laws

MDPI

Article

Indigenous Interests in Outer Space: Addressing the Conflict of Increasing Satellite Numbers with Indigenous Astronomy Practices

Ciara Finnegan

PhD Candidate & Irish Research Council 2021 Government of Ireland Postgraduate Scholarship Recipient, School of Law & Criminology, Maynooth University, W23 E61H Maynooth, Co. Kildare, Ireland; ciara.finnegan.2014@mumail.ie

Abstract: The number of satellites in low Earth orbit is constantly increasing, particularly with the introduction of larger satellite constellations in recent times. This has resulted in a very crowded environment in Outer Space, which poses a number of challenges, not only to activities in Outer Space but also to the activity of observing Outer Space. Prior to humankind's entry into and progressive exploration of Outer Space, the practice of astronomy, what Venkatesan et al. describe as the "millennia-old ability to observe, discover and analyse the cosmos from the surface of the Earth", linked humankind to Outer Space; in particular the Indigenous Peoples whose practice of astronomy is integral to their ways of life. The Indigenous relationship with Outer Space through astronomy requires protection to ensure the continuation of Indigenous culture. However, the aforementioned continual increase of satellites in Outer Space has started to disrupt the view of the night sky and its components from Earth, disrupting the practice of astronomy as a whole and, thus, Indigenous practice. Therefore, humankind's future plans for Outer Space must be constructed with humankind as a whole in mind, including the astronomy practices essential to the way of life of many Indigenous Peoples.

Keywords: indigenous peoples; astronomy; Outer Space; space law

Citation: Finnegan, Ciara. 2022. Indigenous Interests in Outer Space: Addressing the Conflict of Increasing Satellite Numbers with Indigenous Astronomy Practices. *Laws* 11: 26. https://doi.org/10.3390/laws11020026

Academic Editors: Noelle Higgins, Patricia Easteal and Gerard Maguire

Received: 2 February 2022
Accepted: 16 March 2022
Published: 22 March 2022

1. Introduction

Over the past few decades, it has become increasingly evident that Outer Space is central to humankind's present-day functioning, as well as its future. The amount of activity by both States and private actors in Outer Space is constantly escalating, with reliance on the services and opportunities that it provides ever-growing.

An example would be the internet and communications that are essential to the regular use of technology, which is all facilitated by satellites in the various orbits around Earth. While the use of high-speed internet has propelled development forward where the existing satellites render it available, a proportion of the Earth's population does not have access to such facilities and could greatly benefit from them—which is one of the reasons behind the need for the launch of more satellites.

However, the benefits that could be attained from an increased number of satellites, and proposed satellite mega-constellations in Outer Space, also pose a risk to one of the oldest practices associated with Outer Space itself—that of astronomy. While the viewing of the night sky is a practice enjoyed, both professionally and recreationally, by many of humankind, astronomy also constitutes a central practice in the way of life and sense of being of many Indigenous Peoples. The constant addition of satellites into orbits around Earth threatens the night sky and, in doing so, threatens the Indigenous practice of many peoples and the possibility to transfer Indigenous knowledge inter-generationally through that practice.

Thus, while benefits can be achieved for some of humankind by increasing the number of satellites currently in Outer Space, moving forward with these plans should be regulated and designed with input from Indigenous parties who have knowledge on the maintenance of a sustainable relationship with Earth and Sky that arguably could contribute towards greater sustainability in the approaches currently being taken towards Outer Space.

This article aims to investigate, by adopting a descriptive-normative research methodology, the plans for satellite mega-constellations, the impact that these constellations have on astronomical practices and following on from this, the threats that satellite constellations pose to Indigenous astronomy and knowledge. Grounded in this research, this article will then propose recommendations for how Indigenous voices could be better included in decisions made with respect to the approval of plans for satellite mega-constellations. The inclusion of Indigenous voices into decision-making processes is important because Indigenous astronomical knowledge is central to the continuation of Indigenous knowledge systems that long pre-date the creation of satellites by humankind. Any threat to these knowledge systems requires attention. The threat currently posed by satellite mega-constellations to Indigenous astronomy arguably exists as a result of planning in the absence of consideration for all relevant interest-holders, which, as this article will establish, includes Indigenous Peoples and should be rectified through the inclusion of Indigenous voices by means of the avenues that this article will propose.

2. Satellites and 'Mega-Constellations'

2.1. Satellites

With regards to a legal definition of a satellite, the United States Code: Title 51 includes satellites among other space vehicles considered within the category of traffic in Outer Space. For example, the definition of 'aeronautical and space vehicles' consists of a list including "aircraft, missiles, satellites, and other space vehicles, manned and unmanned, together with related equipment, devices, components, and parts" (Legal Information Institute 2010, US Code: Title 51, SubSection 20103, Definition (2)). Thus, satellites constitute one of a number of vehicles that form the traffic in Outer Space. However, a legal definition more specific to the function of a satellite itself is described as "a manufactured object or vehicle intended to orbit the earth, the moon, or another celestial body" (Von der Dunk 2019, p. 1), as referenced by Frans von der Dunk.

Satellites have been associated with Outer Space since humankind's first interaction with the domain with the launch of Sputnik I in 1957. The launch of this satellite constituted the landmark moment that "heralded the dawn of the space age, the space race (initially between the USSR and the United States), and the legal regulation of the use and exploration of outer space" (Freeland 2015, p. 82). Thus, as noted by Trepczynski, "launch and the use of space for communications have been around since the dawn of the space age, with all subsequent development of space law (at least implicitly) needing to account for these basic space activities" (Trepczynski 2021, p. 58). This law will be investigated in Section 3.

Since the launch of the first satellite, the benefits that humankind has reaped have been significant—telecommunications, internet, radio, GPS, and many more daily utilities that would not be possible without the presence of these satellites in orbits around the Earth. These orbits are varied, with low Earth orbit (LEO) being the orbit most discussed with regards to satellite interaction with astronomy. Lyall and Larsen note that "Satellites in LEO are mostly for scientific and remote sensing purposes, although some communications systems also make use of them and the International Space Station (ISS) is in LEO" (Lyall and Larsen 2018, p. 153). There are also GPS satellites in medium Earth orbit (MEO) and satellites in geostationary orbit (GSO). With regards to the designation of spaces for satellites in these orbits, their availability is determined "on a 'first come, first served' basis" (Lyall and Larsen 2018, p. 154), currently regulated by the law that will be discussed in Section 3.

However, while the notion that there is not enough space in the vastness of Outer Space may seem absurd, the traffic of satellites in these orbits has rapidly increased. This

is in order to keep up with global "reliance on satellites for many different applications, including communications, banking transactions, aviation routing, weather observations, disaster management, climate change monitoring, military activities, and other safety and security services" (Mendonça et al. 2015, p. 109).

It is noted by Lyall and Larsen that "[w]hen the use of space began satellites were usually launched singly, and only occasionally with a companion. As time went on, larger and larger satellites were put into space for an expanding variety of functions" (Lyall and Larsen 2018, p. 239). While it could be misconceived that satellites would have negligible impact in terms of size and space in one of Earth's orbits, it is important to be aware that "[c]ommunications satellites in geostationary orbital slots can now be as large as a multi-storey building, with solar panels extending considerably beyond their main bodies" (Lyall and Larsen 2018, p. 240).

However, due to technological advances, there has been a shift away from larger satellites towards smaller satellites. Small satellites can serve a variety of functions that benefit humankind, such as remote sensing, which can monitor weather, natural disasters, water coverage on Earth and many other functions, which it is hoped will contribute towards humankind's ability to live more sustainably. The existing narrative around satellites highlights the benefits and advancements that these humanmade machines have allowed humankind to make and heralds the era of further advancement that new satellite mega-constellations will bring.

2.2. Satellite Constellations

While Bielicki states that satellite constellations are not yet subject to a formal legal definition (Bielicki 2020, p. 246), Wood describes them as "a number of similar satellites, of a similar type and function, designed to be in similar, complementary, orbits for a shared purpose, under shared control" (Wood 2003, p. 13). Furthermore, similarities can be drawn between Wood's definition of satellite constellations and the definition of a 'communications satellite system' provided in the United States' Communications Satellite Act 1962 as follows:

> "The term "communications satellite system" refers to a system of communications satellites in space whose purpose is to relay telecommunication information between satellite terminal stations, together with such associated equipment and facilities for tracking, guidance, control, and command functions as are not part of the generalised launching, tracking, control, and command facilities for all space purposes".[1]

Satellite constellations are not a wholly recent concept—they have existed since the 'Space Race' era. The first constellation of satellites was the Soviet Union's 1968 "Molniya-1 constellation consisting of ten satellites" (Bielicki 2020, p. 247), which was launched in 1965. As to be expected, the other main actor in Outer Space in the 1960′s, the United States, also launched a satellite constellation, specifically "the first global satellite navigation system called 'Transit'. The first satellite of the Transit system was launched in 1960, and until 1968 there was a fully functional constellation of thirty-six satellites" (Bielicki 2020, p. 247). Furthermore, Wood describes that "[t]he 1990s were perhaps the public heyday of satellite constellations" (Wood 2003, p. 13), in this period when the expansion of mobile telephone and broadband services was truly taking off.

Thus, satellite constellations have been in existence since some of humankind's first interactions with Outer Space. However, Bielicki emphasises that "the second decade of the twenty-first century brings about much larger projects, often referred to as mega-constellations. These projects consist of hundreds and even thousands of satellites synchronised under common control" (Bielicki 2020, p. 248).

The present and future situation with regards to satellite constellations is detailed by Williams et al.:

[1] Communications Satellite Act 1962 (US) Section 103(1).

> "Currently operating constellations serve a variety of important and crucial functions for society, including navigation and geodesy (for example, GPS, Galileo and GLONASS), satellite telephony (for example, Iridium), internet and TV (for example, ViaSat, Orbcom, GlobalStar) and Earth observation (for example, Copernicus and Planet). In the future, companies such as SpaceX, Amazon, Samsung, Telesat and OneWeb, and several national entities (for example, the Chinese and Indian Space Agencies) are planning very large constellations in low Earth orbit (LEO)" (Williams et al. 2021, p. 3).

It was in 2019 that Elon Musk's SpaceX began launching the first satellites for the 'Starlink' constellation that would be made up of thousands of satellites in LEO (McDowell 2020, p. 1). It was after this launch that it was realised that some of the satellites in LEO "remained naked eye objects" (McDowell 2020, p. 1) in the sky and this move towards satellite mega-constellations and many of the considerations of its impact on astronomy that form the crux of this article arose.

With the current situation in Outer Space with regards to satellites and mega-constellations outlined, the next section will investigate the law applicable to these satellites and satellite constellations.

3. Satellites and the Space Law Framework

As will be outlined in this section, as space objects, satellites are subject to regulation under the five treaties of the United Nations Space Law framework, as well as standards set by the International Telecommunication Union (hereinafter the ITU), both of which aim to influence domestic legal systems and space law standards for State-based space actors.

3.1. Rights of All Humankind

The central instrument of the current UN space law framework is the 1967 Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies,[2] also known and hereinafter referred to as the Outer Space Treaty. Article I of the Outer Space Treaty sets the tone for which humankind's interaction with Outer Space was envisaged; "[t]he exploration and use of outer space, including the moon and other celestial bodies, shall be carried out for the benefit and in the interests of all countries, irrespective of their degree of economic or scientific development, and shall be the province of all mankind" (1967 Outer Space Treaty, art I). As noted by Koch, with no specific legal definition provided for the 'province of all mankind', this categorisation of Outer Space "remains an elusive concept, open to many interpretations" (Koch 2018, p. 4).

However, it is noted that it remains a distinct concept from that of the 'common heritage of mankind' which is designated to the Moon and any of its resources specifically in Article 11 of the 1969 Agreement Governing the Activities on the Moon and Other Celestial Bodies,[3] hereinafter the Moon Agreement. While no parameters have been set for what constitutes the province of all mankind, it is understood that the 'common heritage of mankind' is "conceived as an expansion of the province of all mankind within international space law" (Koch 2018, p. 7).

Nevertheless, the imprecise nature of the classification of Outer Space as the 'province of all mankind' does not serve to negate the fact that this classification was enshrined in the Outer Space Treaty to highlight an inclusive approach to activities in Outer Space that envisaged benefits for all humankind. Furthermore, Tan highlights that "[t]he 1963 Declaration of Legal Principles relied on strong principles of equity, fairness, and common interest" (Tan 2000, p. 161), which preceded the introduction of the Outer Space Treaty.

---

[2] Treaty on the Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies (adopted 27 January 1967, entered into force 10 October 1967) 610 UNTS 205 (Outer Space Treaty).

[3] Agreement Governing the Activities of States on the Moon and Other Celestial Bodies (concluded 5 December 1979, entered into force 11 July 1984) UNTS vol. 1363, p. 3 (1979 Moon Agreement) art 11.

Reference is made in the Declaration to the "common interest of all mankind",[4] as well as "due regard for the corresponding interests of other States" (1963 Declaration of Legal Principles., art 6), with many of these concepts of interacting with Outer Space while respecting the benefits and interests of others being made legally binding in the Outer Space Treaty.

It is notable that the Artemis Accords, the principles of which outline the aims of the United States and other States that agree to the Accords in the planned mission to return to the Moon, are illustrative of a move away from the viewing of Outer Space as part of the 'global commons' (Vazhapully 2020), which the United States have expressly made clear. For example, Section 10 of the Artemis Accords (NASA 2020, sect. 10) deals with the prospect of space resource extraction but does not make reference to the establishment of a specific regime that would divide those resources equitably among those states most in need, as was envisaged under the aforementioned 'common heritage of mankind' approach in the 1979 Moon Agreement. Nevertheless, the Accords do make frequent references to benefitting humankind.

Overall, the broad wording of humankind (or rather the more dated term of 'mankind') with regards to benefits and interests evident in the Outer Space Treaty would imply an obligation to balance the benefits that could be garnered from Space exploration and utilisation, for example, satellite use, with the interests of maintaining the relationships with Outer Space and the universe that Indigenous Peoples have sustained for thousands of years prior to the creation of the Space Law framework. This is because while it may have been interpreted that the benefits to be garnered would be from increased interaction with Outer Space, the use of the wording of 'mankind' would suggest the interest of all peoples, including not only States without space-faring capabilities but also Indigenous Peoples whose interests in Outer Space may be best preserved by less interaction with Outer Space, as will be discussed in Section 5.

3.2. Responsibilities of Space Actors

While humankind as a whole is envisaged as the beneficiary of what Outer Space has to offer, States are the parties with obligations to uphold with respect to Outer Space activities. With regards to satellite usage, States' obligations pertaining to the registration of the space objects under their responsibility are outlined in the 1974 Registration Convention,[5] as well as any obligations regarding liability that may be invoked if a satellite causes damage being enshrined in the 1972 Liability Convention.[6]

However, the plans for the previously discussed satellite mega-constellations are being spearheaded by private corporations, such as SpaceX. As a commercial private actor, SpaceX, while subject to regulation in domestic law by the United States Federal Communication Commission (Code of Federal Regulations 2022), is not subject to regulation under international space law in the same way as States' space agencies. This begs the question as to where the burden of responsibility for private actors' satellites and soon-to-be satellite mega-constellations falls. Article VI of the 1967 Outer Space Treaty provides the answer that "States Parties to the Treaty shall bear international responsibility for national activities in outer space, including the moon and other celestial bodies, whether such activities are carried on by governmental agencies or by non-governmental entities, and for assuring that national activities are carried out in conformity with the provisions set forth in the present Treaty" (1967 Outer Space Treaty, art VI). Thus, States bear the responsibility for satellites belonging not only to their national space agencies but also those belonging to

[4] United Nations General Assembly, 'Declaration of Legal Principles Governing the Activities of States in the Exploration and Use of Outer Space' (13 December 1963) RES 1962 (XVIII) (1963 Declaration of Legal Principles) preamble, preamble.

[5] Convention on Registration of Objects Launched into Outer Space (concluded 12 November 1974, entered into force 15 September 1976) UNTS vol. 1023, p. 15 (1974 Registration Convention).

[6] Convention on International Liability for Damage Caused by Space Objects (concluded 29 March 1972, entered into force 1 September 1972) UNTS vol. 961, p. 187 (1972 Liability Convention).

private actions within their State. This is further consolidated by the provisions of the 1972 Liability Convention, with Article I outlining that liability for damage caused by space objects would lie with the 'launching State', which is defined as "(i) A State which launches or procures the launching of a space object; (ii) A State from whose territory or facility a space object is launched"(1972 Liability Convention, art I). The latter instance would likely apply to private actors whose space objects, including satellites, are launched from the facilities of a State, with that State then taking responsibility for any damage caused by the launched space object. Consequently, the 1972 Liability Convention serves as another example, alongside the foundational 1967 Outer Space Treaty, that illustrates that, while regulated under domestic law, in the international space law framework, the burden of responsibility from private space actors' activities lies with the States in which these actions are conducted.

However, while States bear this burden or responsibility for satellite registration and liability should damage be caused, neither of these instances results in the obstruction of astronomy—the mere presence of satellites in some of Earth's orbits does this alone. The designation of satellite orbits and the standards surrounding communications satellites, in general, are the responsibility of the ITU.

3.3. The ITU and Satellite Orbits

Satellites, while being the responsibility of the appropriate State with regards to launch, registration, or liability, are also the responsibility of the ITU with regards to allocation of a place in the night sky. Amongst other roles, the ITU grants "allocation of bands of the radio-frequency spectrum, the allotment of radio frequencies and the registration of radio-frequency assignments and, for space services, of any associated orbital position in the geostationary-satellite orbit or of any associated characteristics of satellites in other orbits, in order to avoid harmful interference between radio stations of different countries".[7]

Mendonça et al. highlight that the ITU has an increasingly important role as "[t]he increasing number of satellites being launched has arguably created congestion and competition, particularly at the Geostationary Orbit (GEO)" (Mendonça et al. 2015, p. 109), and the ITU is "the specialised United Nations agency charged with managing radio frequencies and orbital positions for satellites" (Mendonça et al. 2015, p. 109). The management of these orbital positions is made possible by the ITU Constitution, Convention and Radio Regulations, which collectively "establish international rules that aim at avoiding interference in the signals being transmitted through the radio spectrum" (Mendonça et al. 2015, pp. 114–15).

In addition, what the ITU has achieved through expansive membership is "[c]ommunications regulations . . . fairly consistently implemented on the domestic level by almost every State" (Trepczynski 2021, p. 58). The international standards set by the ITU are required to be consistent across the domestic law of Member States. Thus, the result is "an internationally coordinated approach to the use of spectrum, to include its use in and through space, as well as the use of orbital slots, which directly impacts the domestic regulations of all Member States, driving a highly detailed and prescribed approach to communications" (Trepczynski 2021, p. 58).

However, the ITU is only beginning to prepare for constellations of satellites, with Boley and Byres highlighting that "[n]o binding international rules exist on other aspects of mega-constellations" (Boley and Byres 2021). Steps have been taken, as is seen by the fact that "[t]he ITU recently adopted a tiered management approach, whereby listing a mega-constellation in its 'Master Register' depends on certain milestones being met. This deters companies from filing and effectively claiming orbital shells years before they are ready to launch" (Boley and Byres 2021) and maintains some sort of management over the increasing occupation of orbital slots.

[7] Constitution and Convention of the International Telecommunication Union (adopted 1992) art 1(2)(a).

It is further noted that despite the ITU standards, national communications authorities could be "assigning orbital shells to mega-constellations on a first-come, first-served basis, without assessing the effects on other countries" (Boley and Byres 2021). This would undermine all of the work of the ITU in ensuring orbit allocation is correct.

However, for the purposes of the article's investigation, the main consideration of the ITU, as the UN authority specific to satellites (although the UN Committee on Peaceful Uses of Outer Space (hereinafter UN COPUOS) is beginning to consider this article's specific issue of satellite constellations and astronomy, which may indicate a prospective shift in responsibility in the future) (United Nations General Assembly 2021),[8] is that of practicality in allocating orbits and ensuring that the satellite to be launched will be in a position to function and not disrupt the functioning of any other satellites. Whether these satellites in various orbits interrupt astronomical practices is not enshrined as a concern of the ITU.

Provision for practical and functionality considerations appear to come to the fore with regards to the law pertaining to satellites as investigated in this section. The ITU and much of the UN Space Law framework regulate from the perspective of facilitating the acceleration of more satellite activity into orbit. However, as Section 4 will discuss, the increase in satellites in orbit is obstructing the practice of astronomy. While this could be interpreted as an inconvenience that should be tolerated in favour of 'progress', as was noted earlier, the foundational Outer Space Treaty emphasised the use of Outer Space for the benefit of all mankind—including the peoples to whom astronomy is central to their culture and ways of life.

4. How Is the Practice of Astronomy Impacted by Increased Satellite Numbers?

Attempts to preserve the 'right to dark skies' is a cause that has unified both professional astronomers and Indigenous Peoples in recent times based on the fact that astronomy is essentially impossible to practice in certain areas due to the light pollution from large cities and urban areas (Ruggles 2009, p. 14). However, the preservation of the night sky for the purpose of astronomy is no longer threatened just by Earth. As Venkatesan et al. succinctly describe, "[t]he proliferation of Low Earth orbit satellites (LEOsats) at altitudes less than 2000 km threatens our millennia-old ability to observe, discover and analyse the cosmos from the surface of the Earth" (Venkatesan et al. 2020, p. 1043), alluding to the impact and interference that satellites are posing to the practice of astronomy.

While the extent of the impact that the proposed mega-constellations will have is not yet fully known, the potential has already been experienced, as noted by Hecht, when "the first mass launch of 60 Starlink satellites on 23 May 2019 caught astronomers flat-footed, as astronomical photos revealed streaks from the satellites, covering the sky with light pollution" (Hecht 2021). The International Astronomical Union (hereinafter the IAU) expressed its concern regarding the effects of planned satellite constellations in a statement in 2019, which emphasised the IAU's general stance in favour of the maintenance of dark skies and concern that "[w]e do not yet understand the impact of thousands of these visible satellites scattered across the night sky" (International Astronomical Union 2019). This concern was further emphasised in the IAU's Report on Dark and Quiet Skies, which was presented in February 2022 at the Scientific and Technical Subcommittee of UNCOPUOS (International Astronomical Union 2022).[9]

Those practising astronomy in purpose-built institutions with it noted that many of these "institutions and facilities were built on the traditional lands of Indigenous peoples" (Venkatesan et al. 2020, p. 1043) have experienced this light pollution as damaging at certain

[8] United Nations General Assembly (2021) outlines that the session heard a presentation from United States representatives on the topic of 'Perspectives from the United States on coexistence (and sustainability) of large satellite constellations and (terrestrial) astronomy' (para 18(h)(i)), as well as suggestions that the topic of 'General exchange of views regarding satellite system effects upon terrestrial-based astronomy' should be considered at the 2022 session of the Scientific and Technical Subcommittee (para 297).

[9] International Astronomical Union (2022). This report was compiled from working group reports composed at a conference co-organised by UNOOSA in October 2021 and recognized the significance of the maintenance of dark skies for astronomical practices in general, but also for indigenous astronomy.

times for capturing images from their observatories. Massey et al. detail this interference as follows:

> "When a satellite reflecting sunlight passes through the field of view of a telescope, it leaves a characteristic streak of light in images. Software tools to some extent mitigate this contaminant, smoothing out the data to make a cosmetic improvement to the final result. However, the data behind the streak is simply lost, at least in a single frame, although astronomers can stack a succession of images to compensate for that" (Massey et al. 2020, p. 1022).

While this streak of light across images from telescopes caused by satellites reflecting sunlight could be argued as being an 'inconvenience' to the professional practice, it is important to note that this lost data and need for software editing of images will become increasingly frequent occurrences proportionate to the increased number of satellites as they are launched. As noted by Levchenko et al., "[t]he deployment of the Starlink constellation would triple the number of satellites in orbit by itself, and it is only one of many large constellations currently planned" (Levchenko et al. 2020, p. 1014). Thus, satellite constellations would result in more telescope images being interrupted by streaks of light, which has the effect of more data from behind that streak of light being lost, but also more time being spent using software tools to preserve what is left of the telescope images. These interferences arguably impact the practice of astronomy by making the capturing of telescope images of the sky more difficult, tedious, and time-consuming.

The information being lost behind these streaks of light was also highlighted as having a concerning impact on important astronomical research projects, as outlined in the SATCON1Report (American Astronomical Society 2020)[10] as follows:

> "Many astronomical investigations collect data with the requirement of observing any part of the sky needed to achieve the research objective with uniform quality over the field of view. These include studies that are among the highest priorities in the discipline: stellar populations in the Milky Way and neighbouring galaxies; searches for potentially hazardous near-Earth objects; identification of gravitational wave sources such as neutron star mergers; and wide-area searches for transiting exoplanets" (American Astronomical Society 2020, p. 3).

Thus, streaks of light from satellites reflecting sunlight interrupt the consistency of the quality of these important observations. Furthermore, these streaks of light could prevent the detection of "a time-critical aspect and/or a rare, scientifically critical target" (American Astronomical Society 2020, p. 3), which, if this were to occur, would undermine the aims of these astronomical projects.

Astronomical observations and images being interrupted by satellites reflecting sunlight impact the practice of astronomy by requiring additional software to fix astronomical images, affecting the quality of observation research projects or even preventing the detection of one-off space events. Therefore, the impact experienced by professional astronomers is considerable, but the impact is arguably more acute for the Indigenous Peoples, to whom the practice of astronomy is integral.

5. Indigenous Astronomy

The use of the term 'Indigenous Astronomy' in this article is intended to also extend to Indigenous cosmologies—the terminology does not intend to limit Indigenous knowledge and practice to constricted Western notions. Ruggles emphasises that this is a comprehension divide that must be overcome in order to have proper understanding and facilitate an inclusive dialogue (Ruggles 2009, p. 6), such as the one envisaged and suggested in Section 7. Thus, the use of the term 'Indigenous Astronomy' is intended to encapsulate

[10] American Astronomical Society (2020). The recommendations of which were elaborated upon at SATCON 2 in 2021.

all of the diverse relations and interconnections of all Indigenous Peoples with the sky, universe, and celestial bodies therein.

While the practice of astronomy can be generally defined as the observation of the skies and everything contained therein, there is no one definition to encapsulate what Indigenous astronomy means to all Indigenous Peoples, but it is emphasised by Bhathal that Indigenous astronomy "is not based on the hypothetico-deductive system that physicists and astronomers use and validate by observation and experiment; rather it is a knowledge system based on other knowledge traditions" (Bhathal 2006, p. 27). Thus, while Indigenous astronomy pertains to the observation of the sky, stars, constellations and planets, this practice is carried out for reasons assigned by the aforementioned Indigenous cosmologies. Nevertheless, as was evident from the 'Dark and Quiet Skies 2022' report mentioned in Section 4, consultation occurs between modern astronomers and Indigenous astronomers regarding the night sky and as noted by Hollabaugh, "[m]odern astronomy and Native views tolerate each other because they each seek to understand the heavens, albeit from very different perspectives and by asking very different questions" (Hollabaugh 2017, p. 178).

The reasoning behind Indigenous astronomical practices, while distinct to each Indigenous People and also having practical roles in the functioning of Indigenous societies, as will be outlined in the sub-section examples below, is linked to the Indigenous cosmologies of a people. Drahos describes an Indigenous cosmology as "a form of philosophical realism in which a set of entities and objects are claimed to have an independent and knowable existence, an obvious example of these entities being ancestors" (Drahos 2014, p. 32). Bhathal explains that in this Indigenous 'philosophy' as Drahos phrased it, or alternatively, an understanding of the universe, with specific reference to Aboriginal Peoples of Australia and Torres Strait Islanders, "all life—human, animal, bird or fish—is part of an ever-transforming system that can be traced back to the Spirit Ancestors who go about the Earth in an eternal time called the Dreaming" (Bhathal 2006, n 28) and all that is seen on Earth and in the Sky, was made by the work of ancestors to inform and maintain a connection with future generations of their Indigenous Peoples. This is not to imply that the concept of Dreaming is true for all Indigenous Peoples, but rather to illustrate that Indigenous astronomical practices, while in practice similar to the observation of the sky by modern astronomers, are distinct because these practices are underpinned by an understanding of the Earth, cosmos and respective peoples contained therein in relation to a peoples' Indigenous knowledge. For example, Cajete, speaking to Native American astronomies, highlights that "Native astronomies helped to make sense of life and relationships and reaffirm the belief in the interrelationship and interdependence of all things in an animate and living universe" (Cajete 2000, p. 216), which helps to explain how Indigenous astronomy and associated Indigenous knowledge is linked to Indigenous cosmologies and understandings of the universe and of its people, past and present.

Indigenous astronomy practices developed as Indigenous Peoples "observed the natural processes and interrelationships of all things over millennia" (Maryboy 2020, p. 14). These practices have come to constitute a part of the "rich and complex ways of knowing and ways of being and living in this universe" (Maryboy 2020, p. 14) that make up Indigenous knowledge. This Indigenous astronomical knowledge has also evolved "from their lived experience in their distinct places, in spiritual relationships with land and life, and from traditions that change but are millennial" (Million 2013, p. 13); an evolution that is now threatened by the obstruction of the views of the night sky by satellite mega-constellations and with this occupation of orbits with humanmade machines, there is also the threat of encroachment of colonisation into a sacred space for Indigenous Peoples.

While much Indigenous knowledge of astronomy and the sky is passed through oral tradition within Indigenous communities and thus, remains protected, there is a growing awareness of some of the significance of astronomy to various Indigenous Peoples, often due to the work and dissemination of Indigenous scholars themselves, as well as researchers

of Indigenous Peoples. Thus, provided below is a brief overview of just some of the known significances of astronomy to a few of many Indigenous Peoples.

5.1. Ancient Polynesian Peoples and Peoples of Polynesian Descent

For ancient Polynesian peoples, the sky served many roles. The passage of time could be read from "[t]he motions of the heavenly bodies across the sky" (Makemson 1938, p. 381), and the seasonal changes were determined in a similar way. The information obtained from these skyward observations were central to the peoples' way of life, with Makemson highlighting that "it was essential to recognise in advance the proper time for planting the various crops, when the winds might be depended upon for long voyages" (Makemson 1938, pp. 381–82) and the seasonal weather changes.

Furthermore, a practice strongly associated with the ancient Polynesian peoples is seaward voyaging and wayfinding by way of the sky and stars. It is recognised that "[t]o the ancient Polynesian navigator, the sky, particularly the night sky, was a compass, chart, and chronometer. Point out a star to him, and he would tell you the islands to which that star would lead you if you steered your canoe toward the point where it rose or set at the horizon" (Makemson 1938, p. 381). Lewis, in researching the peoples of Polynesia and Micronesia noted "the bold range of Pacific voyaging, even in contact times, and the excellence of indigenous navigational systems" (Lewis 1974, p. 145), highlighting both the historical roots of ancient Polynesian wayfinding knowledge, but also how it survived post-European contact. Thus, this knowledge of how to navigate one's way across the sea from what is visible to the naked eye in the sky is an important part of ancient Polynesian knowledge. This knowledge has been transferred intergenerationally "without the benefit of written communication" (Buente et al. 2020, p. 1280)[11] in the communities of Polynesian descent, but also remains living knowledge, as it must be recognised that "it is not just ancient peoples who carefully track the stars, sun and moon. Many living Indigenous societies follow their ancient knowledge in ways to live today" (Maryboy 2020, p. 20).

However, to view the stars of the night sky is becoming increasingly difficult because, as it was previously noted, many of the satellites forming the constellations in LEO are also visible to the naked eye, despite attempts such as those made by SpaceX in creating 'VisorSats' (satellites with visors attached to reduce the reflection of sunlight from satellites in Starlink) from August 2020, which reduced visibility but did not get rid of it completely (Mallama 2021). The ability to read the constellations of stars could become impossible to navigate with the naked eye due to numerous reflective satellites now occupying what was previously darkness. The need to maintain dark skies, while essential to many Indigenous Peoples, is emphasised by Venkatesan et al. as being especially important "for celestial navigators and the practice of wayfinding by those cultures of Polynesian descent (Hawai'i, Māori and Oceania peoples)" (Venkatesan et al. 2019, p. 1037).

Thus, this Indigenous wayfinding knowledge, so integral to ancient Polynesian peoples and forming a part of the Indigenous astronomical knowledge and heritage of peoples of Polynesian descent today, could be prevented from being practised and transferred intergenerationally within these communities should satellite constellations continue to be approved and formed.

5.2. Navajo People

Maryboy's research on the astronomy of the Navajo people is similarly illustrative of this continued importance of Indigenous astronomical knowledge today, noting that "extensive, albeit guarded star, Sun and Moon knowledge and use . . . for ceremonial and everyday life" (Maryboy 2020, p. 20) remains central to the Navajo people. Temporal and seasonal changes can be read from the star formations, with Navajo Indigenous knowledge informing the people of when their seasons begin and end (Maryboy 2020, pp. 21–22). In

[11] Buente et al. (2020) makes reference to the "sophistication and details of their geographic understanding and seafaring techniques" contained within the Indigenous knowledge that is transmitted through oral traditions, as had been mentioned by (Feinberg et al. 2003).

Young's research of both the Navajo and Pueblo peoples, it is elaborated that these peoples "use this astronomical knowledge both to set their annual calendar and to govern the round of daily activities, thus determining the correct timing for soil preparation, planting, and harvesting of crops, as well as for ceremonies and rituals" (Young 1996, p. 49).

Furthermore, the view of the stars and celestial bodies serves as a celestial story as "[t]he Navajo constellations provide teaching of ways to live in accordance with tribal values"(Maryboy 2020, p. 20), specifically emphasising the familial structures and relations seen in the stars of the night sky and interpreted through the Indigenous knowledge of the culturally distinct meaning behind the various star constellations. Thus, the stars can serve to teach the importance of family, home, and the community in Navajo Indigenous life.

However, this again requires the ability to view the night sky and discern the stars from the reflective satellites with the naked eye in order to pass on these central teachings to new generations of Navajo people.

5.3. Aboriginal Australian and Torres Strait Islander Peoples

The maintenance and transfer of Aboriginal and Torres Strait Islander Indigenous astronomical knowledge are possible because "Aboriginal oral traditions constructed narratives and memory spaces in such a way as to keep the critical information intact through hundreds of generations" (Cropper et al. 2019), which continues to be the case today.

Equipped with this knowledge, observation of the stars and celestial bodies can serve "to predict changing seasons and the availability of food sources. Behind each of these brief accounts is a complex oral tradition that denotes a moral charter and informs sacred law" (Hamacher 2014). The stars and sky contain the physical representations in nature of some of the tenets of Indigenous culture.

While not dissimilar to the stars providing teachings for the Navajo peoples, as previously discussed, it is important to highlight that the traditions, understandings, and interpretations of the night sky are all distinct to each Indigenous People and, thus, must be understood as distinct knowledge-sets that are all being impacted. Furthermore, each Indigenous People are observing different elements of the night sky. For example, the Torres Strait Islander people, as Hamacher notes, also observe "stellar scintillation (twinkling), which enables them to determine the amount of moisture and turbulence in the atmosphere" (Hamacher 2014).

Bhathal notes that the significance of Aboriginal Australian and Torres Strait Islander Peoples' astronomical knowledge has been recognised in the Australian domestic legal system, with references to Indigenous astronomy made during the High Court case of *Mabo and others. v the State of Queensland and the Commonwealth of Australia*,[12] which resulted in Murray Islanders being recognised as having Indigenous land rights. Malo's law, the traditional law of the land by which the Murray Islanders abide and which was relied upon in court, is described as being "related" (Bhathal 2016) to the law of the Stars of Tagai, which constitute the law of the sky and heavens. The inter-generational teaching of Malo's law was outlined in oral statements by plaintiffs as being transferred the way Indigenous astronomical knowledge and understanding was passed on. For example, Sharp highlights how plaintiff James Rice explained how he learned that "[s]ome myths belong to certain clans as do certain stars and winds . . . but the myth of Malo 'belongs to all Murray [Islanders]" (Sharp 1990, p. 27). Bhathal states that the use of the Murray Islander people of the sky and stars to determine agricultural and fishing seasons served as "evidence of the fact that the islanders had been tilling their lands for generations" (Bhathal 2006, p. 30).

Mitchell et al., on behalf of Bawaka Country, a Yolŋu homeland, have collaboratively addressed the activities of actors in Outer Space that foreshadow the prospect of space colonisation, of which occupation of orbits with satellites is associated, from the perspective of the peoples Indigenous to Bawaka Country (Bawaka Country et al. 2020, p. 1). It is

[12] *Mabo and others. v the State of Queensland and the Commonwealth of Australia (No 2)* [1992] HCA 23.

emphasised that occupation of Outer Space and with it, the encroaching of colonial practices into that domain, goes against the responsibility of stewardship to care not only for Earth, but for Country, which is all-encompassing, whereby "Land, Sea and Sky Country are all connected, so there is no such thing as 'outer space' or 'outer Country'—no outside. What we do in one part of Country affects all others" (Bawaka Country et al. 2020, p. 2). The relations and connections between Indigenous Peoples of Bawaka Country and their ancestors and kin, whose spirits travel to Sky Country, are also affected by interaction with Outer Space through the launching and creation of satellite constellations (Bawaka Country et al. 2020, pp. 1, 7). This illustrates how the prospect of satellite constellations negatively impacts not only Indigenous practices drawn from astronomical information or the transfer of Indigenous knowledge and heritage but also the spiritual practices and connections of Indigenous Peoples to their ancestors.

As a result, Indigenous Peoples are facing not only challenges but threats to many aspects of their ways of life and being because of the current number of satellites, before the proposed satellite mega-constellations are even fully formed; meaning that the threats to Indigenous Peoples and the many ways in which they utilise the sky and the universe are only going to increase.

As noted at the beginning of this section, this is just a brief overview of some of the astronomy practices of only a few Indigenous Peoples and thus should be taken as merely a sample of just a few of the many negative effects that will be suffered by Indigenous Peoples and their knowledge if satellite mega-constellations continue to be heralded as the 'way forward' for Outer Space. The "multigenerational experiential wealth contained holistically in Indigenous knowledge"(Venkatesan et al. 2020, p. 1046) should be protected and preserved. As will be discussed in the next section, the rights of Indigenous Peoples are protected in International Law, but not specifically with regards to the night sky. However, Indigenous astronomy and knowledge warrant protection, not just for the continuance of its central character to Indigenous Peoples themselves, but also because, as will be discussed in Section 7, Indigenous knowledge and relationships with the sky have been sustained for thousands of years—and sustainability with Outer Space is the knowledge that humankind could benefit from.

6. Indigenous Rights

It is evident that the continuance of Indigenous astronomical knowledge is at risk of being impeded by the launch of satellites to form mega-constellations. This astronomical knowledge that serves to inform seasonal changes, cultural values and overall Indigenous ways of life is central to Indigenous culture, which is protected in International Law, and this section of this article will briefly outline the legal instruments which provide such protection.

The introduction of an international legal instrument dealing specifically with the rights of Indigenous People came in 1957 when the International Labour Organisation (hereinafter the ILO) adopted the Convention Concerning the Protection and Integration of Indigenous and Other Tribal and Semi-Tribal Populations in Independent Countries, also known as ILO Convention 107[13]. While focusing on Indigenous Peoples, this Convention is recognised as having taken the approach of "promoting the assimilation of indigenous peoples into majority societies" (Anaya 2013, p. 1004). After the creation of its successor convention, it was "declared closed for ratification" (Barelli 2009, p. 958).

The 1989 ILO Convention concerning Indigenous and Tribal Peoples in Independent Countries, hereinafter ILO Convention 169,[14] continues to be the "only international binding treaty on indigenous peoples' rights" (Larsen and Gilbert 2020, p. 83). Wiessner

[13] International Labour Organisation, 'Convention concerning the Protection and Integration of Indigenous and Other Tribal and Semi-Tribal Populations in Independent Countries, n. 107 (adopted 1957) (ILO Convention 107).

[14] International Labour Organisation, 'Convention concerning Indigenous and Tribal Peoples in Independent Countries, n. 169' (adopted 1989) (ILO Convention 169).

describes that "[t]he Convention has as its basic theme the right of indigenous people to live and develop as distinct communities by their own designs" (Wiessner 2008, p. 1156). Thus, while an improvement from its predecessor, "the participation of indigenous representatives during the elaboration of the new treaty was poor" (Stamatopoulou 1994, p. 66), something that was provided during the creation of the UN Declaration on the Rights of Indigenous Peoples (hereinafter UNDRIP).

Anaya notes that the creation of UNDRIP was a feat achieved wherein "[r]epresentatives of indigenous peoples from around the world actively participated in the years of deliberation by the Working Group that began in the early 1980s" (Anaya 2013, p. 992), to result in the declaration being adopted by the UN General Assembly in 2007. It is this declaration that most extensively provides for the protection of the rights of Indigenous Peoples in international law.

It is recognised in the Preamble of UNDRIP that "control by indigenous peoples over developments affecting them and their lands, territories and resources will enable them to maintain and strengthen their institutions, cultures and traditions, and to promote their development in accordance with their aspirations and needs".[15] However, while it is evident that the rapid escalation in satellite numbers in Outer Space does affect Indigenous astronomy, the inclusion of Indigenous knowledge and voices into the ongoing conversations concerning such developments which would not only give Indigenous Peoples this aforementioned control but could also ensure informed future developments,[16] has not yet occurred.

Article 11(1) provides that "Indigenous peoples have the right to practise and revitalise their cultural traditions and customs" (UNDRIP, art 11(1)), which would include Indigenous astronomy, but while Article 25 serves to protect Indigenous lands, noting that "Indigenous peoples have the right to maintain and strengthen their distinctive spiritual relationship with their traditionally owned or otherwise occupied and used lands, territories, waters and coastal seas and other resources" (UNDRIP, art 25), the spiritual relationship of Indigenous Peoples with the space beyond Earth is not protected. Thus, while Indigenous astronomy, as an element of Indigenous culture, is protected, the interconnection between Indigenous Peoples and the universe is not expressly represented in UNDRIP.

Specific and express recognition of these and many more Indigenous Rights in UNDRIP constituted a milestone and "celebratory moment since thousands of Native peoples worked extensively for thirty years to achieve this recognition"(Million 2013, p. 9). However, while of the utmost significance for the recognition of rights of Indigenous Peoples, "legally speaking, United Nations declarations, like almost any other resolution by the General Assembly, are of a mere hortatory nature: they are characterised as 'recommendations' without legally binding character" (Weissner 2011, p. 130). Therefore, while it is envisaged that due to UNDRIP's "character as a pronouncement of the major political organ of the United Nations it will continue to be applied in some measure by the Permanent Forum on Indigenous Issues, the Human Rights Council, and other UN institutions in executing their own programmes and in evaluating state conduct on the subject" (Anaya 2013, p. 1003); its non-binding status could be one of the reasons why Indigenous Rights and the protection of Indigenous astronomy has not been considered in international space law instruments.

Nevertheless, in terms of legally binding protections for the right to culture, Article 27 of the International Covenant on Civil and Political Rights[17] could be availed of by Indigenous Peoples as it provides that "[i]n those States in which ethnic, religious or linguistic minorities exist, persons belonging to such minorities shall not be denied the

[15] United Nations General Assembly, 'United Nations Declaration on the Rights of Indigenous Peoples' (adopted 2 October 2007) A/RES/61/295 (UNDRIP) preamble.

[16] ibid, preamble: Reference is made to the link between sustainability and indigenous knowledge—"Recognizing that respect for indigenous knowledge, cultures and traditional practices contributes to sustainable and equitable development and proper management of the environment".

[17] International Covenant on Civil and Political Rights (adopted 16 December 1966, entered into force 23 March 1976) 999 UNTS 171 (ICCPR).

right, in community with the other members of their group, to enjoy their own culture, to profess and practise their own religion, or to use their own language" (ICCPR, art 27). Therefore, it is arguable that the non-binding nature of the protections of Indigenous culture provided for in UNDRIP is not relevant as there are legally binding protections for minority culture, in which Indigenous Peoples would be included, at the international level. Yet, these are not being considered in conjunction with Outer Space activities.

The Outer Space Treaty, previously mentioned in Section 3, outlines in Article III that "States Parties to the Treaty shall carry on activities in the exploration and use of outer space, including the moon and other celestial bodies, in accordance with international law" (1967 Outer Space Treaty, art III). However, the rights of Indigenous Peoples with respect to their culture, including Indigenous astronomy, are not being given consideration or are rights that are being marginalised by the majority opinion in favour of increased exploration into and use of Outer Space by humankind.

This lack of inclusion of Indigenous Peoples and their rights with respect to the night sky that are being hindered in the wider conversation of relevant parties with regards to Outer Space illustrates a lack of understanding of (i) the fact that the use of 'mankind' in the Outer Space Treaty would include all peoples, (ii) the connections that Indigenous Peoples have with the sky, universe and celestial bodies that far pre-date any interaction of humankind with the domain with the use of humanmade technology and finally, (iii) the need to introduce Indigenous voices into the conversation on satellite mega-constellations. The latter prospect and how this could be achieved will be discussed in the next section.

7. The Inclusion of Indigenous Voices in Planning for Future Space Activity and the Future of the Night Sky

As preceding sections of this article have illustrated, the benefits offered by the creation of satellite mega-constellations by States, as well as private space companies like SpaceX, are substantial—internet services could be made available to areas on Earth where this service, and the advances that it facilitates, was never previously available. However, this projected benefit comes with a caveat—the increased number of satellites required to form these mega-constellations will obstruct the practice of astronomy which, as it has been established, is central to the way of life of many Indigenous Peoples, holding cultural, spiritual, and practical significance in Indigenous knowledge.

This article proposes the inclusion of Indigenous voices into plans for activities in Outer Space, to try and broaden the understanding of the Space community towards the impact increased activity in Outer Space is having on Indigenous Peoples and also, to appreciate the fact that Indigenous Peoples have sustained a relationship with Earth and Sky for thousands of years, something which the rest of humankind cannot attest to in the midst of the climate crisis stemming from the impact of humankind itself on the Earth; and thus, have knowledge of sustainability that could benefit all of humankind.

It is thus necessary to investigate what avenues are available for the proposed inclusion of Indigenous voices in the conversation with international space actors.

As previously noted, the IAU released a statement of concern when SpaceX first launched its satellites to begin its mega-constellation (Massey et al. 2020, p. 1022). It is understood that Indigenous astronomy has gained increased recognition from the IAU in recent times. For example, in 2017, the IAU's catalogue for stars was updated to include 86 new names for stars, names which were derived from "cultures, namely Australian Aboriginal, Chinese, Coptic, Hindu, Mayan, Polynesian, and South African" (International Astronomical Union 2017), to add to the list of star names which were primarily of Arabic, Greek and Latin descent. Furthermore, the IAU Report 'Dark and Quiet Skies' 2022 referred to recent impacts on the astronomy of Indigenous Peoples (International Astronomical Union 2022). These are positive steps forward with regards to the greater interaction of the IAU with Indigenous Peoples affected by the impact of satellites on their astronomical practices. While collaboration between the IAU and Indigenous Peoples would require recognition of the difference between professional astronomy practice and Indigenous

astronomy, which has long pre-dated space exploration and serves as central to the culture and being of Indigenous Peoples today, this recognition is beginning to be seen. However, as the 'Dark and Quiet Skies' Report 2022 went on to be presented at UNCOPUOS, the following avenue could be a future collaboration for Indigenous Peoples and the IAU.

Inclusion of Indigenous voices could also be sought through UNCOPUOS. While a State-centric body, UNCOPUOS does accept the presentation of recommendations, with Massey et al. noting that associations working on the right to dark skies were planning to avail of this option in 2020, with "delegates at the Dark and Quiet Skies for Science and Society meeting ... [to] develop recommendations to be presented to the United Nations Committee On the Peaceful Uses of Outer Space" (Massey et al. 2020, p. 1023), and as previously mentioned, such presentations did occur. This is the same committee that adopted the Guidelines for the Long-Term Sustainability of Outer Space Activities,[18] and thus, UNCOPUOS could benefit from a relationship with Indigenous Peoples with respect to Outer Space activities. However, this relationship would have to be based on a respect for the sacred nature of Indigenous knowledge that has survived millennia through a guarded oral tradition and thus, Indigenous knowledge on sustainable relations with the Earth and sky should not be usurped for the benefit of all humankind in any exploitative way. Rather, as Ruggles notes, "[i]f our aim is to understand something of indigenous perceptions of the cosmos, or indeed of our own science, then this must clearly involve establishing a dialogue" (Ruggles 2009, p. 4) and the international forum of UNCOPUOS may be the best place to do so in order to best preserve the relations with the sky of as many Indigenous Peoples as possible.

However, interaction with the international space law framework may not be something that Indigenous Peoples themselves would want to do based on the lack of consideration that has been given to the effects that Outer Space exploration and activities have had on these peoples in recent times. For example, Venkatesan highlights that "[g]iven the disastrous history of Western colonisation over the past few centuries on Earth and the widespread failure to honour land treaties with Indigenous and minoritised populations, perhaps the lack of compliance with, even the active working around of, the long-term thinking and humanistic goals of the OST and other space treaties are not a surprise" (Venkatesan et al. 2020, p. 1045). Thus, it could be the case that in order for change to occur through the route of international space law, the obligation is on the relevant space-faring States and private actors to take responsibility and invite the inclusion of Indigenous voices.

While, as previously noted, change at the international level could lead to a change of a broader scope and introduce understanding for the astronomical practices of the greatest number of Indigenous Peoples, instigating change at a domestic level and interacting with national Space agencies and authorities could also allow for change that is specific to the needs of certain Indigenous Peoples. Such change could be pioneered through collective or individual mobilisation of members of Indigenous communities or initiatives by the agencies themselves. For example, NASA currently runs the Indigenous Peoples Pilot (NASA 2019), which creates a dialogue and provides training on Earth observation by satellites, and how information obtained from Earth Observation can be utilised to the benefit of Indigenous communities, such as natural resource management. Thus, in this instance, a dialogue is already open on a satellite-related topic, and thus, this dialogue could be expanded to knowledge-sharing on the impact of satellites and proposed mega-constellations on Indigenous astronomy.

There are avenues for Indigenous voices to be included in conversations at domestic and international levels. The time to take this step is arguably now, before the satellite numbers in Outer Space increase any further, causing only more obstruction to the view of the night sky. As previously noted, the Outer Space Treaty makes reference to the benefits and interests of all and that Outer Space is the 'province of all mankind' and while there are

[18] United Nations Committee on the Peaceful Uses of Outer Space, 'Guidelines for the Long-term Sustainability of Outer Space Activities' (adopted 2019) A/74/20.

benefits that could be reaped from satellite mega-constellations, these benefits should also be weighed against the negative impact on the rest of humankind, including Indigenous Peoples. This article proposes that the best way in which these benefits can be balanced is through an open dialogue between the relevant parties and the inclusion of Indigenous voices into the conversation surrounding satellite mega-constellations.

8. Conclusions

This article has outlined the current context in Outer Space with regards to the escalation of the launching and formation of mega-constellations of satellites. While these mega-constellations offer many prospects, such as global internet connectivity, which would be to the benefit of much of 'mankind', as outlined in Section 3, the use of this wording in the Outer Space Treaty was intended to ensure that all of mankind benefitted from the use of Outer Space and currently, this is not the case.

As outlined in Section 4, the impact of the first satellites that will form these mega-constellations are already being seen by professional astronomers and research into the effects on the astronomical practices of Indigenous Peoples and their relationship with the sky and the universe has also highlighted concern for Indigenous astronomy, some of the significances of which are outlined in Section 5.

While Indigenous astronomy constitutes an integral part of the culture of many Indigenous Peoples, there has been no practical work done in ensuring that this intersection between international space law and the rights of Indigenous Peoples is sufficiently regulated. It is in the absence of such regulation that this article proposes the opening of a dialogue, at the international or domestic level, to allow for the inclusion of Indigenous voices in the conversations on the present and future of satellite mega-constellations with respect to their impact on Indigenous astronomy.

Overall, the threat posed by satellite mega-constellations to Indigenous astronomy and associated Indigenous knowledge is a problem that arguably requires immediate attention. While progressive steps have been taken, such as VisorSat by SpaceX, to dim the view of satellites to the naked eye, these attempts at mitigation of the immediate problem do not rectify the wider issue of the need for astronomy, cosmologies and relations with the sky of Indigenous Peoples to be included as important considerations in the planning and decision-making processes in international space activities. Therefore, if the visibility of satellites to the naked eye were to be rectified in the near future, it is argued that the need to include Indigenous voices would remain equally as imperative. As was noted in Section 5.3 with respect to Mitchell et al.'s research of the peoples Indigenous to Bawaka Country, the encroachment of satellites into Outer Space as it currently stands is not only affecting the spiritual connections of Indigenous Peoples to ancestors but could also be interpreted as a modern iteration of colonisation. These are issues pertaining to Indigenous astronomy that cannot be rectified by technological advancement and need to be discussed in an equal dialogue.

While Section 7 suggests both international and domestic avenues to include Indigenous voices, it is likely that currently, the most promising option could be a collaboration between the IAU and Indigenous Peoples in bringing issues forward before UNCOPUOS. The issue of the impact of mega-constellations on the practice of astronomy has already been highlighted at UNCOPUOS as an area of concern, and the IAU has already taken steps towards recognition of the impact of satellite constellations on Indigenous Astronomy. While the aforementioned IAU 'Dark and Quiet Skies' 2022 Report was a positive step, as noted in Section 7, future collaboration would require further recognition of the specific and acute impact on Indigenous Peoples. Any such collaboration would require a large proportion of Indigenous voices and would need to be dealt with appropriately as singular and separate to the impact on professional astronomy. This avenue would also require a willingness from both the IAU and affected Indigenous parties, but the positive first steps have been made.

While this avenue is arguably the most promising option for the inclusion of Indigenous voices in planning processes for satellites in Outer Space, it does not offer a solution to the issue of the negative impact of satellite mega-constellations on Indigenous astronomical practices. A solution will only be achieved through education and appreciation of the unique, distinct, and age-old relationships that Indigenous Peoples have with the sky, cosmos, and universe, which is why the recommendation of this article is that of dialogue including voices from Indigenous Peoples and relevant space actors, which could facilitate the achievement of this education and understanding.

Funding: This research was funded by the Irish Research Council 2021 Government of Ireland Postgraduate Scholarship, project ID GOIPG/2021/724.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Not applicable.

Conflicts of Interest: The authors declare no conflict of interest. The funders had no role in the design of the study, in the collection, analyses, or interpretation of data, in the writing of the manuscript, or in the decision to publish the results.

References

Primary Sources

Legislation

Binding International Instruments

- 1957 ILO Convention concerning the Protection and Integration of Indigenous and Other Tribal and Semi-Tribal Populations in Independent Countries (ILO Convention 107).
- 1966 International Covenant on Civil and Political Rights.
- 1967 Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space (Outer Space Treaty).
- 1972 Convention on International Liability for Damage Caused by Space Objects (Liability Convention).
- 1974 Convention on Registration of Objects Launched into Outer Space (Registration Convention).
- 1979 Agreement Governing the Activities of States on the Moon and Other Celestial Bodies (Moon Agreement).
- 1989 ILO Convention concerning Indigenous and Tribal Peoples in Independent Countries (ILO Convention 169).
- 1992 Constitution and Convention of the International Telecommunication Union.

Binding Domestic Legislation (United States)

- 1962 Communications Satellite Act.

Non-Binding

- 1963 Declaration of Legal Principles Governing the Activities of States in the Exploration and Uses of Outer Space.
- 2007 United Nations Declaration on the Rights of Indigenous Peoples.
- 2019 UNCOPUOS Guidelines on the Long-Term Sustainability of Outer Space Activities.

Case Law

- *Mabo and others. v the State of Queensland and the Commonwealth of Australia (No 2)* [1992] HCA 23.

Secondary Sources

American Astronomical Society. 2020. Impact of Satellite Constellations on Optical Astronomy and Recommendations Toward Mitigation. (SATCON 1). Available online: https://aas.org/sites/default/files/2020-08/SATCON1-Report.pdf (accessed on 9 March 2022).

Anaya, S. James. 2013. The Human Rights of Indigenous Peoples: United Nations Developments. *University of Hawai'i Law Review* 35: 983.

Barelli, Mauro. 2009. The Rome of Soft Law in the International Legal System: The Case of the United Nations Declaration on the Rights of Indigenous Peoples. *International and Comparative Law Quarterly* 58: 957. [CrossRef]

Bawaka Country, Audra Mitchell, Sarah Wright, Sandie Suchet-Pearson, Kate Lloyd, Laklak Burarrwanga, Ritjilili Ganambarr, Merrkiyawuy Ganambarr-Stubbs, Banbapuy Ganambarr, Djawundil Maymuru, and Djawundil Rrawun. 2020. Dukarr lakarama: Listening to Guwak, talking back to space colonization. *Political Geography* 81: 102218. [CrossRef]

Bhathal, Ragbir. 2006. Astronomy in Aboriginal Culture. *Astronomy & Geophysics: The Journal of the Royal Astronomical Society* 47: 27.

Bhathal, Ragbir. 2016. How Astronomy Paved the Way for *Terra nullius*, and Helped to Get Rid of it Too. *The Conversation*, October 13. Available online: https://theconversation.com/how-astronomy-paved-the-way-for-terra-nullius-and-helped-to-get-rid-of-it-too-66703 (accessed on 9 March 2022).
Bielicki, Damian M. 2020. Legal Aspects of Satellite Constellations. *Air & Space Law* 45: 245.
Boley, Aaron C., and Michael Byres. 2021. Satellite Mega-Constellations Create Risks in Low Earth Orbit, the Atmosphere and on Earth. *Scientific Reports* 11. Available online: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8137964/ (accessed on 30 January 2022). [CrossRef]
Buente, Wayne, Chad Kālepa Baybayan, Lala Hajibayova, Mallory McCorkhill, and Roman Panchyshyn. 2020. Exploring the renaissance of wayfinding and voyaging through the lens of knowledge, representation, organization and discovery systems. *Journal of Documentation* 76: 1279. [CrossRef]
Cajete, Gregory A. 2000. *Native Science: Natural Laws of Interdependence*. Santa Fe: Clear Light Publisher.
Code of Federal Regulations. 2022. Title 47: Telecommunication. Available online: https://www.ecfr.gov/current/title-47/chapter-I (accessed on 9 March 2022).
Cropper, Simon, Charles Kemp, Danel R. Little, and Duane W. Hamacher. 2019. Why Do Different Cultures See such Similar Meanings in the Constellations? *The Conversation*, August 16. Available online: https://theconversation.com/why-do-different-cultures-see-such-similar-meanings-in-the-constellations-121981 (accessed on 30 January 2022).
Drahos, Peter. 2014. *Intellectual Property, Indigenous Peoples and their Knowledge*. Cambridge: Cambridge University Press.
Feinberg, Richard, Ute J. Dymon, Pu Paiaki, Pu Rangituteki, Pu Nukuriaki, and Matthew Rollins. 2003. 'Drawing the coral heads': Mental mapping and its physical representation in a Polynesian community. *The Cartographic Journal* 40: 243. [CrossRef]
Freeland, Steven. 2015. The Laws of Was in Outer Space. In *Handbook of Space Security*. Edited by Kai-Uwe Schrogl, Peter L. Hays, Jana Robinson, Denis Moura and Christina Giannopapa. New York: Springer Science & Business Media.
Hamacher, Duane W. 2014. Stories from the sky: Astronomy in Indigenous knowledge. *The Conversation*, November 30. Available online: https://theconversation.com/stories-from-the-sky-astronomy-in-indigenous-knowledge-33140 (accessed on 30 January 2022).
Hecht, Jeff. 2021. Will Satellites Cripple Ground-Based Astronomy? *Optics & Photonics News*. Available online: https://www.optica-opn.org/home/articles/volume_32/may_2021/features/will_satellites_cripple_ground-based_astronomy/ (accessed on 31 January 2022).
Hollabaugh, Mark. 2017. *The Spirit and the Sky: Lakota Visions of the Cosmos*. Lincoln: University of Nebraska Press.
International Astronomical Union. 2017. *IAU Approves 86 New from Around the World*. Paris: IAU, December 11. Available online: https://www.iau.org/news/pressreleases/detail/iau1707/ (accessed on 30 January 2022).
International Astronomical Union. 2019. *IAU Statement on Satellite Constellations*. Paris: IAU, June 3. Available online: https://www.iau.org/news/announcements/detail/ann19035/ (accessed on 30 January 2022).
International Astronomical Union. 2022. *Dark and Quiet Skies II for Science and Society Work Group Reports Published*. Paris: IAU, January 12. Available online: https://www.iau.org/news/announcements/detail/ann22002/ (accessed on 9 March 2022).
Koch, Jonathan Sydney. 2018. Institutional Framework for the Province of all Mankind: Lessons from the International Seabed Authority for the Governance of Commercial Space Mining. *Astropolitics* 16: 1. [CrossRef]
Larsen, Peter Bille, and Jérémie Gilbert. 2020. Indigenous rights and ILO Convention 169: Learning from the past and challenging the future. *The International Journal of Human Rights* 24: 83. [CrossRef]
Legal Information Institute. 2010. United States Code: Title 51.'51 U.S. Code SS 20103—Definitions' U. Available online: https://www.law.cornell.edu/uscode/text/51/20103 (accessed on 9 March 2022).
Levchenko, Igor, Shuyan Xu, Yue-Liang Wu, and Kateryna Bazaka. 2020. Hopes and concerns for astronomy of satellite constellations. *Nature Astronomy* 4: 1012. [CrossRef]
Lewis, David. 1974. Voyaging Stars: Aspects of Polynesian and Micronesian Astronomy. *Philosophical Transactions of the Royal Society of London. Series A, Mathematical and Physical Sciences* 276: 133.
Lyall, Francis, and Paul B. Larsen. 2018. *Space Law: A Treatise*, 2nd ed. London: Routledge.
Makemson, Maud W. 1938. Hawaiian Astronomical Concepts. *American Anthropologist* 40: 370. [CrossRef]
Mallama, Anthony. 2021. Starlink Satellites are Fainter Now—But Still Visible. *Sky & Telescope: The Essential Guide to Astronomy*, January 22. Available online: https://skyandtelescope.org/astronomy-news/starlink-satellites-fainter-but-still-visible/ (accessed on 8 March 2022).
Maryboy, Nancy C. 2020. Process and Relationship in Indigenous Astronomy: Connectivity of Mother Earth and Father Sky. *International Journal of Applied Science and Sustainable Development* 2: 14.
Massey, Robert, Sara Lutcatello, and Piero Benvenuti. 2020. The challenge of satellite megaconstellations. *Nature Astronomy* 4: 1022. [CrossRef]
McDowell, Jonathan C. 2020. The Low Earth Orbit Satellite Population and Impacts of the SpaceX Starlink Constellation. *The Astrophysical Journal Letters* 892: 1. [CrossRef]
Mendonça, Helena Correia, Magda Cocco, and Juliana Macedo Scavuzzi dos Santos. 2015. International Laws Regulating Satellite Communications and Their Intentional Disruption in Times of Peace and Conflict. *Annals Air & Space Law* 40: 105.
Million, Dian. 2013. *Therapeutic Nations: Healing in an Age of Indigenous Human Rights*. Tucson: University of Arizona Press.

NASA. 2019. Indigenous Peoples Pilot: Connecting Knowledge and Strengthening Communities. Available online: https://appliedsciences.nasa.gov/indigenous-peoples-pilot (accessed on 31 January 2022).
NASA. 2020. The Artemis Accords. Available online: https://www.nasa.gov/specials/artemis-accords/img/Artemis-Accords-signed-13Oct2020.pdf (accessed on 9 March 2022).
Ruggles, Clive. 2009. Indigenous Astronomies and Progress in Modern Astronomy. Special Session 5, IAU General Assembly. August 11–14. Rio de Janeiro, Brazil. Proceedings of Science, PoS(sps5)029. Available online: https://arxiv.org/ftp/arxiv/papers/1010/1010.4873.pdf (accessed on 31 January 2022).
Sharp, Nonie. 1990. Contrasting Cultural Perspectives in the Murray Island Case. *Law Context: A Socio-Legal Journal* 8: 1.
Stamatopoulou, Elsa. 1994. Indigenous Peoples and the United Nations: Human Rights as a Developing Dynamic. *Human Rights Quarterly* 16: 58. [CrossRef]
Tan, David. 2000. Towards a New Regime for the Protection of Outer Space as the Province of All Mankind. *Yale Journal of International Law* 25: 145.
Trepczynski, Susan. 2021. Rules of the Domain: The Impact of Law on the Evolution of Space Activities and Technologies. In *Commercial and Military Uses of Outer Space*. Edited by Melissa de Zwart and Stacey Henderson. Berlin/Heidelberg: Springer.
United Nations General Assembly. 2021. Report of the Committee on the Peaceful Uses of Outer Space. UNCOPUOS Sixty-Fourth Session 25 August–3 September 2021 (A/76/20). Available online: https://www.unoosa.org/res/oosadoc/data/documents/2021/a/a7620_0_html/A_76_20E.pdf (accessed on 18 March 2022).
Vazhapully, Kiran. 2020. Space Law at the Crossroads: Contextualizing the Artemis Accords and the Space Resources Executive Order. *Opinio Juris*. July 22. Available online: https://opiniojuris.org/2020/07/22/space-law-at-the-crossroads-contextualizing-the-artemis-accords-and-the-space-resources-executive-order/ (accessed on 9 March 2022).
Venkatesan, Aparna, David Begay, Adam J. Burgasser, Isabel Hawkins, Ka'iu Kimura, Nancy Maryboy, and Laura Peticolas. 2019. Towards inclusive practices with indigenous knowledge. *Nature Astronomy* 3: 1035. [CrossRef]
Venkatesan, Aparna, James Lowenthal, Parvathy Prem, and Monica Vidauri. 2020. The impact of satellite constellations on space as an ancestral global commons. *Nature Astronomy* 4: 1043. [CrossRef]
Von der Dunk, Frans. 2019. International Satellite Law. In *Oxford Research Encyclopaedia of Planetary Science*. Edited by Steven Freeland. Oxford: Oxford University Press.
Weissner, Siegfried. 2011. The Cultural Rights of Indigenous Peoples: Achievements and Continuing Challenges. *The European Journal of International Law* 22: 121. [CrossRef]
Wiessner, Siegfried. 2008. Indigenous Sovereignty: A Reassessment in Light of the UN Declaration on the Rights of Indigenous Peoples. *Vanderbilt Journal of International Law* 41: 1141.
Williams, Andrew, Olivier Hainaut, Angel Otarola, Gie Han Tan, and Rotola Giuliana. 2021. Analysing the Impact of Satellite Constellations and ESO's Role in Supporting the Astronomy Community. 184. Available online: https://www.eso.org/sci/publications/messenger/archive/no.184-sep21/messenger-no184-3-7.pdf (accessed on 31 January 2022).
Wood, Lloyd. 2003. Satellite Constellation Networks. In *Internetworking and Computing Over Satellite Networks*. Edited by Yongguang Zhang. Boston: Springer.
Young, M. Jane. 1996. Astronomy in Pueblo and Navajo World Views. *Archaeoastronomy* 12: 49.