for the Moon. Before starting exploration, the urgency should be used and the opportunity taken to tackle all the sensitive subjects of the moment: the legal status of the Moon and a space traffic management regime around the Earth and around the Moon. The creation of a space traffic management regime itself will directly benefit the legal status of outer space as it calls for a clarification of many issues, e.g. the delimitation between air space and outer space or the definition of a space object and space debris. Another reason is the lack of physical urgency. Because traffic around and on the Moon is not yet congested, it will be easier to control, to monitor and to develop in an efficient way that will be beneficial to all, if certain rules are set in place now. It would be sensible to learn the lessons of what happens around the Earth and not repeat this for other celestial bodies. If it is decided that the resources of the Moon can be used and exploited, the Moon still needs to be respected and used in a sustainable way, all along the process and, more importantly, from the early beginning. In order to study the specificities of traffic management around the Moon, it is important to first understand the current technical and legal status of space traffic management.

3. CURRENT STATUS OF SPACE TRAFFIC MANAGEMENT

The need for a space traffic management regime has been essentially emphasized with respect to the topic of space debris. It is true that this is one of the main drivers for the adoption of a space traffic management regime but it is not the only one. Space

traffic management encompasses a lot of issues that need to be solved and regulations that need to be adopted. As was stated previously, the main aim of space traffic management is to avoid physical and radio-frequency interference between space objects. These interferences are likely to increase as we start to realize that outer space is not as limitless as we first thought – especially accessible outer space. Around the Earth, the orbits most useful for our space activities are limited to a certain number and are, for some of them, overused. This is the case, for example, with the geostationary orbit (GEO) at 36,000 km altitude. However apart from the ITU (International Telecommunications Union) frequency regulations for GEO and partly for LEO, no regulation specifically related to space traffic management is in place. In the Cosmic Study on Space Traffic Management [8] the current status of applicable space law is underlined as well as the need for further development. An important number of issues are addressed in this report. As they can be useful for Earth and for Moon I will cite a number of them here.

From the technical perspective, the current status of radio-frequency interference is rather positive, since this is largely and successfully controlled by the ITU. The case of satellite maneuverability is however more worrying, even though progress has already been made in this area. Avoidance measures are taken more frequently, by satellites in geostationary orbit and also by the International Space Station, but the scope still remains very limited. The element in which the most progress needs to be made is the tracking of space debris. Today the most powerful tools belong to the United States which makes the other States almost totally dependant on them, although Russia and Europe are developing more precise technology. Moreover these tools still have a

limited power as they can only accurately track and register objects bigger than 10cm in diameter in Earth's orbit. This is something that will need to be studied in more detail for space traffic management for the Moon.

From a legal and regulatory perspective, the current status is quite limited as the majority of the instruments that constitute "space law" have been adopted at the beginning of the space age. Whereas the binding treaties have a very wide scope and are by no means detailed enough to provide for a space traffic management regime, the other existing provisions concerning space law have no binding force and, as such, do not provide for an efficient and legally secure regime either. A few examples will be given as illustration.

The Outer Space Treaty of 1967 as well as the Registration Convention of 1975 require the compulsory registration by the launching State of any space object launched into outer space. This registration should take place both at the national and at the international level. This clause however lacks any time constraint, which results in the often late international registration of space objects. In the framework of a space traffic management regime however, pre-notification of launches is a very important element to improve the predictability and scheduling of space activities.

Another example is the case of space debris. Although it has been discussed many times and despite the worries from a large part of the space community, no effective space debris regulation is currently in place. The most important attempt to clarify the needs and expectations towards such a regulation has been made by the Inter-Agency Space Debris Coordination Committee (IADC). Although these recommendations have been

endorsed by the UNCOPUOS in June 2007 as a UN document and are awaiting adoption by the General Assembly in December 2007, they remain only guidelines, and States and companies are not obliged to follow them. Some of the recommendations have been implemented in a number of cases, such as the use of disposal orbits and the venting of propellant and pressurized tanks. This is a good starting point for space traffic management but the practice needs to be generalized and binding rules agreed upon.

The current regulatory status of space traffic management is thus not very developed and needs to be improved. A few of the main issues and ideas that need to be addressed are: pre-launch and pre-maneuver notification, prioritization of space activities, development of re-usable launchers, generalization of sub-orbital flights, orbit “zoning”, re-entry corridors, standardized procedures and international cooperation. The international aspect of space traffic management is very important and a common view is that an international organization should be created to regulate and standardize procedures for space traffic management. The inspiration for this is the International Civil Aviation Organization (ICAO) that is competent for air traffic control. Although this is something that should be taken into consideration, it may seem premature for the space sector. The report on space traffic management by the students of ISU recommends however the creation of an international body, the International Space traffic Management Organization (ISMO) whose role would be similar to ICAO but adapted to the needs of space traffic control. [9]

A step by step approach should be favored, where one of the first steps should probably be standardization. Standardization would be beneficial not only for space debris but also

for communication between satellites and ground stations and would allow better monitoring capabilities. These are some of the general aspects of space traffic management. For the Moon however, some specific constraints need to be taken into account as highlighted here.

4. SPECIFICS OF SPACE TRAFFIC MANAGEMENT FOR THE MOON

If a space traffic management regime is adopted, it will soon be noticed that some requirements and constraints applicable to Earth’s orbit will not be compatible with the lunar environment. Two main factors lead to this reality: the distance between the Moon and the potential “space traffic control centers” on Earth which will make monitoring more difficult; the lunar environment itself, its thin atmosphere and gravity and its lack of infrastructure, represents both an advantage and a disadvantage.

Space debris monitoring, re-entry, end of life of space objects and “zoning”, are the main elements that will bear differences with a regime for Earth orbit. Launch pre-notification and scheduling, coordinated use of transfer orbits and transparency of Moon activities are equally important topics, but will not be discussed in further detail here.

It is important to understand the original intention with which the international community created the current space law regime for celestial bodies. Outer space has already been damaged by the amount of space debris floating around the Earth and the community is now looking at ways to mitigate this. The Moon however has always been something special to humans and the wish to protect it from human abuse should always be a priority. This special protection required for the Moon is comparable to some earthly locations, like Mount Everest

or Antarctica. These places have to a certain extent been effectively protected and remain largely untouched, despite human presence. It is very important that, even though governments and companies wish to exploit lunar resources and settle on the surface, a protection regime is in place to avoid harmful exploitation and damage to the environment.

Therefore space traffic management for the Moon should provide for such clauses of protection of the lunar environment. Two main factors that could damage the Moon in the first stages of exploration are space debris in orbit and debris on the surface. One of the main differences between the Earth and the Moon is that the latter does not have an atmosphere in which space objects can burn up at the end of their life. That is why space debris monitoring will be very different on the Moon. At the end of the life of a satellite, the satellite needs to be de-orbited and crashed on the surface of the Moon in a controlled manner. It should also be taken into account that the Moon's lack of atmosphere has other impacts, noticeably that satellites are able to have a very low orbit of only a few kilometers. However the Moon's gravity makes some orbits very unstable, whereas four orbits seem to be "frozen", meaning a spacecraft can stay in that low lunar orbit indefinitely. [10] This is one of the interesting features that should be taken into account as it might influence crash procedures and safety of lunar activities. The advantage of the Moon is that it is basically empty space and that "crash zones" can thus easily be created. In defining these crash zones, several elements should however be taken into account, such as protection of certain zones, like the former Apollo landing sites, famous craters and zones presenting an interest for exploitation. Also, some space objects have already been crashed on the Moon and

damaged certain sites. This could be considered as a starting point for the definition of crash zones. If space objects are to be regularly crashed on the surface of the Moon, other issues appear too, for example use of nuclear power sources on board the spacecrafts and re-use of the spacecrafts' material.

As for space debris in orbit around the Moon, the main problem will be the tracking and monitoring. Considering the current limited capability of tracking debris in Earth orbit, it can be expected that the possibility of tracking objects in Moon's orbit from the Earth will be very limited. Alternative solutions will thus need to be envisaged, including the installation of tracking infrastructure on the lunar surface. The issue of "zoning" which is difficult to implement around the Earth, might be easier for the Moon, not only on the surface but also in orbit. "Zoning" means to create specific zones for specific activities, to avoid interference between these activities and to protect them. "Zoning" ideas that have appeared already for space traffic management around the Earth are for example in-orbit zones specially dedicated to military activities or zones reserved for manned missions to reduce risks of collision. These same ideas can apply around the Moon, especially for manned missions. If zones on the surface of the Moon can be created for the crashing of satellites, a special orbit can be defined as well for the phase prior to the de-orbiting of space objects, like a transfer orbit. As was already mentioned, on the surface of the Moon some areas could be protected and some areas specifically defined for exploitation. Some locations have already been explored and already bear traces of human or robotic activities, we should try to limit the number of these "touched" zones, without hindering further exploration and exploitation, as it

increases our knowledge. A possibility for this could be a prioritized regime for human or robotic missions that develop less invasive technologies for exploring the Moon.

In the context of space traffic management around the Earth, the idea of giving priority to certain space activities, for launch opportunities mostly but also for in-orbit maneuvering, has been largely thought about. Moon exploration should be taken into account in this concept and it needs to be defined amongst the space faring nations what priority should be given to lunar missions.

Equally, if different entities wish to conduct activities in the same region of the Moon at the same time, it might be necessary to define criteria for prioritization. However as it will be very difficult to think about every possibility and in order to avoid disagreement between governments and organizations, it might be better to implement compulsory pre-notification in an early phase of design of the mission to allow better international mission planning and diplomatic negotiations between governments.

Overall the most important thing for a sustainable exploration of the Moon seems to be international cooperation in these issues of space traffic management. It will most probably be difficult to achieve as many riches are hoped to be drained from the Moon and strong national interests are in balance. However the Global Exploration Strategy seems to be a good start with the right intentions. It is however difficult to hope for international cooperation all through the process of exploration and exploitation, and it is thus a crucial necessity to make the adoption and implementation of a space traffic management regime for the

Earth and the Moon a prior condition to further lunar exploration. This represents a big challenge for the space community but is as necessary as the adoption of the space treaties in the sixties, before setting foot on the Moon for the first time.

5. CONCLUSION

Although it may seem premature or even utopia to call for a space traffic management regime for the Moon, we strongly believe that the current political conditions in the space community should be used as an incentive to develop detailed legal and regulatory regimes for the exploration and use of outer space and celestial bodies. This is valid for space traffic management in general, Earth and Moon, but also for the legal status and exploitation conditions of the Moon, other celestial bodies and outer space as a whole.

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