



HAL
open science

Reinventing treaty compliant “safety zones” in the context of space sustainability

Lucas Mallowan, Lucien Rapp, Maria Topka

► To cite this version:

Lucas Mallowan, Lucien Rapp, Maria Topka. Reinventing treaty compliant “safety zones” in the context of space sustainability. *Journal of Space Safety Engineering*, 2021, vol.8 (n°2), pp.155-166. <hal-03585522>

HAL Id: hal-03585522

<https://hal.science/hal-03585522v1>

Submitted on 8 Mar 2022

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.



HAL Authorization

**TOULOUSE
CAPITOLE**
Publications



« Toulouse Capitole Publications » est l'archive institutionnelle de
l'Université Toulouse 1 Capitole.

Reinventing treaty compliant “safety zones” in the context of space sustainability

Lucas Mallowan, Lucien Rapp, Maria Topka

Université Toulouse 1 Capitole

Pour toute question sur Toulouse Capitole Publications,
contacter portail-publi@ut-capitole.fr



Reinventing treaty compliant “safety zones” in the context of space sustainability

Lucas Mallowan, Lucien Rapp*, Maria Topka

Chaire SIRIUS/IDETCOM - Faculté de droit - Université Toulouse-Capitole, Toulouse F-31042, France

ARTICLE INFO

Keywords:

Safety zones
New space
Artemis accords
Deconfliction of space activities
OST
Moon treaty
Non appropriation principle
Space law
Maritime law
Aviation law
State's jurisdiction
Extra-territorial jurisdiction in outer space

Article history:

Received 16 February 2021
Received in revised form 22 April 2021
Accepted 6 May 2021
Available online 26 May 2021

ABSTRACT

This paper questions the concept of safety zones, tracing it to maritime and military law, in order to unpack its potential legal uses, applications and implications in the current context of the New Space economy. To achieve this, it starts by investigating the historical foundations of safety zones rooted in the Cold-War-era legal literature and then move on to a larger discussion of how such zones can be balanced with the non-appropriation principle. Then, this paper examines a number of legal analogies, as they appear in maritime law, aviation law as well as relevant examples in outer-space law. Lastly, it attempts to sketch the outline of a “solution” that identifies the criteria, to be used in order to model a potential safety zone that strikes a balance between the industry’s growing concerns and requirements on one hand, and the legal prohibitions that preclude sovereign claims on outer space on the other hand. Particular attention is given to the special case of the United States’ extraterritorial jurisdiction in outer space.

1. Introduction

The establishment of protective zones around space objects —such as exclusion zones, keep-out zones and safety zones— has long been a contentious issue in space law. These zones have been proposed as a way for traditional stakeholders, mainly government entities, to maintain exclusive rights to the immediate orbital space surrounding their various space assets stationed in orbit. A hot-topic issue in the context of the Cold War, the question of such zones, and in particular, safety zones, reemerges today.

On 15 May 2020, in the framework of the so-called “Artemis Accords”,¹ NASA announced its intention to propose to the international community a dozen common principles “for a Safe, Peaceful and Prosperous Future” to guide the exploration and use of outer space and more particularly, US-led lunar activities. Officially introduced on October 13, 2020, the Artemis Accords [1] set out the principles to which other States are also expected to adhere to in their participation in the Artemis program.

One of the issues that the Artemis Accords address is the exploitation of space resources, and within this context, the deconfliction of operations on the Moon and other celestial bodies. In this respect, the Accords constitute in fact a continuation of the initiatives² begun in the early 2010s to promote the possibility of exploiting space resources, whether they be satellite debris or natural resources that could be extracted from celestial bodies, such as asteroids and the Moon.

Among the principles enunciated is in particular the establishment of “safety zones”,³ placed under the aegis of Article IX of the Outer Space Treaty (OST) [2], which crystallizes the obligation to avoid harmful interference. The implementation of safety zones could be an increasingly pressing concern for both government and non-governmental entities: As non-traditional market entrants vie for greater access to space, new challenges arise with regard not only to space traffic management (STM), but also to intellectual property, data privacy, third-party liabil-

² These initiatives include: the *Space Resource Exploration and Utilization Act* of 2015 (which did not pass Congress and did not become U.S. law); Title IV of the U.S. *Commercial Space Launch Competitiveness Act* of 2015; and more recently, the *Executive Order 13914* of April 6, 2020.

³ Section 11 of the Artemis Accords, titled “*Deconfliction of Space Activities*”.

* Corresponding author.

E-mail addresses: lucien.rapp@ut-capitole.fr (L. Mallowan), lucien.rapp@ut-capitole.fr (L. Rapp), maria.topka@ut-capitole.fr (M. Topka).

¹ The Artemis Accords are part of the Artemis program launched in 2017 by U.S. President Donald Trump. This program is articulated in several stages, the end-point of which should be the sending of astronauts on the lunar ground in 2024. Ultimately, the goal is to build a sustainable infrastructure on the Moon’s surface in preparation for future missions to Mars. Despite NASA’s leadership, space agencies around the world are invited to collaborate in this program.

ity, or in-orbit insurance. These challenges are exacerbated by the progressive placing in orbit of constellations of thousands of micro-satellites which will exponentially increase the number of orbited space assets in the coming years, despite radio-frequency spectrum allocation and orbital slot availability remaining a finite and scarce resource.

It is therefore not surprising that the concept of safety zones – resurfaces, bringing along questions concerning the possibility of claiming (quasi-)exclusive rights of orbital space usage and “sanctuary zones” on celestial bodies, even where such uses enter in potential conflict with the Outer Space Treaty.

During the Cold War era, safety zones were discussed primarily as a means for conflict deterrence. But what used to be, during this period, a fairly straightforward dilemma, has shifted today from a space race mindset into the grayer area of market-driven competition between private businesses in the New Space economy.⁴

The generalization of protective zones around assets and/or operations in space, whether they are, for example, safety zones, self-defense zones, keep-out zones etc., raises the delicate problem of their compatibility with the treaties governing space activities, starting with the Outer Space Treaty. The establishment of such zones may be regarded by critics as part of a logic, if not of appropriation of space, at least of achieving exclusive (to a greater or lesser degree) control of the use of areas in space, eventually transforming them into specific actors’ “spheres of influence” [3], which would evidently be in conflict with the OST principle of non-appropriation. After all, the OST expressly states that outer space is not subject to “national appropriation by claim of sovereignty, by means of use or occupation, or by any other means” (emphasis added). However, as will be seen, this provision has prompted divergent interpretations due to the ambiguity surrounding the term “national appropriation”, as well as due to the question whether the term “outer space” only encompasses the surfaces of celestial bodies or whether it also includes space resources that they may contain.

This paper will therefore question the concept of safety zones by tracing it to maritime and military law, in order to draw parallels and unpack its potential legal uses, applications and implications in the current context of the NewSpace economy. To achieve this, we will start by investigating the historical foundations of safety zones rooted in the Cold-War-era legal literature (Section 2). Then, we will examine a number of legal analogies, as they appear in maritime law, aviation law and outer-space law (Section 3). Subsequently, we will move on to a larger discussion of how safety zones can be balanced with the non-appropriation principle (Section 4). Particular attention will also be given to the special case of the United States’ extraterritorial jurisdiction in outer space (Section 5), which puts an interesting spin on the subject of safety zones, as the United States and other countries may recognize implicit jurisdictional powers in space. These powers do not amount to a claim of sovereignty per se, but they could create zones where a state may impose its own rule of law upon a non-sovereign territory. Lastly, we shall attempt to sketch the outline of a “solution” that identifies the criteria, which need to be used in order to model a potential safety zone that strikes a balance between the industry’s growing concerns and requirements on one hand, and the legal prohibitions that preclude sovereign claims on outer space on the other hand (Section 6).

⁴ In the present article we employ the term “NewSpace” to refer to the modern-day shift from a heavily State-dominated and government-dependent space sector towards a space “ecosystem” that is more participatory and thus characterized by an increasing participation of private actors, as well as more commercialized and thus more market-oriented and profit-driven. NewSpace ultimately aims to render access to and the uses of space more efficient, affordable and even profitable. The term “NewSpace economy” refers herein to the aggregate of economic activities being carried out by both private and governmental actors within and/or in relation to the NewSpace ecosystem.

2. Historical perspectives on safety zones and relevant concepts

The rationale behind the concept of protective zones around objects or missions in space is rooted in the protection of these space assets and these operations from threats and hostile activity against them—a concern that was all the more pressing during the Cold War, where geopolitical adversaries feared the neutralization of their assets by the use of space weapons, such as space mines [4].

Historically, various names have been used to describe this concept’s various manifestations, such as: safety zones, keep-out zones, security zones, caution zones, zones of self-defense, zones of exclusivity, etc. (collectively referred to herein as “protective zones”). Despite the varying nomenclature and features, such zones can broadly be associated with the two following categories:

- i) either asset-specific zones surrounding determined man-made space objects, or
- ii) mission-specific zones established in specific regions in outer space (“area-based”) and assigned to a specific State or group of States ‘claiming’ that area to conduct a mission or operation (rendering these zones, thus, State-specific as well),

both of which may constitute “[areas] of space through which the space objects of other nations could not pass without permission” [5,6].

A typical manifestation of asset-specific protective zones are keep-out zones. One of the first comprehensive attempts to provide a legal framework to such zones in space has been a US Congress mandated report issued by the Office of Technology Assessment (OTA) in the 1980s [7], which defined unilaterally declared or negotiated keep-out zones as “a volume around a space asset, off limits to parties not owners of the asset”. While the OTA report failed to address the issue of the legality of keep-out zones under the OST national appropriation prohibition, it sketched out a basic set of rules to attempt to define them [8]. The OTA Basic Set of Rules recommended:

- Keep 100 kilometers and three degrees out-of-plane from foreign satellites below 5000 km.
- Keep 500 km from foreign satellites above 5000 km except those within 500 km of geosynchronous altitude.
- One pre-announced close approach at a time is allowed.
- In the event of a violation of the rules above, the nation of registry of the satellite most recently initiated a maneuver “burn” is at fault and guilty of trespass.
- Satellites trespassing upon safety zones may be forcibly prevented from continued trespass.”

Despite being comprehensive and specific, such a definition is however hardly convincing in today’s context. It rather reflects the originally intended purposes of keep-out zones in space, such as the need to “secure permanently orbiting weapon installations as part of national space-based infrastructure,” which would even justify immediate reprisal or destruction of any trespassing object [9].

On the other hand, in the 1980s, Wohlstetter and Chow [10] proposed the “self-defense zones (SDZ)” model, which they contrasted to the “keep-out zone” concept. Self-defense zones were conceived as broad, predefined areas intending to protect a mission in its entirety; they would thus include all space assets used to carry out the mission, rather than a single specific space object [10]. The SDZ—which according to Wohlstetter and Chow should be determined through international agreements—, would allow a state to secure a predetermined area in order to give it the necessary room to conduct its mission while also permitting innocent routine operations of foreign satellites within this area. The number of space systems that a state would be able to deploy within the confines of this zone would not be limited. Rather, the SDZ would be more closely contingent upon the mission duration, but also would depend on other factors such as satellite population and the developments in offensive and defensive space technologies (see [10], in particular p. 63).

Table 1
Asset-based vs. mission-specific zones and their parameters.

	Asset-based safety zone	Mission-specific area-based safety zone
Object	Protecting a specific space object	Claiming exclusive rights to a specific area in which a mission is conducted
Scope/Location	Established permanently around the space object	Geographic area identified based on where the mission is taking place
Duration	Lifespan of a space object	Mission duration
Nature	Personal rights (held by the holder)	Rights in rem (attached to the occupied zone)
Rights	Occupy, quiet enjoyment, prohibit access, alienation (cede, pledge)	Occupy, operate, control access, manage the rights granted to occupants, alienation (cede, pledge)
Holder of rights	- Exercise of rights: owner of the space object, operator, various/shared stakeholders - Rights management: State	Management and exercise of rights: State
Enforcement	Gradual, reasonable, proportionate. Restrictions imposed, publicly declared and/or appropriately notified. May justify reprisal or immediate destruction of the intruding object.	Gradual, reasonable, proportionate. Restrictions imposed, publicly declared and/or appropriately notified. Rights to inspect, mediate, expel if deemed necessary.

The mission-centered feature of this model aims to provide states with more flexibility than the space-object-centered proposal. The asset-based approach essentially limits the safety zone to giving space objects sufficiently wide berth to operate safely, predicated on considerations of just how wide such a safety berth ought to be without amounting to an OST Article II violation. By contrast, by binding the exclusive zone to a mission rather than to a satellite, Wohlstetter and Chow's proposed model attempts to strike a delicate balance by "reserving" parts of space for the exclusive rights of a state without actually claiming outright sovereignty over the reserved portions.

The self-imposed limitations of this model, aimed at safeguarding against unlawful sovereign claims, would be: i) the temporary nature of the exclusive occupancy (i.e. the duration of the mission) and ii) limitation on the types of exclusions that a state would be allowed to enforce. The primary object of self-defense zones in space is to deter surprise attacks, and, accordingly, states would only be allowed to filter out intruding space objects that would potentially threaten security. The zone would not prohibit third-party use of a same space sector, and enforcement measures would have to be gradual, reasonable and proportionate, with rights to inspect, to mediate and only to expel in serious situations [10].

For a comparison between the features of these two models see Table 1.

A third approach refers to the concept of "exclusive economic zone" and consequently, relates to the rights exercised therein (see [11]). An exclusive economic zone (developed in more detail in Section 3.1) implies the exercise of sovereign (mostly economic) rights within an area that is not part of the territory of the respective State. These rights in turn raise several questions pertaining to:

- i) Their nature: Are they property rights *stricto sensu*, or only rights of control? Can they be dismembered into *usus*, *fructus* and *abusus*?
- ii) Their enforcement (opposability to third parties) and their scope: Are they compatible with a right of innocent passage or free access to space? Do they establish a systematic authorization regime? How to make them compatible with the fact that the protected object is in motion? Are these rights attached to a protected area, to a space object, or to the extracted and exploited resources?
- iii) Property rights thereon: who owns them, the State or its nationals? In the latter case, would the owner be the operator of the space object concerned? The operator authorized to operate in a given space area? Its financial backers, if it has transferred its rights to them?
- iv) Their regime: are they transferable? Are they valuable? Can they, for example, appear on the assets side of the balance sheet of the owner of the protected space object?

As for safety zones in particular, they have been defined as zones "within which the states on whose registry the objects are carried would exercise their sovereign rights of jurisdiction and control" [12]. Safety zones in space would not lead to appropriation of areas in space and on celestial bodies, but, rather, they would be similar to safety zones

in maritime law: "[j]ust as the establishment of such zones cannot be interpreted as appropriation of territory, so the establishment of safety zones around space objects cannot be seen as a sovereignty claim to the territory or space occupied by these zones" [12]. Safety zones would extend to a reasonable distance around a facility and their purpose would be to ensure the security of the facility by promoting safe traffic in its vicinity [13].

Notwithstanding, whereas safety zones used to be an essentially theoretical issue back in the Cold-War era, they reemerge today in much more practical terms. As outer space is nowadays less of a purely State-dominated realm used as a geostrategic backdrop for superpower signaling than it once was, it is now evolving into a more complex sector that is characterized by a plurality of actors and new forces shaping the space industry. These developments are something the legal landscape has been called to adapt to and reflect. Chief among these forces are private initiative, free enterprise, and the reticence of commercial operators to have state regulators overcrowd outer space with regulations that hamper innovative uses of technology.

In this context, in order to secure their assets and their investments, not only governmental players but also commercial operators are presently pressing closer towards the realization of a model that would eventually allow them to (potentially) unilaterally declare safety and security zones around critical space objects in outer space.⁵ This, evidently, raises anew the question of non-appropriation of outer space, but also highlights its clash with the OST-enunciated freedom of use of outer space, as will be demonstrated below.

Our discussion therefore warrants a reevaluation of the non-appropriation principle and the conditions under which it might be conceivable for state and non-state actors to declare lawful safety zones. But prior to delving into this issue, it is helpful to examine a number of relevant analogies which demonstrate how safety zones and their various guises have been implemented in the maritime-, aviation- and space law fields so far.

3. Safety zones through legal analogy (maritime, air and outer space)

3.1. The maritime analogy

The principle of non-appropriation of outer space, the freedom of exploration and use of outer space, as well as the principle that all States

⁵ In fact, one salient consequence of safety zones resurfacing is reflected in space insurance, with the potential of redefining the legal landscape for this niche industry. Safety zones could be, for example, a prior condition for insurance companies to provide coverage, or the deciding factor in how insurable interest and indemnity, claims handling, liability and due diligence with regard to space assets will be determined and adjudicated in the near future. And to approach this topic from the opposite point of view, space companies might also want to secure such exclusivity zones to prevent scrutiny even from insurers.

shall enjoy free access to all areas of outer space and celestial bodies, are overarching space law principles that run parallel to the doctrine of freedom of the seas. The freedom of the seas has been a mainstay of maritime law since Grotius's seminal 1609 work "Mare Liberum". According to Perlman [14], "for as long as the notion of 'space law' has existed, people have analogized it to the law of the sea ... [B]oth sea and outer space are mediums of travel, require vessels for human transport, are perilous, and virtually unlimited in scope ... but they also embody intangible ideas of the pursuit of exploration, possibility, expansion, technological evolution, colonization, scientific experimentation, fascination with the unknown, and increased freedom of movement.". Yet even the concept of the freedom of the seas has gradually evolved over the centuries and today it is not considered to be an absolute right, as nations have laid claim on internal waters, territorial waters, contiguous waters, even enjoying specific sovereign and exclusive usage rights within maritime zones that are not part of their territory, such as the exclusive economic zone.

Whereas internal and territorial waters have always fallen within the sovereign boundaries of the state, zones that establish some form of exclusivity based on "use-related control" (see [15]), such as the exclusive economic zone (EEZ) and maritime exclusion zones in the high seas, are much more recent concepts and constitute a clean break with customary doctrine. Exclusive economic zones were formally recognized by the 1982 United Nations Convention on the Law of the Sea ("UNCLOS") [16]. The EEZ is adjacent to the territorial sea and extends up to "200 nautical miles from the baselines from which the breadth of the territorial sea is measured" (Articles 55 and 57 UNCLOS). Although the EEZ does not constitute territory of the coastal State, the latter enjoys sovereign economic rights therein (e.g. exclusive exploitation of natural resources, construction of offshore installations, scientific research). That said, the coastal State cannot restrain the freedoms of navigation and overflight within this zone, as long as they are exercised with due regard to its laws and regulations (Article 58 UNCLOS).

Within the EEZ, the coastal State is allowed to lawfully establish permanent safety zones around artificial islands, installations and structures (Article 60 UNCLOS). Their radius can extend up to 500 meters around these installations, and the coastal States may exert exclusive jurisdiction within them, which it may enforce with reasonable and proportional force. Although the UNCLOS does not define the scope of protective measures that can be employed within safety zones, state practice demonstrates that they are essentially areas of restricted navigation [17]. The International Maritime Organization (IMO) recommends that governments ensure that ships flying their flag do not wrongly enter or pass through duly established safety zones unless specifically authorized (IMO Resolution A.671 [16,18]).

The power of states to push their sovereign reach well beyond their immediate borders and within international waters has been tested yet again with the concept of maritime exclusion zones. Maritime exclusion zones are zones on the high seas that belligerents might establish at times of war, and which have the effect of restricting access to ships within the designated area [19]. These zones have been described as "one of the most controversial issues in the law of armed conflict at sea" due to their ability to restrict the customary freedom of the high seas [20]. In the absence of recognized and mutually agreed-upon standards, some naval warfare legal scholarship, which has examined the lawfulness of maritime exclusion zones in the context of armed conflict at sea, raises a number of insights into how safety zones in space might be approached. The San Remo Manual [21], compiled by the International Institute of Humanitarian Law, is of particular interest in this regard: It has served as a blueprint model establishing the conditions in which maritime exclusion zones might ensure the least possible encroachment on the freedom of the seas for third party nations (see Table 2).

The salient feature of these stipulations is that exclusion zones, in order to be lawful, cannot be absolute and unilateral, but rather they must be bounded in terms of size, of purpose, of duration, of enforcement mechanisms, of guarantees (proportionality, safe passage, etc.) and of

Table 2

Proposed stipulations of the International Institute of Humanitarian Law [5,21].

Conditions to ensure the least possible restrictions of the freedoms of the high seas
- The same body of law applies both inside and outside the zone;
- The extent, location, and duration of the zone and the measures imposed shall not exceed what is strictly required by military necessity and the principles of proportionality;
- Due regard shall be given to the rights of neutral States to legitimate uses of the seas;
- Necessary safe passage through the zone for neutral vessels and aircraft shall be provided (i). where the geographical extent of the zone significantly impedes free and safe access to the ports and coasts of a neutral State; and (ii). in other cases where normal navigation routes are affected, except where military requirements do not permit; and
- The commencement, duration, location, and extent of the zone, as well as the restrictions imposed, shall be publicly declared and appropriately notified.

legal regime. These markers are reproducible for any type of protective zone, be it in the high seas or in space. The underlying argument for these conditions is that a state's hold on an area beyond national jurisdiction (ABNJ) cannot be permanent, absolute or sovereign; rather, it is temporary, limited and conditional.

3.2. The air analogy

Aviation law may also serve as a field from which analogies could be drawn in order to lay down the parameters for a potential model for safety zones in space.

The Convention on International Civil Aviation [22] ("Chicago Convention") foresees, for example, the establishment, in the territory of a State, of areas over which the flight of aircraft may be restricted or even prohibited (Article 9 of the Chicago Convention). Such restriction and/or prohibition of overflight must, however, be justified by legitimate reasons, such as military necessity or public safety. The extent and the location of such prohibited areas should be established in a reasonable manner, so as not to interfere unnecessarily with air navigation. Moreover, aircraft of the State that enacts this restriction and aircraft of other States should not be subject to differentiated treatment in respect to whether they are allowed or not to flight over these zones.

Of course, whereas outer space is a non-sovereign area, Article 9 of the Chicago Convention concerns areas which are part of a State's territory. Nevertheless, the parameters set forth in this article (namely, reasonably established extent and location of this zone, legitimate justification, minimization of interference with international navigation, no discrimination between who can or cannot traverse this zone) may still constitute interesting criteria that could be taken into account in the establishment of safety zones in space.

Maritime exclusion zones, introduced in Section 3.1, may also deny or restrict international civil aviation, considering that aircraft over these zones run the risk of being attacked [19]. For this reason, the establishment of any zone that could affect international aviation requires the relevant notification to the ICAO, and its delimitation must be carried out reasonably and in proportion to the military necessity they are being established for [19].

Apart from international practices, State practice may also serve as a potential model for what protective or exclusion zones in space could shape up to be.

US law, for example, foresees the designation of "Special Use Airspace" areas for operations which require imposing limitations on the use of airspace by non-participating aircraft [19]. Such areas can include: i) restricted airspace, ii) prohibited airspace, iii) military operations areas, iv) warning areas, v) alert areas, and vi) controlled firing areas (see [23]). Among these, it is interesting to note that "warning areas" are usually designated in international airspace. However, since states do not have the legal capacity to prevent flights through warning

areas, they serve rather as a warning of the danger that aircraft may encounter if they enter the zone [19]. Moreover, several States have established "Air Defense Identification Zones" (ADIZ) in international airspace. The International Civil Aviation Organization (ICAO) defines ADIZ as special designated airspace zones within which aircraft must comply with special identification and/or reporting procedures [24]. For example, the US Code of Federal Regulations (CFR) requires the ready identification, location, and control of all aircraft entering the US ADIZ for reasons of national security (14 CFR § 99.3).

Despite these parallels, however, in the advent of NewSpace, and considering the advances in aerospace technology, there are a number of gaps in the airspace - outer space analogy which legal scholars are at pains to fill.

Chief among these gaps is the unclear delimitation between airspace and outer space. While no foreign aircraft is permitted to intrude sovereign airspace as per Article 6 of the Chicago Convention, the applicable restrictions seem less clear in the case of intruding or spying spacecraft. Without an agreed boundary between airspace and outer space, when is a foreign spacecraft an intruder rather than a lawful observer? And, most crucially, how far ought states to be allowed to extend their upward boundaries to protect their sovereign airspace, and where should these same boundaries stop in order to protect the common good, which is outer space?

Importantly, neither the term "airspace" nor "outer space" are provided with a specific definition within the relevant treaties. However, identifying an exact boundary line between the two is crucial in understanding governments' power—or lack thereof—to set claims on areas above the Earth's surface. In examining this question, two different schools of thought have emerged: the prevailing spatialist approach versus the emerging functionalist viewpoint. Spatialism holds that world governments should agree on one imaginary and arbitrary line drawing the boundary between airspace and outer space. One commonly accepted such line is the one suggested by Theodore von Kármán (drawn at 100 kilometers above the Earth's sea level), which has also been recognized by the Fédération aéronautique internationale [25]. However, the development of modern military and commercial technology that enables vehicles and other devices (e.g. observation craft, stratospheric balloons, high altitude drones, space elevators) to operate in sub-space, near-space and even orbital space,⁶ have elucidated the limitations inherent to this definition.

Such systems do not fall into neat categories and can easily straddle legal definitions. As a result, the emerging functionalist school of thought has attempted to provide a more flexible approach to differentiating between sovereign airspace and non-sovereign outer space. It considers the nature, characteristics, functionalities and purpose of the air- or spacecraft in question. It aims at determining whether the vehicle should be considered as an aircraft, rendering it therefore subject to airspace law and answerable to the sovereign states above which it operates, or whether it is a spacecraft, thus falling within the scope of the various space treaties and eschewing sovereign jurisdiction.

According to the functionalist approach, the legal characterization of a space object would be established using the traditional legal standard of the balance of probabilities, whereby the likeliest actual use and the attending characteristics indicate the actual intended and true use of the space object. In a legal dispute, it would befall the operator to prove that the space object falls into a different category and that the opposite legal regime should apply. Drawing from these concepts, a functionalist approach to exclusion zones in space precludes a precise definition of a lawful range (a given distance in kilometers), since its recognition or attribution would depend on the specific purpose of the space mission or the space system [8]. Economy in the use of low Earth orbital space would lead to smaller exclusion zones, although for some purposes larger ones would be required [8].

3.3. The orbital space and celestial bodies analogy

International discussion on Space Traffic Management—a pressing agenda for space regulators today—has not addressed the issue of safety zones directly. However, even despite this absence, the issue of safe and sustainable space operations in an increasingly overcrowded (and much-littered) orbital environment invites discussion of *res communis*, equal access to space resources (navigational space itself, becoming a resource as soon as launching windows become scarce) and the non-appropriation principle.

At its most basic level, the need for exclusive space zones arises from the fact that space traffic requires a minimum standard of coordination since the gradual orbital overcrowding with space objects renders space traffic hazardous. In this respect, the inevitable question of territorially strategic occupancy of space systems (e.g. by remaining stationed in a determined position for an indefinite period of time) is eventually bound to be challenged, not solely as a STM concern, but also as an implicit Article II violation due to quasi-exclusive claims to a space zone. Such implicit challenge might, for instance, arise from the deployment of swarm technologies in orbit, which could create a *de facto* exclusion zone by simply occupying a theoretically free navigation zone and prohibiting entry in it by invoking the threat of collision. On the other hand, while STM does not concern itself at *prima facie* with issues of sovereignty in space, STM traffic and operational coordination may itself constitute a possible (but very real) restriction of the absolute freedom of access and use of outer space, such as prescribed by Article I of the OST.

Current STM recommendations for safer space operations—such as those emerging from the 2011 European Union Code of Conduct and the 2018 Committee on the Peaceful Uses of Outer Space (COPUOS) Guidelines for the Long-Term Sustainability of Space Activities (LTSSA)—advise a series of measures. These aim at improving debris mitigation, collision avoidance and monitoring of space weather, through specific consultation and information sharing mechanisms between countries conducting space activities [26]. The implementation of such a regime would call for a comprehensive set of harmonized safety standards, which would *inter alia* include: launch, in-orbit, reentry and spaceflight protocols, maneuver prioritization rules, clarified definitions of space law terms ('space object', 'fault', 'liability', etc.), harmonized national licensing systems, and, crucially for our purposes, revamped orbital zoning rules [26]. Establishing such standards would bear deep implications for the space insurance industry, considering that, at the present, insurers must learn to reposition themselves in a sector that is increasingly risk-prone and where the costs of underwriting space activities become increasingly steep [27].

In overlapping operational and navigational safety with orbital zoning and with the necessity to redefine space objects, STM implicitly cracks the door open to draw in the topic of safety exclusion zones, which have the potential to redefine areas of ownership in space.

One analogy that lies much closer to the topic at hand is the partitioning of sovereignty above the International Space Station (ISS). The case of the ISS poses an interesting alternative to the issue of sovereignty rights in space and how these can—albeit to a limited extent—bypass the non-appropriation principle. It is worth noting that the ISS also has defined a 200-meter keep-out zone (cf. Table 3), meaning that external vehicles are only permitted to fly in this zone with approval and within a defined approach corridor and the only permitted exceptions to this 200-meter rule concern ISS survey missions [28]. Moreover, the ISS has a "nominal approach ellipsoid" (which extends four kilometers both in front and behind the ISS path and two kilometers above, below, and beside it) for the purposes of reducing the chance of collisions and to make the intent of nearby objects clear [28]. However, the legal complexity lies within the ISS itself, and how sovereignty is apportioned above the station.

The ISS is composed of different segments, each belonging to and subject to the jurisdiction and control of the Partner that respectively provided it. Therefore, different legal regimes apply to different seg-

⁶ I.e., at altitudes between 20 to over 100 kilometers above the Earth.

Table 3
"One-size-fits-all" standard?

ISS	OTA	GEO	LEO	Orbital spots (GEO/ITU) (to avoid collision and interferences)	SpaceX Starlink Sats (minimum crossing distance between satellites)
200 m	100 km	73 km	5 km	1000 km (1800 parking spots)	90 km

ments of the ISS, even while the ISS forms a whole. Several more or less appropriate analogies have been used to illustrate the jurisdictional partitioning above the ISS. An example would be diplomatic representation and sovereign state recognition of embassy extraterritoriality and inviolability, as per the 1961 Vienna Convention on Diplomatic Relations [29]. The ISS has no fixed territorial referent, no fixed coordinates, and although it is of course possible to plot its course, the sovereign claims attached to it are considered to be in constant flux—something which has been described as quantum sovereignty [30]. Based on these considerations, the question may be raised whether the establishment of safety zones or other protective zones in space would also lead to different legal regimes applying to different areas in outer space and on celestial bodies. Nevertheless, such an analogy would not be fully justified considering that ISS is a space object, consisting itself of several modules, over every one of which the States of registry retain jurisdiction and control as per Article VIII OST. By contrast, any protective zone beyond the Earth would be established in an area in orbit or on a celestial body which are not subject to national appropriation by any means, and thus not subject to a State's jurisdiction and control.

Another practical manifestation of safety zones that has gained increased traction, is its use as a way to facilitate rendezvous and proximity operations. Rendezvous and proximity operations (RPO) generally refer to orbital maneuvers in which two spacecraft arrive at the same orbit and approach at a close distance (without this rendezvous necessarily being followed by a docking procedure) [28]. More specifically, "rendezvous" refers to the process of matching the plane, altitude, and phasing of two (or more) satellites, while the term "proximity operations" describes the process in which two (or more) satellites in roughly the same orbit intentionally perform maneuvers to affect their relative states [28]. RPO enables servicing activities, such as remote inspection, refueling, repair, parts replenishment, as well as orbit maintenance or orbit transfer and the de-orbiting of spacecraft [31]. Due to the nature of these activities, for reasons of safety an RPO activity may require the designation of keep-out spheres around the "Client" (the spacecraft that is the recipient of the operation), including the establishment of safe distances which, if not respected, would lead to abort or other operations prior to docking [32]. Safety zones in those instances may help prevent unannounced or uncoordinated close approaches, an ability which would serve both security and (possibly) competition purposes.

Moreover, Chow raises an additional argument in respect to RPOs: namely that RPO abilities are also dual-use technologies which could be employed for nefarious purposes, such as for example the unsolicited de-orbiting of or general meddling with an adversary or competitor satellite [33]. Due to this possibility, States may have to establish protective zones around their satellites or missions in order to protect them from ill-intentioned RPO attempts.

It is overall evident that negotiating the lawfulness of safety zones vis-à-vis the OST's non-appropriation principle will likely impact any type of rendezvous and proximity operations, irrespective of the purpose they serve.

Finally, the introduction of the Artemis Accords in 2020 has sparked anew heated debate around the issue of non-appropriation in many aspects, safety zones being one of them. Namely, the Accords call their Signatories to establish safety zones around operations on the Moon as a way to implement their obligations under the Outer Space Treaty. These zones are promulgated as an operationalization of the provisions of Article IX OST on due regard and prevention of harmful interference: The Signatories are called to use safety zones in a manner that protects

public and private personnel, equipment, and operations from harmful interference and to establish safety zones so as to enable the safe and efficient extraction and utilization of space resources. The purpose of these zones is, thus, to facilitate deconfliction of activities and, ultimately, ensure the sustainability of activities in the exploration and use of space.

The Accords define safety zones as the areas within the limits of which "nominal operations of a relevant activity or an anomalous event could reasonably cause harmful interference". Thus, at first glance, they are not asset-based, but rather area- or mission-based protective zones. Furthermore, the Accords also set forth the principles that the establishment of such zones should abide by. According to these, safety zones must be delimited in a reasonable manner, meaning that their size and scope must be consistent with relevant scientific principles and reflect the nature of the operations being conducted, as well as the environment they are conducted in. Moreover, these zones are not intended to be permanent, but must end when the operation ceases. In fact, their size and scope are also expected to change so as to adapt to and reflect the status changes that the relevant operations undergo over time.

The Accords also call for the establishment of coordination and information sharing mechanisms with respect to the establishment and operation of safety zones. The Artemis Signatories commit to coordinate with each other to avoid any harmful interference and for this purpose, they are encouraged to provide information and notifications regarding the nature and the location of the activities being conducted within these zones.

Having considered the above, it must be said that the topic of safety zones under the Accords has certainly proven to be rather controversial. Some writers [34] assert that safety zones would result in the exclusion of other actors from entry, which would effectively jeopardize free access to outer space and may amount to appropriation. Others [35], on the other hand, contest this claim and emphasize that safety zones should be differentiated from keep-out zones (which would indeed have an exclusionary effect). The rationale behind safety zones lies in the need to ensure the safety of space activities by exercising due regard and avoiding harmful interference; it is not founded on appropriation considerations. Moreover, as Sundahl [35] points out, the Artemis Accords reflect to a considerable degree the Hague International Space Resources Governance Working Group's "Building Blocks for the Development of an International Framework on Space Resource Activities" ("Hague Building Blocks") [36]. The Hague Building Blocks—which were developed by a consortium consisting of legal scholars and stakeholders from government, industry, universities and civil society—recommend the establishment of safety zones (or other area-based safety measures) as a way to assure safety of operations and avoid any harmful interference with the space activity taking place within the area in question.

For these purposes, the Artemis Signatories are expected to respect safety zones, inform and coordinate with each other so as to avoid any interference. Requiring other Signatories to respect one's safety zone does not imply national appropriation or assertion of sovereign rights, nor do safety zones under the Accords render NASA "the gatekeeper of the Moon", as Sundahl emphasizes [35]. After all, the Accords underline that, in their use of safety zones, the Signatories must respect the principle of free access to all areas of celestial bodies, as well as all other provisions of the Outer Space Treaty—and this includes the non-appropriation principle, too.

4. Analysis of the non-appropriation principle in light of present day challenges

Regardless of their merits and their defects, given the rapid progress of industrial, economic as well as security pressures involved, safety zones seem a quasi inevitability. In the face of the legal challenges they may induce, relying on the applicability of the OST is ever less satisfactory, due to the ambiguities and uncertainties arising from it [37]. Mills argues that failure to resolve such lingering issues merely increases the “incentives to withdraw from the outer space regime, or at least to try to radically amend its provisions” [30]. This may prove to be the case with the Artemis Accords: Safety zones are being introduced as a practical implementation of the OST provisions on due regard and harmful interference, and, as mentioned above, it is purported that their establishment does not violate the principle of free access to all areas of space; but whether that is true will depend on the level of exclusion that such zones will entail in practice.

The immediate legal problem is that any protective zone that results in exclusion of other States or their nationals will enter in direct conflict with the OST’s non-appropriation principle [38], which prohibits the exercise of sovereign rights by states as well as private appropriation by business entities. Indeed, most scholars agree that establishing, for example, a ‘keep-out’ zone over a portion of outer space or a celestial body would be an appropriation in violation of the OST [39]. The interrelated concepts of “public purpose” and “common interest of Mankind” constitute the overarching themes of the international space law framework [40]. However, these warranties and principles are not extended to private entities, as, indeed, space law is State-centric and thus its provisions are formulated as sets of rights and obligations addressed to States only [41].

This leaves wide open the question of the extent to which private entities are bound to the same limitations and entitled to same protections as the States. Therefore, one of the many dangers of failing to adapt the non-appropriation principle to the changing industrial context, is for private entities to circumvent the appropriation prohibition imposed on states with self-appointed (or purchased) *de facto* long-term occupancy rights. Such a scenario can be imagined in the context of off-world mining and even, in much more practical terms, in the case of orbited geosynchronous satellites. Because operators are granted time for replacement of faulty satellites before they lose their priority for a given orbital slot, operators who can afford to relaunch satellites when necessary can also potentially secure near-perpetual occupation of specific orbits irrespective of satellite lifetime [42,43]. Thus, although the ITU system enjoys wide acceptance among States, it could be exploited in a manner that may *de facto* amount to an Article II OST violation (for example, to follow the wording of the OST, it could be considered a *de facto* appropriation by means of use or occupation). Following this analogy, safety zones could similarly be employed to achieve, in practice, perpetual occupation of an area in space.

Sovereignty claims have traditionally been made on the basis of land territory, or *terra firma*. By contrast, international legal scholarship recognizes space as being a *res communis* (as opposed to *res nullius*), a legal characterization which ostensibly prohibits states from asserting sovereignty rights into space. It is therefore difficult to argue how property rights could legally be established in outer space, unless a relevant international framework is adopted [40]. From a narrow perspective, it is only the ownership of objects launched into outer space (including objects landed or constructed on a celestial body, and of their component parts) which is not affected by their presence in outer space (as per OST, Article VIII) and which states may legally hold on to [40]. A narrow interpretation of the non-appropriation principle makes the occupation and/or ownership of natural resources on celestial bodies equally problematic, putting legal doctrine at odds with industrial progress.

Notwithstanding, although exclusive and permanent occupation of extraterrestrial surfaces is prohibited as per Article II OST, a growing number of States are viewing the large-scale extraction and removal of

off-world mineral resources as permissible and even compliant with the Outer Space Treaty, as evidenced by the signing of the Artemis Accords or the enacting of relevant American [44] and Luxembourg [45] legislations which allow for the appropriation of space resources. This constitutes a contradiction that classical interpretations of the OST are unable to resolve. Moreover, with the growing space industry racing ever closer to the commercial—and indeed, industrial—utilization of space and its vast resources, equal access to space resources for all becomes all the more difficult to ensure. On the other hand, however, it would be difficult to fathom how investments could be made in the commercial exploitation of a resource, if those resources or the celestial body containing them must be either kept intact as a preserve for all of humankind, or shared with any or all competing parties. Similarly, it would be difficult to envision how such investments could be made if not a minimal level of safety is ensured around a space object or an operation (e.g. a mining activity).

An added layer of difficulty arises from space law’s failure to provide definitive legal qualifications for space objects. Apart from providing that space objects remain under the jurisdiction of the State of registry when launched in space (Article VIII OST) and that they include any component part of a space object (Article I of the Liability Convention), the space law treaties fail to define space objects in more concrete terms. Further, they make no reference to space objects conceived, assembled or manufactured directly in space (with the exception of objects constructed on celestial bodies as per Article VIII OST), and it remains as yet an open-ended question whether such objects would warrant different considerations than those launched from Earth (for a more detailed discussion on that matter see [46]). Notwithstanding, space objects can differ so widely in scope, purpose, size and location that attaching a lawful safety zone to any such object could stretch the concept of safety zones. Safety zones could include everything, from a narrowly defined radius around a space object (to prevent collisions or unwarranted interference or surveillance) to wide swaths of space where entry of foreign objects would be restricted, if not prohibited (at least temporarily) so as to enable the carrying out of large-scale activities while also preventing third-party scrutiny throughout the duration of the operations.

It is noted that Newsome [5] raises an outlier argument, first brought forth by Rothblatt [47] in the 1980s, suggesting essentially that, since space objects need a certain area of operation around them in order to perform their intended functions unencumbered, such an area ought to be considered intrinsic to space objects themselves. As such, this area or zone is “really more a part of the space object than of space itself” [5,47]. Following this thesis to its logical conclusion would mean that the non-appropriation principle would merely sanction the lawful length of the radius of such a zone—an argument, which has failed to gain much traction with legal scholars.

At the same time, however, the commercial development of space and the deployment of novel technologies tend to give Rothblatt’s thesis renewed impetus. If safety zones violate the non-appropriation principle, as legal purists would argue, then the free access to space might in turn be violated because space systems would not be able to operate safely. This issue would arise, for example, if space asset owners/operators were not able to fend against acts of harmful interference, unwarranted surveillance or even kinetic threats, such as deliberate collisions. Moreover, issues such as the overcrowding of space by competitors’ assets or by space debris must imperatively be considered, as well. Indeed, pushed to the ultimate scenario of extreme space pollution as suggested by Kessler [48], too strict or too broad an interpretation of the non-appropriation principle might conceivably jeopardize basic space operations. A hypothetical increase of risk associated with an increase in space traffic or space debris could cause operations to become more hazardous and therefore less cost-efficient. Furthermore, lack of a right to establish protective zones around assets could also render their operation more costly due to a likely rise in insurance premiums. These elevated costs could deter or even hinder access to space. Recognizing minimal safety areas to ensure ample maneuverability for space sys-

tems might in fact serve the non-appropriation principle by guaranteeing equal access and a level playing field for all actors involved.

In the meantime, in the absence of a legal regime overhaul, Turrini [37] evokes the very real possibility of a return to natural law doctrine such as inspired by John Locke—a doctrine which was used to justify colonialism—, where property rights were considered a mere consequence of labor and of the capacity to derive benefits from the land and its resources. As Turrini [37] recounts, colonists' ownership rights were qualified as *imperium* and they superseded the rights of the native populations (qualified as *dominium*), since the colonists' activities were considered to be more labor-intensive and wealth-producing than those carried out by less technologically advanced native populations. While antiquated colonial doctrine cannot and should not be used as a basis for discussing the advancement of ownership regimes in space, the very real argument can be made that, in the absence of a revised non-appropriation standard, it is not unlikely that space might eventually turn into a Wild West that is occupied and exploited by the largest and strongest players. Thus, the unintended consequence of the non-appropriation principle is that it might very well turn space into a no man's land where weaker industry (or even state) players are excluded by their *de facto* incapacity to compete with overwhelmingly larger players. A tightly controlled legal framework recognizing some form of limited and temporary exclusive rights to space exploitation—in the form of safety zones, for example—might serve as a compromise that levels the playing field for all players. In this sense, it might be argued that, even if safety zones might not follow the OST to the letter, they help pursue the spirit in which it was made.

5. Safety zones and the case for extraterritorial jurisdiction in outer space

The concept of extraterritorial jurisdiction, understood as the authority of a State to extend its jurisdiction to its nationals when they are located outside its territory [14] (alternatively also referred to as “personal jurisdiction”), might pose a more viable alternative to the establishment of safety zones through international agreements. The reason for this is that extraterritorial jurisdiction may serve as one roundabout way of extending terrestrial regulatory powers in space without infringing upon the OST restrictions on claiming sovereignty in space. It may provide a greater level of consistency with the international requirements set out by the space treaties, particularly if we recall that the Outer Space Treaty requires States to regulate the conduct of their nationals in space and to ensure its conformity with the Treaty by establishing relevant authorization and supervision mechanisms (Article VI OST).

Theoretically, first of all, insofar as the OST bounds member states to the “common interest” clause, the regulatory power and oversight that states exert over private actors performing commercial operations in space ought to be distinguished from an illicit claim of sovereignty. However, when a state effectively establishes its own rule of law over commercial operations in a territory devoid of legal status, whether this be space itself or an extraterrestrial surface, the line between jurisdiction and sovereignty might become quite tenuous. Such a reading is based on what legal scholars have pointed out to be an increasingly hard to reconcile gap between the injunction of Article II OST, stating that “outer space ... is not subject to national appropriation by claim of sovereignty”, and Article VI OST, which stipulates that “states shall bear international responsibility for national activities [including through] authorization and continuing supervision”.

Given that governments must oversee and control the activities and operations of domestic private entities in space, such oversight becomes increasingly difficult to implement without deploying “police powers”⁷

⁷ The term “police powers” refers to “[t]he inherent and plenary power of a sovereign to make all laws necessary and proper to preserve the public security, order, health, morality, and justice.” (Source: [49])

in space [14]. Where the OST has only foreseen state-sanctioned uses of space and space resources, the increasing commercial exploitation of space today renders even more imperative that governments enhance their oversight mechanisms. In this context—and considering that private actors are not themselves subject to international space law—, police powers have been suggested to be implicit in the terms “authorization” and “supervision” since it is the States that are expected to regulate their nationals' space activities (see [14]; cf.: U.N. General Assembly Resolution 59/115 [50], in which the General Assembly recommended that States consider enacting and implementing national laws authorizing and providing for continuing supervision of the space activities of non-governmental entities under their jurisdiction as a way to fulfill their international obligations under the space law treaties). However, to the extent that governments are able to extend their police powers over private entities' activities, exerting that same police power over the territory or the area where such activities are deployed becomes similarly implicit, and, in fact, necessary.

Considering that in light of the Article VI OST provisions on “international responsibility”, “authorization” and “continuing supervision”, States can extend their extraterritorial jurisdiction on national space activities in outer space, the mechanisms established for this purpose may also regulate safety zones. Thus, taking U.S. federal law as an example, it may be suggested that the difficulties or restrictions⁸ barring the setup of safety zones and other zones of protection in space could be circumvented by expanding on the current constitutional powers that enable the US Congress to regulate commercial activities in space (which, after all, is also sanctioned by Article VI OST). These powers include the Commerce Clause, as well as the Admiralty and Offences Clauses [14].

The Commerce Clause contained in Article I, Section 8, Clause 3 of the US Constitution stipulates that the US Congress has the power to regulate commercial activities with foreign nations as well as between US states. This gives federal authorities the power to regulate any economic or non-economic activity that has a substantial effect on interstate commerce, or which involves a substantial number of items that pass through channels of interstate commerce, including US rivers, highways, and airspace [14]. With respect to outer space, the argument can be made that private commercial space activities, regardless of whether they are conducted by American companies or by foreign companies together with an American counterpart, are likewise liable to fall under US regulatory powers. This is because i) any such economic pursuit is bound to have a commercial substance and therefore an effect on US commerce, and ii) both US companies and non-US companies doing business with the US are bound to use US airspace and therefore use US channels of interstate commerce. Moreover, Perlman has suggested that space companies might fall under the scope of the Commercial Clause, given that most of them use at least some level of US technology or intellectual property to build, launch or operate their spacecraft [14]. Such technology is bound to have been obtained through interstate commercial transactions and could therefore fall under the power of the Interstate and Foreign Commerce Clause.

As a result, the U.S. Congress could extend its jurisdiction—and, consequently, any eventual provisions on the establishment of safety zones around a space object or a commercial operation in space—on the grounds that such space objects or missions may have an effect on U.S. commerce, or the actors involved are American nationals (both natural and legal persons); but it could even be extended on foreign nationals on grounds that a technology being used is American and/or involved interstate commerce.

Lastly, in recognizing the US Congress' intrinsic powers to police the high seas by punishing acts of piracy and other felonies committed on the high seas, the US Constitution's Admiralty Clause has been suggested as a vehicle for possibly extending US civil laws (related to crimes and

⁸ Such difficulties may include e.g. the failure to conclude an international instrument concerning the establishment of safety zones or other protective zones.

felonies, but also to insurance, commerce, salvage rights, etc.) into space [14]. In a similar fashion, other States could also extend their criminal laws in space in order to punish any unlawful activities occurring there. It can be envisaged, in turn, that pertinent criminal laws might also cover issues related to safety zones, such as e.g. the legal consequences of harmful interference occurring due to non-respect of a safety zone.

Based on these considerations, a national legislative body, such as the U.S. Congress, may be able to unilaterally legislate on safety zones in space for commercial purposes, without the need to establish them on the basis of international arrangements. Notwithstanding, any such legislation or legal mechanism would have to be in conformity with a State's obligations under the Outer Space Treaty and international law in general.

6. A reinterpretation of the non-appropriation principle and possible solutions and avenues for further exploration of safety zones in the newspace era

Considering the ambiguities that surround the non-appropriation principle, legal scholars have proposed various avenues to balance protective zones with the existing treaty restrictions. The common theme of these various avenues involves a reevaluation of the basic tenets underlying the non-appropriation principle. Such theoretical issues must be resolved first before an actual discussion of particular characteristics, such as safety zone radius and restriction/enforcement rules, can take place.

Initially, the underlying rationale behind such zones was predicated on the protection of State security interests. For instance, Newsome [5] recalls a study commissioned by the US Department of Defense and conducted by the Reagan Administration's Commission on Integrated Long-Term Strategy in the 1980s [51], which concluded that the safety interests of the US would be better served by the implementation of internationally agreed-upon instruments on "self-defense zones" around space objects, rather than by the implementation of arms ban agreements. The report stated that such zones would not affect normal, non-threatening satellite operations, but they would be employed to defend against hostile intrusion (see [51], p. 55).

Such security considerations have not dissipated in the present day. For example, during the Paris Air Show in 2019, the French Ministry for the Armed Forces' exhibit on "what space operations could be like in a few years" presented a scenario in which a country that had declared a "space exclusion zone" would remove an intruding satellite from this zone with the help of a so-called "small bodyguard satellite" (which may eventually carry active defensive weapons since France does not consider active defense as an offensive strategy) [52]. The Ministry announced that France will be deploying such satellites starting 2023 [53]. Earlier in the same year, the Consortium for Execution of Rendezvous and Servicing Operations (CONFERS), established by the U.S. Defense Advanced Research Projects Agency (DARPA), released guidelines [54] in which it proposed the establishment of "safety zones, and keep-out spheres or volumes for RPO and [on-orbit servicing] activities" as means to ensure spaceflight safety [52].

As concerns the commercial use of space, such an approach could be justified today by the fact that States and businesses invest significant resources in highly technologized space systems, which, once in space, fail to enjoy the same level of protection as they would within their own jurisdictions on Earth. Therefore, the deployment of similar protective zones to ensure the safety of and protect assets and property in space would presumably be a welcome development. Nevertheless, such a solution does little to advance the discussion of the conformity of these zones with the OST provisions on non-appropriation and free access to all areas of space, and more specifically, the topic of space resources and the rights to exploit them.

As for the latter issue, although the production of space resources hardly constitutes a claim of sovereignty, it can just as easily be argued that it goes directly against the principle of space as a global

commons. So, in his 1970 landmark article "Legal Aspects of the Utilization of Outer Space" [55], Goedhuis proposed to reconcile the non-appropriation principle with property rights in outer space by way of the following set of criteria, which in his view, would render outer space occupation and exploitation lawful:

- i) the area under consideration cannot be subject to appropriation,
- ii) all countries must share in its management,
- iii) there must be an active sharing of the benefits reaped from the exploitation of these resources, and,
- iv) the area must be utilized exclusively for peaceful purposes [55].

However, within the context of commercial competitiveness, it is hard to imagine space mining being carried out without space mining companies imposing an exclusive claim on the benefits derived from such an activity, considering the staggering investments required. Goedhuis' proposal merits interest in terms of legal history, and it may very well be reconcilable with the non-appropriation principle; however, from a commercial standpoint, it is hardly a viable solution.

One suggested avenue to resolve this dilemma is to make a distinction between resources (movable goods) and areas or off-world real estate (immovable goods), and restricting the non-appropriation rule to territorial claims only [37]. In other words, the argument can be made that as soon as those potential mineral resources are displaced from their original location, their intrinsic nature might be altered from immovable to movable goods. This would mean that they would cease to be an intrinsic part of the real estate, but rather they would constitute deposits of movable goods, and therefore a commercial operator might lawfully appropriate them. Of course, these arguments could be challenged by the 1979 Moon Agreement's provisions, but not on sufficient grounds, considering its limited acceptance.

Turrini [37] suggests that allowing Earth entities to establish at least some level of exclusive rights of space usage might in fact be preferable to strict non-appropriation rules. Binding commercial exploitation of space resources with some form of territoriality and ownership might conceivably lead to a more responsible utilization of space resources and might more closely link space activities to jurisdictional scrutiny and even some form of extended extraterritorial liability regime. In the absence of such ownership, the ability to enforce liability rules becomes highly tenuous, and it becomes virtually impossible to guarantee accountability and compliance standards in the context of such operations.

As the contemporary space sector and the NewSpace ecosystem open space up for commercial exploitation, the challenge that is posed to the existing legal regime hinges on private stakeholders wanting to declare unilateral safety and security zones or exclusive economic zones to protect their space assets and investments, which however require implicit territorial occupancy. In other words, the reexamination of the non-appropriation principle in the face of contemporary industry pressures must contend with the inherent conflict between commerce and the use of space as a province of mankind.

A 1993 Manfred Lachs Space Law Moot Competition case concerning the commercial exploitation of the Moon between the fictional parties Xavage and Adastra [56], has had to settle just such an issue. In that fictional case, Adastra had set up a nuclear-powered laser fence system to secure its mining operations on the Moon and to fend off any potential intruders. Despite being a hypothetical situation, its verdict issued a few interesting pointers to reach a compromise safety zone, striking a balance between third-party states' rights to free access and protecting the mining entity's moon operations:

'In order for a Keep Out Zone to be valid under international law, the area to which access is denied, the extent of the denial, and the means with which the zone is enforced must be reasonable in relation to the activity being protected. ADASTRA's Keep Out Zone fails the test of reasonableness. ADASTRA's zone goes well beyond the needs of its mining activities and is, in effect, an illegal appropriation of the Area.... ADASTRA's laser fence clearly excludes other states from the Keep Out Zone and ADASTRA's activities within the zone - exercising dominion over

Table 4
Conceptual approaches to safety zones.

Parameters	Concept 1: Asset-dependent Exclusionary Zones	Concept 2: Self-Defense Zones	Concept 3: Functional / Non-Interference Zones
1) Location where the zone will be established:	Surrounding critical/essential space assets	Zones surrounding the area where a mission is taking place (thus encompassing several space objects that are used to carry out the mission).	Region within which other space objects could interfere (internationally or unintentionally) with a mission, and the safety of operations would be compromised.
2) Rationale behind the establishment of such zone:	Preventing close approaches of other space objects to the space object in question. This is done by excluding other space objects or actors in space from entry within the zone. Established for safety reasons (e.g. preventing collisions), but also following security considerations (e.g. unwarranted surveillance), etc.	Mainly based on security and defense considerations: protecting the operation or mission from adversaries, such as the avoiding of instantaneous surprise attacks, deliberate harmful interference, or other ill-intentioned activities.	Sustainability of operations and deconfliction of activities; due regard and avoidance of harmful interference; safety of operations both for those conducting them as well as third parties; space traffic management considerations; minimizing frequency interference (cf.: the ITU allocates orbital slots in geostationary orbits in a manner so as to minimize frequency interference by satellites). - Allocation of positions in orbital space or on celestial bodies based on an international regime. - Delimitation of the zone is done reasonably and based on scientific principles. - Coordination, information exchange, notification and transparency mechanisms among interested parties. - Potential temporary access restrictions (depending on mission profile and the reasons justifying them).
3) Implementation:	Established as a radius that may extend to a specific distance around a space object. It is an area of space through which space objects of other nations could not pass without permission. Non-respect of the zone may lead to: forcible prevention of trespass; avoidance maneuvers to prevent e.g. collisions; may even lead to mission abort depending on the function of the space object.	Broad zones around specific areas in space or on celestial bodies, apportioned to states or groups of states. Limited rights of passage; “innocent passage” and/or innocent/routine operations are permitted. A violation of the established zone and relevant transit rules by an invading satellite would justify its inspection, expulsion, or destruction. “Bodyguard” satellites may also be employed for this purpose. Enforcement measures would be reasonable, gradual and proportionate. Apportioning of areas in space and the delineation of self-defense zones are done based on an international regime.	Temporary (Mission/Operation duration)
4) Duration	Permanent (throughout the space-object's lifetime)	Temporary (Mission/operation duration)	Temporary (Mission/Operation duration)
5) Proposed type of instrument regulating the respective zone:	International agreement; soft law instruments such as guidelines or rules of the Road (potentially established under the COPUOS).	International agreement	International agreement; soft law instrument (e.g. guidelines); some aspects may potentially be regulated unilaterally through national legislation.
6) Examples/comparable concepts:	ISS 200 m keep-out zone; a keep-out zone around a RPO Client.	Compare with the sovereign rights that accompany the UNCLOS EEZ concept: they are rights exercised by a single State on an area that does not belong to its territory and they are granted based on an international agreement.	Safety zones under the UNCLOS; the safety zones regime under the Artemis Accords; warning areas in international airspace (U.S. aviation law).

the Moon's natural resources - are clearly state functions. Remove the laser fence and ADASTRA is no longer exercising exclusive jurisdiction within the Keep Out Zone because other states are free to exercise their right of exploration and use. ...ADASTRA's laser fenced Keep Out Zone fails the test of reasonableness. The fence is not necessary for mining as ADASTRA would have this Court believe.... ADASTRA's Keep Out Zone was unreasonable in purpose since it was intended to restrict free access to the moon. ADASTRA's nuclear powered laser fence and accompanying Keep Out Zone sent a clear message to anyone wishing to enter the Area: "Don't even try, and if you do, your attempt will be resisted with violence" [57].

This case is significant in that it proposes a “test of reasonableness”, which attempts to draw a compromise between third parties equal access rights and a (private or government) investor's rights to protect its assets. A model safety zone should clearly avoid illegal appropriation and, considering that the exercise of exclusive jurisdiction might be unlawful, it may potentially invalidate the theory extending US extraterritorial jurisdiction in outer space to mimic the effects of a safety zone. Mining activities in this context should be considered lawful insofar as they do not prohibit other parties to undertake a similar activity. But while Adastral would be precluded from prohibiting access to others, it would still be entitled to protect its infrastructure and mining operations

from hostile intrusions and harmful interference in a manner that is proportionate with the threat. The enforcement of a self-defense protocol would necessarily have to be measured and gradual.

The guiding principles of this model are echoed in Newsome's [5] three-pronged legal test to determine the lawfulness of outer space security and safety zones. Newsome's three criteria are as follows:

- i) transparency in creating and maintaining a zone: this also includes divulging the exhaustive set of parameters of any such zone (e.g. physical coordinates, intended uses and purpose, restrictions attached thereto and relevant enforcement rules);
- ii) establishment or operation of a zone does not grant sovereign rights, be they called safety or security zones; and
- iii) the law that applies outside a zone, also applies inside the zone.

Moreover, according to Newsome, the lawful character of safety and security zones in space is contingent upon their precise geospatial location and their specific connection to a space object or to a space mission.

Lastly, the Hague International Space Resources Governance Working Group's Building Blocks of 2019 [36] suggest, inter alia, that an international framework should be put into place that would allow States to establish a safety zone, or another area-based safety measure, around an area in which a space resource activity would take place. The aim

of this zone would be to assure safety and avoid harmful interference; it should not impede the free access to any area of outer space by personnel, vehicles and equipment of another operator. Nevertheless, the Working Group also recognizes that, depending on the area-based safety measure, access may be restricted temporarily; but this may only be done as long as timely public notice has been provided that sets out the reasons justifying such restriction.

From all of these proposals, as well as the analogies presented in Section 3, the following conclusions can be drawn, which are summarized in Table 4 below. Three different conceptual approaches to safety zones are presented, which, taking into account the international context, must each time be adapted to the commitments made in the five international space law treaties:

- (i) Zones designed to protect assets deemed essential (see Concept 1 in Table 4): The approach here is geographical and spatial, conceived as a zone of protection around an asset in space. Access within this zone would be mostly off-limits to other spacecraft. Due to potential clashes with the Outer Space Treaty, this approach lends itself to a definition of such zones through the adoption of internationally agreed-upon instruments (binding and/or non-binding) and guidelines concerning their delimitation.
- (ii) A protective zone conceived as a means of self-defense, but which is simultaneously combined with the right of innocent passage and, more generally, the right to explore and use space (see Concept 2 in Table 4). The rationale is to protect a mission against adversaries and security threats. The approach adopted is then in a way existential. Moreover, its implementation is not very far from that of the law of the sea concept of the EEZ: within its EEZ, the coastal State essentially enjoys sovereign exclusive rights in an area that is in fact not part of its territory. In a similar fashion, a self-defense zone would entail to a certain degree exercise of supposedly sovereign rights. Sovereignty would result here not from a territory, but from rights granted to a State, which are then granted by the State to the prospective occupant of an orbital position or an area on a celestial body. Evidently, the definition of such defensive zones would necessitate the conclusion of relevant international binding agreements, just as the sovereign rights in the EEZ were granted following the conclusion of the UNCLOS.
- (iii) The safety zone interpreted from a functional approach, namely maintaining long-term sustainability of operations (see Concept 3 in Table 4): The establishment of such a zone is founded on considerations of due regard and the need to avoid interferences that could have harmful effects on the operation, or the persons and space objects involved in it. Such zones would entail an element of exclusion (e.g. temporary access restrictions), but it would ultimately be predicated on safety considerations, similar to safety zones under the UNCLOS, as well as space traffic management considerations. The exercise of the full rights would arise from the allocation of positions by the State based on international rules or an international regime (similar to the aforementioned EEZ framework or the ITU regime, which also entails an element of exclusion since an orbital slot allocated to a State cannot be allocated to another). Overall, this approach reflects the provisions of Article IX OST, which requires Signatory States to respect the corresponding interests of all other States Parties to the Treaty and to avoid harmful interference. Safety zones under the Artemis Accords constitute a pertinent example since their stated purpose is the deconfliction of activities on the Moon and other celestial bodies with the aim to ensure sustainability of operations.

7. Conclusion

Obviously, at this point, the particulars of safety zones still need to be worked out by the international community and by legal scholars. Most pressing for proponents of safety zones, parameters, such as the

maximum radial distance or the measures allowed to exclude or expel unwanted third parties and intruders, remain unaddressed. Attempts to draw up overly specific safety zone plans, such as were made in the 1980s, have remained to a large degree fruitless and are today regarded as historical curiosities. So, unless the underlying conceptual and philosophical issues are fully resolved, efforts to design model plans specifying the perimeter within which a space vehicle may or may not approach a hypothetical safety zone, will remain largely vain and may lead to arbitrary delimitations and fault-lines.

The rapid progress of technology is bound to exacerbate these concerns. This would in particular be the case with activities, which, through sheer physical occupation of a territory or a resource, could preclude all others from entering even without an actual claim to sovereignty. Examples include the deployment of swarm systems in outer space, or mining operations on an off-world surface.

For now, the fact remains that the non-appropriation principle continues to be a cornerstone of outer space law and a notion threaded through all legacy space treaties. Reinventing safety zones that are treaty-compliant, requires corollary consensus with the international community. This can only be achieved through a common understanding of concepts such as the “shared and global commons”, “preserve for all of mankind”, and even, on a much more concrete level, reaching consensual definitions of what constitutes a space object, and the rights and responsibilities that accompany its use. While much has been made about the private sector’s push for safety zones, public actors should recognize their stake in regulating an area where a serious legal gap exists. Evidently, by introducing the Artemis Accords and requiring the Artemis program participants to adhere to the principles the Accords enunciate, the US is already taking some first steps in this direction.

Declarations of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

CRedit authorship contribution statement

Lucas Mallowan: Resources, Writing – original draft. **Lucien Rapp:** Supervision, Conceptualization, Methodology, Validation, Writing – review & editing. **Maria Topka:** Writing – review & editing.

Reference

- [1] NASA, The Artemis Accords: principles for cooperation in the civil exploration and use of the moon, mars, comets, and asteroids for peaceful purposes (“Artemis Accords”), signed at the 71st International Astronautical Congress (IAC), held virtually on Oct. 13, 2020.
- [2] Treaty on principles governing the activities of states in the exploration and use of outer space, including the moon and other celestial bodies (“Outer Space Treaty”), opened for signature on Jan. 27 1967. UNTS vol. 610, p. 205.
- [3] G. Wang, NASA’s Artemis Accords: the path to a united space law or a divided one?, *The Space Review*. (2020). <https://www.thespacereview.com/article/4009/1> (accessed January 7, 2021).
- [4] F.K. Schwetje, *Protecting space assets: a legal analysis of “keep-out zones”*, *J. Space Law* 15 (1987) 131–146.
- [5] R. DalBello, “Rule of the Road”: Legal Measures to Strengthen the Peaceful Uses of Outer Space, in: *Proceedings of the Twenty-Eighth Colloquium on the Law of Outer Space, held in Stockholm, Sweden, October 7–12, 1985*, pp. 8–12.
- [7] US Congress Office of Technology Assessment, *Anti-Satellite Weapons, Countermeasures, and Arms Control (OTA –1.S –281)*, US Government Printing Office, Washington, D.C., 1985 <https://aerospace.csis.org/wp-content/uploads/2018/09/OTA-Report-on-ASAT-Weapons-and-Countermeasures-1985.pdf>.
- [8] P.Q. Collins, *Legal Considerations for Traffic Systems in Near-Earth Space*, in: *Proceedings of the Thirty-Second Colloquium on the Law of Outer Space, held in Torremolinos-Málaga, Spain, October 11–13, 1989*, pp. 296–303.
- [9] W. von Kries, *Space-Based Defenses and the Law of Outer Space*, in: *Proceedings of the Thirtieth Colloquium on the Law of Outer Space, Held in Brighton, United Kingdom, October 10–17, 1987*, pp. 106–108.

- [10] A. Wohlstetter, B.G. Chow, Self-Defense Zones in Space, Marina del Rey, CA, 1986 <http://albertwohlstetter.com/writings/19860615-AW-Chow-SDZsInSpace.pdf>.
- [11] J.K. Schingler, Imagining Safety zones: Implications and Open Questions, *The Space Review*, 2020 <https://www.thespacereview.com/article/3962/1> accessed January 8, 2021.
- [12] G. Zhukov, Y. Kolosov, *International Space Law*, second ed., Statut, Moscow, 2014.
- [13] U. Mukherjee, Recalibrating the Moon Treaty to the Domain of Development, in: M.J. Sundahl, V. Gopalakrishnan (Eds.), *New Perspectives on Space Law: Proceedings of the 53rd IISL Colloquium on the Law of Outer Space, Young Scholar Sessions*, 2011, pp. 222–235.
- [14] B. Perlman, U.S. Grounding, *Commercial space regulation in the constitution*, *Georgetown Law J.* 100 (2012) 929–966.
- [15] G. Rodotheatos, From sea to outer space and back: political, economic, and environmental considerations for ocean-based space launching activities, in: G.D. Kyriakopoulos, M. Manoli (Eds.), *The Space Treaties at Crossroads*, Springer, Cham, 2019, pp. 109–124.
- [16] U.N. Convention on the Law of the Sea (“UNCLOS”), concluded at Montego Bay, Jamaica, Dec. 10, 1983, U.N.T.S. 1982, p. 397.
- [17] S.O. Williams, Offshore Installations: Practical Security and Legal Considerations, Center for International Maritime Security., 2013 <http://cimsec.org/offshore-installations-practical-security-legal-considerations/7872>.
- [18] IMO Resolution A.671(16) “Safety Zones and Safety of Navigation Around Offshore Installations and Structures”, adopted on October 19, 1989. IMO Doc. A 16/Res.671 (Nov. 30, 1989). [https://www.wcdn.imo.org/localresources/en/KnowledgeCentre/IndexofIMOResolutions/AssemblyDocuments/A.671\(16\).pdf](https://www.wcdn.imo.org/localresources/en/KnowledgeCentre/IndexofIMOResolutions/AssemblyDocuments/A.671(16).pdf).
- [19] M. Bourbonniere, L. Haecck, Military aircraft and international law: *Chicago Opus 3*, *J Air Law Commer.* 66 (2001) 885–978.
- [20] C. Michaelsen, Maritime exclusion zones in times of armed conflict at sea: legal controversies still unresolved, *J. Conf. Secur. Law* 8 (2003) 363–390.
- [21] L. Doswald-Beck, *San Remo Manual on International Law Applicable to Armed Conflicts at Sea*, International Institute of Humanitarian Law, Grotius Publications: Cambridge University Press, Cambridge, UK, 1995.
- [22] Convention on International Civil Aviation (“Chicago Convention”), concluded in Chicago on Dec. 7, 1944, entered into force Apr. 4, 1947. U.N.T.S. vol. 15, p. 295.
- [23] US Department of Transportation Federal Aviation Administration, *Aeronautical Information Manual*, 2019 https://www.faa.gov/air_traffic/publications/media/aim_basic_8-15-19.pdf.
- [24] ICAO Annex 15 to the Convention on International Civil Aviation, fourteenth ed., *Aeronautical Information Services*, 2013.
- [25] L. de Gouyon Matignon, The delimitation between airspace and outer space, *Space Legal Issues* (2019) <https://www.spacelegalissues.com/the-delimitation-between-airspace-and-outer-space/>. accessed January 8, 2021.
- [26] Y. Takeuchi, Space traffic management as guiding principle of the international regime of sustainable space activities, *J. East Asia Int. Law* 4 (2011) 319–334.
- [27] M. Lucas-Rhimbassen, C. Santos, G.A. Long, L. Rapp, Conceptual model for a profitable return on investment from space debris as abiotic space resource, 8th European Conference for Aeronautics and Aerospace Sciences (EUCASS), 2019 1–4 July, doi:10.13009/EUCASS2019-602.
- [28] R. Reesman, A. Rogers, *Getting in Your Space: Learning from Past Rendezvous and Proximity Operations*. Center for Space Policy and Strategy - The Aerospace Corporation, 2018. <https://aerospace.org/sites/default/files/2018-05/GettingInYourSpace.pdf>.
- [29] Vienna Convention on Diplomatic Relations, done at Vienna on Apr. 18, 1961, entered into force on Apr. 24, 1964. U.N.T.S. vol. 500, p. 95.
- [30] K. Mills, Who will own outer space: governance over space resources in the age of human space exploration, in: U. Landfester, N.-L. Remuss, K.-U. Schrogl, J.-C. Worms (Eds.), *Humans in Outer Space - Interdisciplinary Perspectives*, Springer, Vienna, 2011, pp. 15–27.
- [31] B.A. Corbin, A. Abdurrezak, L.P. Newell, G.M. Roesler, B. Lal, *Global Trends in On Orbit Servicing, Assembly and Manufacturing (OSAM)*, Institute for Defense Analyses, Alexandria, Virginia, 2020 <https://www.ida.org/-/media/feature/publications/g/gl/global-trends-in-on-orbit-servicing-assembly-and-manufacturing-osam/d-13161.ashx>.
- [32] C.A. Drewien, R.C. Byrd, S.E. Slezak, M.R. Ackermann, *The Always/Never Safety Framework for Satellite Rendezvous and Proximity Operations and On-Orbit Servicing*, SANDIA Report SAND2020-3908, Albuquerque, New Mexico, 2020.
- [33] B.G. Chow, Space traffic management in the new space age, *Strat Stud. Q.* 14 (2020) 74–102.
- [34] A. Boley, M. Byers, U.S. policy puts the safe development of space at risk, *Science* 370 (2020) 174–175, doi:10.1126/science.abd3402.
- [35] M.J. Sundahl, U.S. space policy: an international model, *Science* 370 (2020) 1045, doi:10.1126/science.abf2324.
- [36] The Hague International Space Resources Governance Working Group, *Building Blocks for the Development of an International Framework on Space Resource Activities*, 2019. <https://www.universiteitleiden.nl/binaries/content/assets/rechtsgeleerdheid/instituut-voor-publiekrecht/lucht-en-ruimterecht/space-resources/bb-thissrrwg-cover.pdf>.
- [37] P. Turrini, The sky’s not the limit: legal bonds and boundaries in claiming sovereignty over celestial bodies, in: T. Natoli, A. Riccardi (Eds.), *Borders, Legal Spaces and Territories in Contemporary International Law*, Springer International Publishing, Cham, 2019, pp. 173–209, doi:10.1007/978-3-030-20929-2_7.
- [38] H. Bittlinger, ‘Keep-Out Zones’ and the Non-Appropriation Principle of International Space Law, in: *Proceedings of the 31st Colloquium on the Law of Outer Space, held in Bangalore, India, October 8-15, 1988*, pp. 6–12.
- [39] B. Abrams, First contact: establishing jurisdiction over activities in outer space, *Georgia J. Int. Comp. Law* 42 (2014) 797–824.
- [40] G.D. Kyriakopoulos, Positive Space Law and Privatization of Outer Space: Fundamental Antinomies, in: G.D. Kyriakopoulos, M. Manoli (Eds.), *The Space Treaties at Crossroads*, Springer, Cham, Switzerland, 2019: pp. 1–13.
- [41] F. von der Dunk, *International space law*, in: F.von der Dunk, F. Tronchetti (Eds.), *Handbook of Space Law*, Edward Elgar Publishing, Cheltenham, UK and Northampton, MA, USA, 2015, pp. 29–126.
- [42] C. Billing, There’s a parking crisis in space – and you should be worried about it, the conversation. (2017). <http://theconversation.com/theres-a-parking-crisis-in-space-and-you-should-be-worried-about-it-83479> (accessed April 11, 2021).
- [43] B. Cohen, Use versus appropriation of outer space: the case for long-term occupancy rights, in: *Proceedings of the International Institute of Space Law 2014 (57th IISL Colloquium on the Law of Outer Space: Nandasiri Jasentuliyana Keynote Lecture on Space Law & 6th Young Scholars Session, Held in Toronto, Canada in 2014)*, Eleven International Publishing, 2015, pp. 35–52.
- [44] U.S. Commercial Space Launch Competitiveness Act, Public Law 114–90, of Nov. 25, 2015. <https://www.congress.gov/114/plaws/publ90/PLAW-114publ90.pdf>.
- [45] Loi du 20 juillet, sur l’exploration et l’utilisation des ressources de l’espace, *Journal officiel du Grand-duché de Luxembourg* 674 (2017) July 28, 2017 <http://legilux.public.lu/eli/etat/leg/loi/2017/07/20/a674/jo/en>.
- [46] L. Rapp, M. Topka, L. Mallowan, Which jurisdiction for private in-space assembled autonomous platforms? *Space Policy* 56 (2021) 101413, doi:10.1016/j.spacepol.2021.101413.
- [47] M.A. Rothblatt, *State Jurisdiction and Control in Outer Space*, in: *Proceedings of the 26th Colloquium on the Law of Outer Space, Held in Budapest, Hungary, October 10-15, 1983*, pp. 135–138.
- [48] D.J. Kessler, B.G. Cour-Palais, Collision frequency of artificial satellites: the creation of a debris belt, *J. Geophys. Res.* 83 (1978) 2637–2646, doi:10.1029/JA083iA06p02637.
- [49] B.A. Garner, *Police power*, *Black’s Law Dictionary*, second ed., West Publishing Co., St. Paul, MN, 2009.
- [50] Application of the concept of the “launching State”, G.A. Res. 59/115, U.N. Doc. A/RES/59/115, Dec. 10, 2004.
- [51] U.S. Commission on integrated long-term strategy Discriminate Deterrence: Report of the Commission on Integrated Long-Term Strategy, 1988 <https://apps.dtic.mil/dtic/tr/fulltext/u2/a277478.pdf> accessed April 7, 2021.
- [52] B.G. Chow, H. Sokolski, The United States should follow France’s lead in space, *SpaceNews* (2019) <https://spacenews.com/the-united-states-should-follow-frances-lead-in-space/>. accessed April 13, 2021.
- [53] France’s New Space Defense Strategy, *SatelliteObservation.Net.* (2019). <https://satelliteobservation.net/2019/07/27/frances-new-space-defense-strategy/> (accessed April 13, 2021).
- [54] Consortium for Execution of Rendezvous and Servicing Operations (CONFERS), *CONFERS Recommended Design and Operational Practices*, 2019. <https://www.satelliteconfers.org/wp-content/uploads/2019/02/CONFERS-Operating-Practices-Approved-1-Feb-2019-003.pdf>.
- [55] D. Goedhuis, Legal aspects of the utilization of outer space, *Neth. Int. Law Review* 17 (1970) 25–50.
- [56] International Institute of Space Law Case Concerning the Commercial Exploitation of the Moon (Xavage vs. Adastra), *Manfred Lachs Space Law Moot Court Competition*, 1993 <https://iisweb.org/lachsmoot/problems/prob1993.pdf>.
- [57] International Institute of Space Law, 2nd Manfred Lachs Space Law Moot Court Competition, 1993: Case Concerning the Commercial Exploitation of the Moon (Xavage v. Adastra), in: *Proceedings of the Thirty-Sixth Colloquium on the Law of Outer Space, held in Graz, Austria, October 16-22, 1993*.