# Making NewSpace for Sustainability

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**Abstract**

The NewSpace revolution in general, and the vast use of small satellites in particular, is truly outstanding. The author alone supported the launch of over 600 small satellites during her career. It seems that with the democratization of outer space, and increase in its accessibility, this revolution is now complete, but are the current exciting events sustainable?

Matters such as space debris, space traffic management and the contamination of outer space are not dealt with in the UN space treaties, and the newer UN Guidelines for the Long-term Sustainability of Outer Space Activities, lack a legally binding nature.

In addition, pollution on Earth relating to launch activities seems like a non-issue in an era which prompts urgent regulatory action against climate change. Recent protests by astronomical scientists who warn against a process which would forever change our skies, are not heard loudly in the industry's meeting rooms.

In this paper, the author will suggest regulatory solutions to deal with the challenge of creating a thriving NewSpace industry on one hand, and ensuring the sustainability of outer space, and Earth, for future generations, on the other hand. The author will base the paper on her experience working in the NewSpace industry, and her postdoctoral research, focusing on the topic.

**Keywords:** space law, sustainability, NewSpace, regulation, space industry, environment

## 1. Introduction

Article I of the Outer Space Treaty, writes about the "freedom of exploration and use of outer space".[1] The notion of outer space being free from claims of

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1 Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies, 1967 610 U.N.T.S. 205 (hereinafter: "Outer Space Treaty").

state sovereignty, and the freedom to explore and use it, is at the core of international space law.
The same treaty does include legal provisions in its Articles, which restrict, at least to some extent, this absolute freedom in Article I.[2] At the same time, these restrictions seem almost meaningless when contemplating the urgent need to ensure the sustainable use of outer space.
In the era of the climate change global crisis on one hand, and a dramatic proliferation in space activities on the other hand, there is awareness to the need to keep space sustainable, however, concrete actions to ensure the sustainable use of outer space are too little, and perhaps, too late.
This paper aims to map the main challenges to the sustainable use of outer space, through four case studies. These cases will be elaborated in the first section of the paper.
The second section shall map the legal and regulatory challenges to ensuring the sustainable use of outer space, both on the national and international level, and through legally binding instruments and soft law.
The third section shall include suggestions to dealing with the challenges elaborated in the first two sections.
The final section shall include conclusions.

## 2. Mapping the challenges

### 2.1. Light pollution caused by mega satellites constellations vs. scientific astronomic research

SpaceX's Starlink is the satellite constellation with the largest number of satellites to date. It already includes more than 3,000 satellites in LEO, and the number should increase.[3] Shortly after its launch, astronomers raised concerns over the light pollution such large number of satellites would create. Having dark skies is crucial for astronomic research, and too much light which reflects from these satellites has adverse effect on the images telescopes produce.
In fact, the light pollution in relation to space increased by 10% when comparing the pollution before Starlink was launched, as of 2021, which is a

2 Neta Palkovitz, Exploring the Boundaries of Free Exploration and Use of Outer Space - Article IX and the Principle of Due Regard, some Contemporary Considerations, IISL Proceedings of the Colloquium on the Law of Outer Space, 2014, page 93.

3 Adam Mann, Tereza Pultarova and Elizabeth Howell, SpaceX Starlink internet: Costs, collision risks and how it works, Space.com, 14 April 2022. Available online: https://www.space.com/spacex-starlink-satellites.html.

dramatic figure, as scientists explain.[4] Of course, Starlink and SpaceX are not alone. OneWeb, Amazon and others are busy with planning and launching record breaking numbers of satellites, most of them to LEO and some to MEO.

The scientific community led by the International Astronomical Union (IAU), USA[5] has presented a comprehensive report on this subject at UN COPUOS. The 279 pages report, includes both technical recommendations for the sustainability of astronomical research in the mega-constellation era, and regulatory ones:

> "Ultimately, the industry mitigation measures will need codification in national regulation in terms of setting standards and also in finding ways to overcome the barriers of sharing proprietary data. While observatories and industry can implement technical-focused mitigations, further actions are needed from the astronomy community, which includes the wider community of scientists, institutions, societies and governments that support and enable astronomical science. A broad set of recommendations cover actions needed from policymakers and national regulators, which includes standards organisations and economic development agencies, and the range of international policy and coordination bodies such as the Committee on Radio Astronomy Frequencies (CRAF) set up with national policymaker representation."[6]

It is important to note that Starlink already proved its importance, by SpaceX granting communications services via the constellation to the Ukraine during the war with Russia.[7] Both scientific interest and commercial ones which aid persons internationally, are valid and meaningful. These interests, however, must be balanced through a carefully crafted policy, and by the appropriate legal and regulatory tools.

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4 Rayan Morrison, Satellite mega-constellations including SpaceX's Starlink are now a WORSE threat to astronomy than light pollution, experts warn Daily Mail, 7 February 2022. Available online: https://www.dailymail.co.uk/sciencetech/article-10486455/SpaceXs-Starlink-WORSE-threat-astronomy-light-pollution-experts-warn.html; Brian Resnick, Astronomers are very frustrated with Elon Musk's satellites: Who will save the night sky? Vox , last updated 29.04.2021 https://www.vox.com/science-and-health/22396388/space-x-elon-musk-starlink-too-bright-astronomy-stars-pollution.

5 See IAU's website: https://www.iau.org/.

6 UN COPUOS, IAU et al, *Dark and Quiet Skies for Science and Society: Report and recommendations* 2021, page 31. Available online: https://www.iau.org/static/publications/dqskies-book-29-12-20.pdf.

7 Christopher Miller, Mark Scott and Bryan Bender, *UkraineX: How Elon Musk's space satellites changed the war on the ground,* Politico, 8 June 2022. Available online: https://www.politico.eu/article/elon-musk-ukraine-starlink/

### 2.2. Increased liability due to potential probable collisions in LEO and space debris

Congestion in LEO may threaten the long term sustainable use of such low orbits. In that respect, it is less meaningful whether the space objects function or not (meaning active satellites vs. space debris), the challenge is how to mitigate collision risks in such a congested environment, allowing all players a safe use and utilization of their space assets.

With the launch of several mega-constellations which include thousands of satellites each, the magnitude of space objects in LEO is rapidly and dramatically increasing. With such an increase, the probability of collisions increases as well. Although there were no collision events recently, more near-hit events seem to happen.[8]

Taking Starlink again as an example, the media reported the following near collision case:

> "SpaceX received more backlash in September 2019, when the European Space Agency (ESA) announced that it had directed its Aeolus satellite to undertake evasive maneuvers and avoid crashing into "Starlink 44," one of the first 60 satellites in the megaconstellation. The agency took action after learning from the U.S. military that the probability of a collision was 1 in 1,000 – 10 times higher than ESA's threshold for conducting a collision-avoidance maneuver.
>
> In August 2021, Hugh Lewis, the head of the Astronautics Research Group at the University of Southampton, U.K. and Europe's leading space debris expert, told Space.com that Starlink satellites represent the single main sources of collision risk in low Earth orbit.
>
> According to computer models, at that time, Starlink satellites were involved every week in about 1,600 encounters between two spacecraft closer than 0.6 miles (1 kilometer). That's about 50% of all such incidents. This number rises with every new batch of satellites launched into space. By the time Starlink deploys all 12,000 satellites of its first-generation constellation it could reach 90%, Lewis said."[9]

The lack of Space Traffic Management (STM) rules, together with the fact that unlike in GEO, there are no slots allocated per satellites in LEO (this is

8 Brett Tingley, *2 big pieces of space junk nearly collide in orbital 'bad neighborhood'*, SpaceCom, 28 January 2023. Available online: https://www.space.com/space-debris-near-miss-orbital-bad-neighborhood.

9 Adam Mann , Tereza Pultarova and Elizabeth Howell, SpaceX Starlink internet: Costs, collision risks and how it works, Space.com , 14 April 2022. Available online: https://www.space.com/spacex-starlink-satellites.html.

because the orbital dynamics in LEO would not allow such practice), the fact that objects travel in LEO with great speed and finally the fact that some small satellites in LEO lack manoeuvring capabilities, make this environment especially susceptible to accidents.

Collisions between satellites hinder the sustainable use of LEO since: they create small debris particles which causes a cascading effect of increasing debris and potentially damage many more satellites – as described by Kessler[10]; they cause immediate loss of service capacity to the satellite operator, which may cause loss of revenue, in addition to the financial loss derived from the lost satellite as an asset, and; with each collision incident insurance premiums may increase, making third party liability insurance more expensive for operators.

To conclude, by placing more and more satellites in LEO without a clear binding policy which considers collision avoidance, the number of accidents will increase, making the use of LEO more expensive and riskier to operators. In addition, the current guidelines aiming to mitigate space debris seem to be outdated considering current activities in LEO, and their status on the international level is still non-binding.[11]

### 2.3. Exo-environmental impacts due to Lunar activities and other celestial bodies

The Artemis Accords[12] mark humanity's return to the Moon. This time, as opposed to the race to the Moon during the 1960's, industry is involved together with governments.

Commercial enterprises which involve the Moon typically aim to enable mining of natural resources, to gather data on the Lunar environment and composition for commercial purposes and build infrastructure of cargo vehicles- Moon lenders to enable supply from Earth to the Moon.[13]

Remarkably, SpaceIL which is a non-profit organization, managed to build a Lunar spacecraft, launch it with NewSpace practices at a fraction of the cost of a traditional Lunar journey, and crash-land on the surface of the Moon.[14]

This initiative was originally part of the Google Lunar X Prize competition[15] which sparked the imagination of the non-governmental space sector, and encouraged it to try and reach for the Moon.

10 D.J. Kessler et al., Collision frequency of artificial satellites: the creation of a debris belt, J. Geophys. Res. (1978).

11 IADC Space Debris Mitigation Guidelines, Rev.2, IADC-02-01, 2020, Available online: https://orbitaldebris.jsc.nasa.gov/library/iadc-space-debris-guidelines-revision-2.pdf.

12 Artemis Accords: Principles for Cooperation in the Civil Exploration and Use of The Moon, Mars, Comets, and Asteroids for Peaceful Purposes (13 October 2020).

13 See for instance, Blue origin, ispace, and SpaceIL.

14 Jeff Foust, SpaceIL lander crashes on moon, SpaceNews, 11 April 2019. Available online: https://spacenews.com/spaceil-lander-crashes-on-moon/.

Analysing this situation, NASA published a set of guidelines, aimed to preserve historic Apollo Lunar landing sites.[16] These guidelines do not protect the Moon's environment as such, but rather establish keep out zones around the historic landing sites.

There is no doubt that the proliferation of governmental and non-governmental Lunar activities will interfere with the Moon's environment. Mining activities are especially meaningful in this context. With very little legal provisions which protect the Lunar environment,[17] and with the encouragement to mine the Moon in certain jurisdictions,[18] explicitly allowing such activities, it seems that action is needed in order to ensure the long term sustainability of Lunar activities.[19]

Apart from the Moon, mining activities are likely to be performed on asteroids. Legally speaking, asteroids are considered as "celestial bodies" and thus, enjoy similar limited protection in international law.

### 2.4. Pollution on Earth due to launch activities

Under the ETS emission trade scheme, emissions are monitored and restricted by monetary means. The aviation industry went through a challenging regulatory process to reduce emissions from aircrafts, with the regulator's realization that enough is enough, and there is an urgent need to reduce such emissions:

> "The EU ETS is a cornerstone of the EU's policy to combat climate change and its key tool for reducing greenhouse gas emissions cost-effectively. It is the world's first major carbon market and remains the biggest one."[20]

Did you ever contemplate how polluting launch vehicles are? Most of them still use dangerous materials as propellant, and each traditional rocket launch

15 See Google Lunar X Prize's website: https://www.xprize.org/prizes/google-lunar.

16 NASA's Recommendations to Space-Faring Entities: How to Protect and Preserve the Historic and Scientific Value of U.S. Government Lunar Artifacts, 20 July 2011. Available online: https://www.nasa.gov/pdf/617743main_NASA-USG_LUNAR_HISTORIC_SITES_RevA-508.pdf.

17 See author analysis in: Neta Palkovitz, Exploring the Boundaries of Free Exploration and Use of Outer Space- Article IX and the Principle of Due Regard, some Contemporary Considerations, IISL Proceedings of the Colloquium on the Law of Outer Space, 2014.

18 See discussion in: Tanja Masson Zwaan and Neta Palkovitz, Regulation of space resource rights: Meeting the needs of States and private parties, QIL 30 January 2017. Available online: http://www.qil-qdi.org/author/tanja-masson-zwaan-and-neta-palkovitz/.

19 *Ibid.*

20 ETS official webpage on the Earopean Union's website: https://climate.ec.europa.eu/eu-action/eu-emissions-trading-system-eu-ets_en.

involves noise pollution, and emissions. Yet, it seems that the space industry, unlike the aviation industry, is unaffected by the urgent need to combat climate change in respect of launch activities.

There is no doubt that launch services are vital to sustain the space industry, both NewSpace and the traditional space activities depend on them. The question is how to balance the need of launching space objects with the need to protect Earth's environment, and combat the threatening climate change phenomenon.

It is worth to note that the aviation and space industries are developing "green" solutions for less polluting flights and launches. For example, Dawn Aerospace is developing a space cargo vehicle which will be able to launch satellites using non-toxic propellant, and without the need to operate from a traditional launch pad.[21] The space plane takes off from a standard runway, and the rocket engines are fired at a high altitude, reducing pollution dramatically.

## 3. Mapping the legal challenges

### 3.1. Many avenues and instruments, but little harmonization

Space law is a complex creature which constantly exists in two dimensions, the national and the international. While its basic instruments are treaties on the international level, the instruments which concern sustainability are often in the form of guidelines which lack a legally binding effect.[22]

Not all states are members to all treaties, and only some of them have national laws concerning space activities. These laws, where exist, are not harmonized with space laws in other jurisdictions. Some national laws may have reference to environmental interests and sustainable use, while others do not.[23]

Soft law is also formed by different stake holders, be it scientific communities, like in the case of the IADC Space Debris Mitigation Guidelines, which were then adopted by UN COPUOS, or governmental organizations and agencies promoting codes of conduct.[24]

The lack of standardization in this respect is especially challenging when considering commercial non-governmental space activities. Private

21 See Dawn Aerospace's website: https://www.dawnaerospace.com/.

22 See also next subsection.

23 See comparative analysis regarding "environmental protection" in national space laws: National Space Legislation: A Comparative and Evaluative Analysis, Annette Froehlich and Vincent Seffinga Eds. (2018), pages 173-177.

24 European Code of Conduct for Space Debris Mitigation, Issue 1.0, 28 June, 2004, Available online: https://www.unoosa.org/documents/pdf/spacelaw/sd/2004-B5-10.pdf.

corporations can be established in jurisdictions which adopted a more lenient regime concerning sustainability and environmental protection.
In other words, in order to achieve a sound regulatory system which can promote sustainability in space and on Earth, it is not enough to have a few advanced jurisdictions, the effort must be joined, preferably on the international level, to maximize harmonization, and strive to best practices and industry standards.

### 3.2. Lack of binding effect

One of the most significant instruments which aim to mitigate space debris and thus promote long term sustainability in space, are the IACD space debris guidelines. These became an industry standard, however, they are not legally binding per se. This has an effect on compliance, since not all operators are bound by these guidelines. Some jurisdictions "imported" the guidelines from the international non-binding level, to a national binding one, by incorporating a reference to international standards in their national space laws.[25]
Similarly, the Guidelines for the Long-term Sustainability of Outer Space Activities have no legally binding status.[26]

### 3.3. Lack of compliance assurance mechanisms

With the complex legal system which is comprised of norms without a legally binding effect, it is difficult and even impossible to ensure compliance.

### 3.4. Lagging behind industry

It is no wonder that space regulation come as a response to industry trends. It is extremely challenging to predict the market and act to regulate it preemptively.
On the other hand, in this manner of producing regulation, unwanted activities may only be mitigated, not before certain expectations by the industry are formed.
This practice is problematic since it makes it more difficult for entrepreneurs to plan their space endeavors ahead, and space activities as such, require long term planning.
This also affects industry members motivation to comply with regulation which restricts them from executing plans which are already on-going.

25 For instance: Australia, China, The Netherlands, France and the UK all refer to space debris standards in their national space laws, see: National Space Legislation: A Comparative and Evaluative Analysis, Annette Froehlich and Vincent Seffinga Eds. (2018), pages 173-177.

26 Guidelines for the Long-term Sustainability of Outer Space Activities, UN Doc. A/AC.105/2018/CRP.20, available online: https://www.unoosa.org/res/oosadoc/data/documents/2018/aac_1052018crp/aac_1052018crp_20_0_html/AC105_2018_CRP20E.pdf.

In recent years, venture capital investors have also entered the NewSpace market. For them, clarity regarding regulatory obstacles is extremely important as well, as it is a factor in deciding in which enterprise to invest.
To conclude, staying connected with industry trends is important in order to produce meaningful regulation which will enjoy good compliance rates and fruitful cooperation between regulatory bodies and industry. Time is crucial is this respect.

## 4. Suggested solutions

### 4.1. National (space) laws, licencing requirements and corporate responsibility

The author maintains that national space laws are the most effective tool to regulate space activities. Although flags of convenience will probably exist, the states are the ones responsible for the conducts of their nationals in outer space pursuant to Article VI of the Outer Space Treaty.[27]
State laws are binding on nationals, they usually include penalties for lack of compliance,[28] and can rely on existing enforcement mechanisms.
In case of light pollution and pollution due to launch activities, promoting sustainability and environmental protection can be done by enacting laws which are not necessarily space related.
Two examples show the potential of using such legislation to promote sustainability in space activities:

> "La Palma was the first place in the world to apply the Sky Law promoted by the Institute of Astrophysics of Canary Island in 1988, a specific law was passed designed to protect the quality of the night sky for the purpose of astrophysical observation, which was a giant step forward in defence of the sky on a world-wide scale. This law protects La Palma from light, atmospheric and radioelectrical pollution, as well as preventing interference from aviation routes."[29]

27 For deep analysis of state obligations and practices with respect to Article VI *see*: Neta Palkovitz, Regulating a Revolution: Small Satellites and the Law of Outer Space, 2020, pages 63-90.
28 David Shepardson, FCC fines Swarm $900,000 for unauthorized satellite launch, Reuters, 21 December 2018. Available Online: https://www.reuters.com/article/us-usa-satellite-fine-idUSKCN1OJ2WT.
29 UN COPUOS, IAU et al, Dark and Quiet Skies for Science and Society: Report and recommendations 2021, page 188. Available online: https://www.iau.org/static/publications/dqskies-book-29-12-20.pdf.

A different example shows that applying laws on space activities may make a difference, if the regulator wishes to ensure sustainability of space activities by nationals, there is a way:

> "In a recent FCC approval of SpaceX orbital operations, the FCC notes that SpaceX does not need to conduct a National Environmental Policy Act (NEPA) assessment of its operations. (This would require assessing the environmental impact of the satellites; stemming from a 1986 FCC decision, satellites are exempt from NEPA.) The FCC writes it "will continue to monitor this situation" when it comes to astronomy interference."[30]

In this case there is justification to re-assess this exemption which was given in the context of space activities in 1986. Clearly, the magnitude of space activities in the US has changed dramatically in the course of almost 40 years. Further, the emergence of NewSpace operators show that different stake holders are enjoying this exemption in our time.
Promoting national regulatory arrangements which will apply on corporates, using legal tools as corporate responsibility are also measures to consider.

### 4.2. Incentives for "green space"

Instead of forbidding polluting space activities, there is also an option to give incentives to "green" activities, which are in line with long term sustainability goals.
Such incentives may come in the form of grants to businesses which develop green space technology, preferable terms on operations license can also be a motivating solution for operators.
In such an example, a "green space operator" may get favourable license fees for instance.
It is possible for the state to ask for a lower minimum sum to cover against third party liability in cases of green space operators, effectively giving such operators a discount in insurance premium prices they have to pay in order to obtain their operation license.

### 4.3. Next step- harmonization

The first step is to establish a set of laws which would effectively promote the long-term sustainability of space activities, in outer space and on Earth. The second step should be focusing on harmonization.

30 Brian Resnick, Astronomers are very frustrated with Elon Musk's satellites: Who will save the night sky? Vox, last updated 29.04.2021, available online: https://www.vox.com/science-and-health/22396388/space-x-elon-musk-starlink-too-bright-astronomy-stars-pollution.

Firstly, unity of laws may cause customary international law to crystallize on the longer term, which means international regulation will be formed even if no consent on a new treaty is reached.[31]
Secondly, unification will promote and enable cooperation in space activities between entities from different jurisdictions.
Thirdly, eliminating flags of convenience as an option to circumvent regulatory efforts is important in this context. Both space and Earth belong to us all, and nature and climate do not distinguish us according to nationalities. We must protect our environment and ourselves by a joint effort.

### 4.4. Continue efforts in COPUOS and other international fora

Efforts to steer international law towards protecting the environment and promoting long term sustainability must continue. Adopting the UN Guidelines on the Long Term Sustainability of Outer Space[32] is a good step in that direction.
In the future, the author hopes that such guidelines will gain a legally-binding status, and include more concrete rules and principles industry can follow without ambiguity.

## 5. Conclusions

This paper mapped four main challenges which states, and industry, will have to face in connection to sustainability and the environment.
These four case studies: light pollution, increase in liability for operators, protecting Lunar and asteroid environments and protecting Earth's environment from pollution due to launches, are only selected contemporary examples. More challenges may arise in the future, but, the way we choose to deal with the current challenges will be meaningful for those challenges which will come next.
As shown, the current legal system is complex, and not always effective or sufficient in order to generate full compliance by both states and industry.
Focusing on creating effective national legislation which will make a difference is at the highest importance in the author's opinion. These national instruments can either forbid polluting activities, create incentives for entrepreneurs to develop green space technology, or both.

31 Neta Palkovitz, Regulating a Revolution: Small Satellites and the Law of Outer Space, 2020, see discussion in chapter 2.

32 Guidelines for the Long-term Sustainability of Outer Space Activities, UN Doc. A/AC.105/2018/CRP.20, available online: https://www.unoosa.org/res/oosadoc/data/documents/2018/aac_1052018crp/aac_1052018crp_20_0_html/AC105_2018_CRP20E.pdf.

Harmonization and progress at the international level are also extremely important, however, less responsive to industry trends, and therefore, these are only part of the solution.
In conclusion, even though the need is to regulate the commons, the type of regulation would probably be distributed rather than centralized-internationally.
Be it distributed or centralized, the time to give priority to the long-term sustainability of outer space and Earth, and creating a productive synergy between regulators and industry, is now.