Indigenous Rights and the Night Sky: Reconciling Satellite Mega-Constellations with Indigenous Astronomical Traditions

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Abstract— The rapid expansion of satellite mega-constellations in low Earth orbit (LEO) has introduced significant challenges for astronomy, particularly for Indigenous communities whose astronomical traditions are deeply interwoven with cultural, spiritual, and practical knowledge systems. While these satellites provide essential global services, such as internet connectivity, their increasing numbers obstruct the night sky, threatening Indigenous relationships with celestial bodies that have been sustained for millennia. This disruption not only impacts Indigenous astronomy but also raises broader ethical concerns regarding the governance of Outer Space. International space law, including the Outer Space Treaty, asserts that space is the "province of all mankind." However, the interests of Indigenous Peoples have largely been overlooked in discussions surrounding satellite deployment. Existing legal frameworks, such as the UN Declaration on the Rights of Indigenous Peoples (UNDRIP) and the International Covenant on Civil and Political Rights (ICCPR), offer protections for Indigenous cultural practices, yet their applicability to Outer Space remains unaddressed. The lack of Indigenous representation in decision-making processes related to space governance further exacerbates these challenges. This paper argues for the inclusion of Indigenous voices in shaping policies that impact their ability to practice and preserve astronomical traditions. Potential pathways for engagement include collaboration with international organizations like the International Astronomical Union (IAU) and the United Nations Committee on the Peaceful Uses of Outer Space (UNCOPUOS), as well as domestic initiatives with national space agencies. Recognizing Indigenous knowledge systems as a vital part of humanity's shared relationship with the cosmos is essential to ensuring that the expansion of space activities is both inclusive and sustainable. By fostering dialogue and integrating Indigenous perspectives into space governance, it is possible to strike a balance between technological progress and the protection of cultural heritage.

Keywords: Indigenous Peoples, astronomy, Outer Space, satellite mega-constellations, space law.

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INTRODUCTION

Outer Space has become an indispensable domain for modern civilization, shaping contemporary life and humanity's future. Over the past few decades, there has been a sharp increase in space activities, driven by both state actors and private enterprises. The dependence on satellite-based services—ranging from global communications to navigation, climate monitoring, and disaster response—has grown exponentially.

One of the most significant developments in recent years is the expansion of high-speed internet access through satellite constellations. While these advancements have provided immense benefits, including improved connectivity in underserved regions, they have also introduced new challenges. The aggressive deployment of satellite mega-constellations, intended to bridge the global digital divide, has resulted in a proliferation of artificial objects in orbit. This increase in satellites poses risks not only to orbital sustainability but also to long-standing terrestrial traditions such as astronomy.

Astronomy has long been a universal human endeavor, practiced for millennia by various civilizations. However, for many Indigenous communities, astronomy is not merely a scientific pursuit but an integral aspect of cultural heritage, spiritual practice, and knowledge transmission. The night sky serves as a celestial archive, preserving stories, navigational techniques, and ceremonial traditions that have been passed down through generations. The rapid encroachment of artificial satellites into this sacred observational space threatens Indigenous Peoples' ability to engage in traditional astronomical practices, thereby disrupting their cultural continuity.

Despite the growing recognition of Indigenous rights in various policy arenas, decisions regarding space governance and satellite deployment have largely excluded Indigenous perspectives. As a result, satellite proliferation has proceeded without adequate consideration of its cultural and epistemological consequences. To rectify this, it is imperative to integrate Indigenous voices into decision-making processes, ensuring that space policies reflect a holistic and sustainable approach.

This article employs a descriptive-normative research methodology to examine the implications of satellite mega-constellations for Indigenous astronomy. It explores the ways in which these developments threaten traditional astronomical practices and the transmission of Indigenous knowledge. Based on this analysis, the article proposes mechanisms for incorporating Indigenous perspectives into space governance, emphasizing the importance of inclusive policymaking to safeguard the cultural and scientific heritage of all humankind.

The unchecked expansion of satellite constellations, without due consideration of Indigenous interests, highlights a broader issue of governance in Outer Space. As humanity ventures further into the cosmos, ethical considerations must play a central role in shaping space policies. This article argues that the preservation of Indigenous astronomy is not merely a cultural concern but a fundamental question of justice,

requiring proactive engagement with Indigenous communities in the planning and regulation of satellite constellations.

SATELLITES AND MEGA-CONSTELLATIONS

Satellites

The legal definition of a satellite is encompassed within broader space law frameworks. The United States Code, Title 51, classifies satellites under the category of "aeronautical and space vehicles," which also includes aircraft, missiles, and other space vehicles. Specifically, it defines these as "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)). This broad classification places satellites as integral elements of space traffic. However, a more specific legal definition describes a satellite as "a manufactured object or vehicle intended to orbit the earth, the moon, or another celestial body" (Von der Dunk 2019, p. 1). This definition, as outlined by Frans von der Dunk, captures the fundamental role of satellites in space operations.

Since the launch of Sputnik I in 1957, satellites have been a defining component of human activity in outer space. The launch of this first artificial satellite marked a revolutionary moment, signifying "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). As Trepczynski highlights, "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). The regulatory framework surrounding satellites and space activities will be explored further in Section 3.

Over the decades, satellites have become indispensable to modern civilization, facilitating telecommunications, internet connectivity, radio broadcasting, GPS navigation, remote sensing, and many other services that shape daily life. These technological advancements rely on various orbital zones, each serving distinct purposes. Low Earth Orbit (LEO) is particularly significant for satellites interacting with Earth-based activities, including astronomical observations. 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). Other key orbital regions include Medium Earth Orbit (MEO), which hosts GPS satellites, and Geostationary Orbit (GSO), which is crucial for telecommunications and weather monitoring. The allocation of these orbital slots follows a "first come, first served" principle, governed by international space regulations that will be examined in the next section (Lyall and Larsen 2018, p. 154).

While the concept of an overcrowded outer space may seem counterintuitive, satellite traffic has surged dramatically in response to humanity's increasing reliance on

space-based applications. Satellites are now integral to "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).

Initially, satellites were typically launched individually or occasionally in small groups. However, as technological capabilities advanced, the size, complexity, and number of satellites in orbit expanded significantly. Lyall and Larsen observe that "when 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). Contrary to the assumption that satellites have a negligible spatial footprint, many modern communications satellites are comparable in size to multi-story buildings, with extended solar panels adding further dimensions (Lyall and Larsen 2018, p. 240).

However, recent technological advancements have shifted the industry towards smaller, more cost-effective satellites. These small satellites—often referred to as CubeSats or nano-satellites—perform critical functions such as Earth observation, weather monitoring, disaster response, and environmental tracking. By offering cost-effective and flexible deployment options, small satellites are seen as key tools in fostering sustainable development and addressing global challenges. As satellite technology continues to evolve, the emergence of large-scale satellite constellations, particularly mega-constellations, marks a new era in space infrastructure.

Satellite Constellations

Despite their widespread presence, satellite constellations lack a formalized legal definition. As Bielicki observes, "satellite constellations are not yet subject to a formal legal definition" (Bielicki 2020, p. 246). However, Wood provides a functional description, defining 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). This definition closely aligns with the terminology used in the United States' Communications Satellite Act of 1962, which describes a 'communications satellite system' 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."

Satellite constellations have been an integral aspect of space infrastructure since the mid-20th century. The Soviet Union pioneered the concept in 1965 with its Molniya-1 constellation, a network of ten satellites that became fully operational in 1968 (Bielicki 2020, p. 247). In parallel, the United States developed and launched the Transit system,

the world's first global satellite navigation network. By 1968, this system had evolved into a fully functional constellation of thirty-six satellites (Bielicki 2020, p. 247).

The 1990s marked a pivotal era in satellite constellations, driven by the rapid expansion of mobile telephony and broadband services. As Wood notes, "[t]he 1990s were perhaps the public heyday of satellite constellations" (Wood 2003, p. 13). However, contemporary developments in the 21st century are pushing the scale of satellite constellations even further. Bielicki emphasizes 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).

Current and upcoming satellite constellations serve diverse applications, spanning navigation, telecommunications, Earth observation, and global internet coverage. Williams et al. provide an overview of existing and planned constellations:

"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).

One of the most prominent recent developments in satellite mega-constellations is SpaceX's Starlink project. In 2019, SpaceX began launching satellites for its ambitious Starlink network, which aims to deploy thousands of satellites in LEO to provide global broadband internet access (McDowell 2020, p. 1). However, the rapid expansion of Starlink and similar constellations has raised concerns about their visibility from Earth. Notably, some of these satellites "remained naked eye objects" (McDowell 2020, p. 1), prompting discussions on their impact on astronomical observations and space sustainability.

With the current trajectory of satellite constellations moving toward large-scale deployments, regulatory and legal frameworks will need to evolve to address emerging challenges in orbital congestion, space debris management, and international governance. These legal considerations will be explored further in Section 3.

SATELLITES AND THE SPACE LAW FRAMEWORK

Satellites, as space objects, fall under the regulatory scope of international space law. This section examines how the five core treaties of the United Nations (UN) Space Law framework, alongside the regulatory standards set by the International Telecommunication Union (ITU), shape the legal environment for satellite operations. These legal instruments aim to establish norms that influence domestic space law and provide guidance for State-based space activities.

Rights of All Humankind

The cornerstone of the 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**, commonly known as the **Outer Space Treaty**. Article I of this treaty establishes a foundational principle that space activities should be conducted for the collective benefit of all nations, stating:

"The 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).

Despite its significance, the phrase "*province of all mankind*" remains undefined in legal terms, leaving room for multiple interpretations (Koch 2018, p. 4). While this principle implies inclusivity in space activities, it does not equate to the more defined concept of the "*common heritage of mankind*", which is specifically designated to the Moon and its resources under **Article 11 of the 1979 Agreement Governing the Activities on the Moon and Other Celestial Bodies** (hereinafter the **Moon Agreement**). The *common heritage of mankind* is considered an extension of the *province of all mankind* within international space law, particularly concerning resource distribution and equitable access (Koch 2018, p. 7).

The classification of outer space as the *province of all mankind* was embedded in the Outer Space Treaty to promote a global, equitable approach to space exploration. This principle has historical roots in the **1963 Declaration of Legal Principles Governing the Activities of States in the Exploration and Use of Outer Space**, which emphasized equity, fairness, and the "*common interest of all mankind*" (Tan 2000, p. 161). The Declaration also introduced the concept of "*due regard for the corresponding interests of other States*" (1963 Declaration of Legal Principles, art. 6), which was later incorporated into legally binding provisions of the Outer Space Treaty.

However, recent developments suggest a shift away from viewing outer space as part of the *global commons*. The **Artemis Accords**, a set of principles guiding the United States and its partners in planned lunar exploration, reflect this changing perspective. Section 10 of the **Artemis Accords** (NASA 2020, sect. 10) acknowledges space resource extraction but does not establish a framework for equitable distribution of those resources, as envisaged under the *common heritage of mankind* principle in the **Moon Agreement** (Vazhapully 2020). Instead, while the Accords frequently reference benefits for *humankind*, they focus more on securing access and usage rights rather than ensuring broad economic redistribution.

The inclusive terminology used in the Outer Space Treaty suggests that space exploration and satellite usage should be balanced against other interests, including those of Indigenous Peoples. Many Indigenous cultures have long-standing connections with celestial bodies, viewing them through cosmological, spiritual, and cultural lenses. The increasing human presence in space, particularly through satellite mega-

constellations, raises ethical questions about whether these activities align with the interests of all peoples—not just space-faring nations but also communities that seek to preserve their traditional relationships with the night sky.

Responsibilities of Space Actors

While outer space is designated for the benefit of all humankind, the responsibility for ensuring compliance with space law lies with **States**. Regarding satellite operations, States are obligated to register their space objects under the **1976 Convention on Registration of Objects Launched into Outer Space** (hereinafter the **Registration Convention**) and assume liability under the **1972 Convention on International Liability for Damage Caused by Space Objects** (hereinafter the **Liability Convention**).

However, unlike the early decades of space exploration, where national space agencies were the primary actors, the modern satellite industry is increasingly driven by private corporations. Companies such as **SpaceX** are at the forefront of deploying satellite mega-constellations, yet as private entities, they are primarily subject to national regulations rather than direct international oversight. For example, SpaceX operates under domestic laws such as the **United States Federal Communications Commission (FCC) regulations** (Code of Federal Regulations 2022).

Nevertheless, international space law still holds States accountable for the activities of private space actors. **Article VI of the Outer Space Treaty** establishes 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).

This provision makes it clear that governments are ultimately responsible for both state-run and private satellite activities. The **1972 Liability Convention** reinforces this responsibility, defining the *launching State* 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). Under this framework, if a commercial satellite—such as one from **SpaceX**—causes damage, the liability falls upon the State that authorized the launch or hosted the launch facility. This highlights an inherent challenge in the regulatory framework: while national laws govern private satellite operations, international responsibility remains with the State. This dynamic will become increasingly significant as the number of commercial satellites grows, especially in the era of mega-constellations.

The ITU and Satellite Orbits

While States are responsible for launching and registering satellites, the **International Telecommunication Union (ITU)** governs the allocation of **radio**

frequencies and orbital slots. The ITU plays a crucial role in preventing signal interference and ensuring the efficient use of orbital space. Its mandate includes:

"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" (ITU Constitution).

The ITU's role has become increasingly vital as competition for satellite orbits intensifies. According to Mendonça et al., the surge in satellite launches has led to **congestion and competition, particularly at the Geostationary Orbit (GEO)**, making ITU regulations more important than ever (Mendonça et al. 2015, p. 109). Through its **Constitution, Convention, and Radio Regulations**, the ITU establishes international rules to **avoid interference in radio signals** and facilitate coordination among nations (Mendonça et al. 2015, pp. 114–15).

One of the ITU's notable achievements is ensuring that **national communications regulations align with international standards**. Trepczynski notes that **ITU regulations are consistently implemented at the domestic level by nearly every State**, leading to a highly structured approach to space communications (Trepczynski 2021, p. 58). However, despite its role in frequency and orbit management, the ITU **has yet to establish binding regulations on mega-constellations**. Boley and Byres highlight that: "No binding international rules exist on other aspects of mega-constellations" (Boley and Byres 2021).

In response to growing concerns, the ITU recently introduced a **tiered management approach** for registering mega-constellations. This system prevents companies from reserving orbital slots indefinitely by requiring them to meet specific milestones before final registration (Boley and Byres 2021). However, challenges remain, as some **national communications authorities allocate orbital slots on a first-come, first-served basis**, potentially undermining ITU efforts (Boley and Byres 2021).

While ITU regulations focus on practical satellite functionality, they do not explicitly address **the impact of satellites on astronomical research**. Section 4 will explore how the rapid increase in satellites is affecting astronomical practices and space sustainability.

THE IMPACT OF INCREASED SATELLITE NUMBERS ON ASTRONOMY

The preservation of dark skies has become a significant concern uniting professional astronomers and Indigenous Peoples, as artificial light pollution from urban development has already rendered astronomical observations difficult or impossible in certain regions (Ruggles 2009, p. 14). However, in recent years, the threat to observational astronomy has extended beyond Earth's surface. The exponential increase in satellite deployments, particularly in Low Earth Orbit (LEO), has introduced new challenges that interfere with humanity's ability to observe, analyze, and interpret celestial phenomena.

As Venkatesan et al. observe, "[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). This growing congestion of satellites, particularly the rise of 'mega-constellations' such as Starlink, has introduced a new dimension of interference that complicates astronomical research and raises ethical concerns about the preservation of the night sky as a shared resource.

The Impact of Satellite Mega-Constellations on Astronomical Observations

While the full extent of the impact that planned mega-constellations will have on astronomical observations is not yet entirely known, early indications suggest significant disruptions. Hecht documents how the first large-scale launch of 60 Starlink satellites on 23 May 2019 took astronomers by surprise, as astronomical images revealed prominent streaks of reflected sunlight from the satellites, effectively contaminating observations and obstructing important celestial data (Hecht 2021).

This issue has prompted growing concern from the International Astronomical Union (IAU), which released a statement in 2019 emphasizing the need to protect dark skies for scientific purposes. The IAU noted that "[w]e do not yet understand the impact of thousands of these visible satellites scattered across the night sky" (International Astronomical Union 2019). Subsequent reports, such as the IAU's 2022 *Report on Dark and Quiet Skies*, have continued to raise alarms about the implications of this rapid increase in satellite numbers, emphasizing that careful assessment is necessary to mitigate the risks posed to astronomy (International Astronomical Union 2022).

One of the most immediate concerns relates to how these satellites interfere with ground-based telescopes, particularly those situated at world-class observatories. Many of these facilities were established on sites selected for their pristine night skies—often on the traditional lands of Indigenous Peoples, who have long relied on celestial observations as an integral part of their cultural and spiritual practices (Venkatesan et al. 2020, p. 1043). The introduction of artificial interference into these previously untouched skies represents not only a scientific challenge but also a cultural and ethical issue.

Light Pollution and Data Loss in Astronomical Imaging

One of the most visible effects of satellite mega-constellations on astronomy is the presence of streaks of light in telescope images. As Massey et al. explain:

> "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 some might argue that such interferences are merely inconveniences that can be addressed through post-processing techniques, the reality is that the increasing frequency of satellite streaks makes such mitigation efforts both resource-intensive and insufficient in fully restoring lost data. With every additional satellite launched, the likelihood of astronomical images being disrupted rises proportionally.

Levchenko et al. emphasize the scale of this challenge, noting that "[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). As companies such as Amazon (Kuiper) and OneWeb continue to expand their satellite networks, the cumulative effect of these constellations on telescope images will become increasingly severe. This means that astronomers will not only lose more critical data but will also have to invest additional time and computational resources into salvaging affected images—making astronomical research more complex, costly, and time-consuming.

Disruptions to Scientific Research and Discovery

The contamination of astronomical images by satellite reflections is not merely an aesthetic issue; it has far-reaching consequences for scientific research. Many cutting-edge astronomical investigations require consistently high-quality data from the entire night sky. As outlined in the *SATCON1 Report* by the American Astronomical Society, these studies include:

"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)

The introduction of bright satellite trails across observational fields compromises the uniformity of these data sets, making it difficult to conduct precise analyses of faint celestial objects. Moreover, because some astronomical events—such as supernovae or gravitational wave detections—are transient and occur unpredictably, the presence of satellite streaks at the wrong moment could result in the permanent loss of a crucial scientific opportunity. The *SATCON1 Report* warns that these interruptions could prevent astronomers from detecting "a time-critical aspect and/or a rare, scientifically critical target" (American Astronomical Society 2020, p. 3), thereby hindering fundamental discoveries about the nature of the universe.

Broader Implications for Astronomy and Indigenous Perspectives

The adverse effects of increased satellite numbers on astronomy extend beyond professional research institutions. Indigenous communities, whose traditions

incorporate deep astronomical knowledge passed down over generations, are particularly affected by the disruption of the natural night sky. As Venkatesan et al. argue, "[t]he loss of an unpolluted night sky disproportionately impacts Indigenous Peoples who have relied on the stars for navigation, timekeeping, and spiritual practices" (Venkatesan et al. 2020, p. 1045). This raises critical ethical questions about whose interests are prioritized in space governance and whether the expansion of satellite infrastructure should proceed without meaningful consultation with affected communities.

Ultimately, the challenge of balancing technological progress with the preservation of astronomy—both as a scientific discipline and as a cultural heritage—will require international cooperation and policy interventions. The International Astronomical Union, alongside organizations such as the United Nations Committee on the Peaceful Uses of Outer Space (UNCOPUOS), has begun exploring mitigation strategies, including satellite design modifications that reduce reflectivity. However, as satellite numbers continue to rise at an unprecedented rate, it remains to be seen whether such measures will be sufficient to safeguard the integrity of astronomical research and the fundamental human connection to the stars.

INDIGENOUS ASTRONOMY

The term *Indigenous Astronomy*, as used in this article, also encompasses Indigenous cosmologies. This terminology does not seek to constrain Indigenous knowledge and practice within rigid Western scientific definitions. Ruggles (2009, p. 6) underscores the need to bridge this comprehension divide in order to foster a proper understanding and facilitate an inclusive dialogue, as envisioned in Section 7. Therefore, *Indigenous Astronomy* is intended to encapsulate the diverse relationships and interconnections that Indigenous Peoples have with the sky, the universe, and celestial bodies.

While the practice of astronomy is broadly defined as the observation of the skies and everything within them, there is no singular definition that fully encapsulates what Indigenous astronomy means to all Indigenous Peoples. Bhathal (2006, p. 27) emphasizes that Indigenous astronomy differs fundamentally from the hypothetico-deductive system used by physicists and astronomers, which is validated by observation and experiment. Instead, it is rooted in other knowledge traditions, where celestial observations are deeply embedded in Indigenous cosmologies. These cosmologies inform the reasons behind Indigenous astronomical practices, distinguishing them from the purely empirical approach of modern astronomy.

Despite these differences, there has been increasing engagement between modern astronomers and Indigenous scholars. The *Dark and Quiet Skies 2022* report (discussed in Section 4) reflects ongoing consultations between modern astronomers and Indigenous experts regarding the night sky. As Hollabaugh (2017, p. 178) notes, "[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." This mutual engagement underscores the necessity of respecting and preserving Indigenous astronomical traditions, which continue to be integral to Indigenous ways of life.

The foundations of Indigenous astronomy are intricately linked to Indigenous cosmologies, which shape not only celestial observations but also their broader significance within Indigenous societies. Drahos (2014, p. 32) describes Indigenous cosmologies as a form of philosophical realism, wherein entities and objects—such as ancestors—are recognized as having an independent and knowable existence. Bhathal (2006, n. 28) further elaborates on this perspective in the context of Aboriginal and Torres Strait Islander Peoples, explaining that "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." In this cosmology, the celestial bodies are not merely objects of scientific inquiry but are deeply embedded in the spiritual and cultural fabric of Indigenous life.

This perspective is not exclusive to Australian Indigenous Peoples. Cajete (2000, p. 216), in discussing Native American astronomical traditions, notes 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." Indigenous astronomy, therefore, is not only about celestial observations but also about maintaining a deep, interwoven relationship with the cosmos, which informs governance, seasonal cycles, and social structures.

Indigenous astronomical knowledge has developed over millennia, through careful observation of the natural world and its interrelationships (Maryboy 2020, p. 14). This knowledge forms part of the rich and complex ways of knowing and being that constitute Indigenous epistemologies. As Million (2013, p. 13) notes, this knowledge has evolved "from their lived experience in their distinct places, in spiritual relationships with land and life, and from traditions that change but are millennial." However, this long-standing knowledge is now under threat. The increasing occupation of Earth's orbits with artificial satellites represents not only a physical obstruction to celestial observations but also an encroachment of colonial influence into a sacred domain for Indigenous Peoples.

While much Indigenous astronomical knowledge is protected within oral traditions, there has been growing recognition of its significance, largely due to the work of Indigenous scholars and researchers of Indigenous traditions.

INDIGENOUS RIGHTS

The increasing presence of satellite mega-constellations poses a significant challenge to the preservation and continuation of Indigenous astronomical knowledge. For many Indigenous communities, the night sky is not merely a collection of celestial objects but a foundational element of their cultural identity, informing seasonal changes, spiritual beliefs, and traditional ways of life. This intrinsic connection between Indigenous cultures and astronomy is recognized under international law, which

protects Indigenous rights and traditions. However, despite these legal safeguards, Indigenous voices have largely been excluded from discussions on the governance of outer space and satellite proliferation. This section outlines the international legal instruments that provide for the protection of Indigenous rights and examines their relevance to contemporary space governance.

The first major international legal instrument addressing Indigenous rights emerged in 1957 with the adoption of the *Convention Concerning the Protection and Integration of Indigenous and Other Tribal and Semi-Tribal Populations in Independent Countries* (ILO Convention 107) by the International Labour Organisation (ILO). While this convention focused on Indigenous Peoples, it largely promoted their assimilation into majority societies rather than affirming their distinct cultural identities (Anaya 2013, p. 1004). Recognizing its limitations, the convention was later replaced by the *ILO Convention Concerning Indigenous and Tribal Peoples in Independent Countries* (ILO Convention 169) in 1989, which remains "the only international binding treaty on Indigenous Peoples' rights" (Larsen and Gilbert 2020, p. 83). Unlike its predecessor, ILO Convention 169 explicitly upholds the right of Indigenous Peoples to preserve their unique cultures and ways of life. As Wiessner observes, "[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). However, the treaty's drafting process saw limited participation from Indigenous representatives (Stamatopoulou 1994, p. 66), which contrasts with the extensive Indigenous involvement in the development of the *United Nations Declaration on the Rights of Indigenous Peoples* (UNDRIP).

UNDRIP, adopted by the UN General Assembly in 2007, is the most comprehensive international instrument protecting Indigenous rights. Anaya notes that the declaration was the result of decades of advocacy, with "[r]epresentatives of Indigenous Peoples from around the world actively participating in the years of deliberation by the Working Group that began in the early 1980s" (Anaya 2013, p. 992). The declaration recognizes the right of Indigenous Peoples to self-determination and control over their cultural heritage, land, and resources. Its preamble affirms 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."

Despite this recognition, the rapid expansion of satellite networks in outer space has not included meaningful consultation with Indigenous communities, whose cultural and spiritual traditions are impacted by such developments. While Article 11(1) of UNDRIP states that "Indigenous peoples have the right to practise and revitalise their cultural traditions and customs" (UNDRIP, art 11(1)), which would logically include Indigenous astronomical knowledge, there is no explicit reference in UNDRIP to the cultural or spiritual significance of outer space itself. Similarly, Article 25, which affirms Indigenous rights to land and resources, specifies 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). However, this provision does not extend protection to Indigenous spiritual connections with the cosmos.

The exclusion of Indigenous perspectives from space governance discussions underscores a broader issue—the non-binding nature of UNDRIP. While UNDRIP represents a milestone in Indigenous rights advocacy, it does not carry legal force in the same way as treaties or conventions. As Wiessner explains, "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" (Wiessner 2011, p. 130). Nevertheless, UNDRIP has influenced international human rights mechanisms, as Anaya notes: "[d]ue 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).

While UNDRIP itself lacks binding authority, Indigenous Peoples can also appeal to legally binding protections under the *International Covenant on Civil and Political Rights* (ICCPR). Article 27 of the ICCPR states that "[i]n those States in which ethnic, religious or linguistic minorities exist, persons belonging to such minorities shall not be denied the 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). This provision offers a stronger legal foundation for Indigenous claims to cultural rights, including their right to maintain and protect their astronomical traditions. Despite this, Indigenous concerns have not been sufficiently integrated into international space law.

The *Outer Space Treaty* (OST), previously discussed 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, in practice, international space governance has not adequately considered the rights of Indigenous Peoples, whose cultural and spiritual relationships with the cosmos are being disrupted by satellite proliferation. The marginalization of Indigenous perspectives in outer space governance is rooted in three key issues:

1. The prevailing interpretation of the term 'mankind' in the Outer Space Treaty fails to account for the diverse cultural and spiritual worldviews of Indigenous Peoples, despite the fact that they are part of the global human community.
2. The deep historical and spiritual connections that Indigenous communities have with celestial bodies—connections that predate modern scientific exploration—are not sufficiently acknowledged in space law or policy discussions.
3. Indigenous voices remain largely absent from the decision-making processes surrounding the governance of space activities, particularly in relation to satellite mega-constellations.

Addressing these gaps requires a fundamental shift in how space governance frameworks engage with Indigenous communities. The absence of Indigenous representation in outer space decision-making not only violates principles of self-determination but also overlooks valuable knowledge systems that could contribute to more sustainable and ethical approaches to space exploration. The following section will explore potential mechanisms for ensuring Indigenous participation in shaping the future of outer space governance.

THE INCLUSION OF INDIGENOUS VOICES IN PLANNING FOR FUTURE SPACE ACTIVITY AND THE PRESERVATION OF THE NIGHT SKY

As explored in previous sections, the development of satellite mega-constellations by both states and private space companies, such as SpaceX, promises substantial benefits—most notably, the expansion of internet access to remote and underserved regions. This advancement has the potential to bridge digital divides and facilitate economic, social, and educational opportunities for many communities worldwide. However, this projected benefit comes with significant trade-offs, particularly concerning the night sky, which holds profound cultural, spiritual, and practical significance for Indigenous Peoples. The increasing number of satellites threatens to obstruct astronomical practices that have been central to Indigenous knowledge systems for millennia.

To address this growing concern, this article advocates for the meaningful inclusion of Indigenous perspectives in the planning and governance of outer space activities. Such inclusion would serve a dual purpose: first, to broaden the understanding of space policymakers regarding the impact of satellite proliferation on Indigenous cultures, and second, to recognize the unique relationship Indigenous communities have sustained with both the Earth and sky. This perspective is particularly relevant in the context of the ongoing climate crisis, where Indigenous knowledge of sustainability—developed over thousands of years—offers critical insights that could benefit all of humankind.

Given these considerations, it is necessary to explore the potential avenues through which Indigenous voices can be integrated into the discussions and decision-making processes surrounding space governance.

a) Existing Efforts to Acknowledge Indigenous Astronomy

There have been some positive steps toward recognizing the cultural significance of Indigenous astronomy. For example, in response to the launch of SpaceX's first satellites, the International Astronomical Union (IAU) issued a statement expressing concerns about the potential impact of satellite mega-constellations on astronomical observations (Massey et al. 2020, p. 1022). Additionally, the IAU has increasingly acknowledged Indigenous astronomical traditions. In 2017, the organization updated its star catalog to include 86 new star names derived from diverse cultures, including Australian Aboriginal, Chinese, Coptic, Hindu, Mayan, Polynesian, and South African

traditions (International Astronomical Union 2017). This was a notable shift from previous conventions, where most star names were derived from Arabic, Greek, and Latin sources.

Further progress was made with the IAU's 2022 *Dark and Quiet Skies* report, which explicitly referenced the impact of satellite mega-constellations on Indigenous astronomical traditions (International Astronomical Union 2022). While these efforts signal increased recognition of Indigenous perspectives, they remain limited in scope and effectiveness. Importantly, collaboration between the IAU and Indigenous communities must go beyond symbolic acknowledgment; it must recognize the fundamental differences between professional astronomy and Indigenous astronomy, which has long predated modern space exploration and remains central to the cultural and spiritual identity of Indigenous Peoples today.

b) Potential Avenues for Indigenous Inclusion in Space Governance

One potential avenue for Indigenous inclusion is through the United Nations Committee on the Peaceful Uses of Outer Space (UNCOPUOS). While UNCOPUOS is traditionally state-centric, it does allow for the submission of recommendations by non-governmental organizations and expert groups. Massey et al. note that advocates for dark skies protection planned to leverage this mechanism in 2020 by developing recommendations to be presented before UNCOPUOS (Massey et al. 2020, p. 1023). Since this same committee has already adopted the *Guidelines for the Long-Term Sustainability of Outer Space Activities*,18 it stands to reason that UNCOPUOS could benefit from a formalized relationship with Indigenous representatives.

However, any such relationship must be based on respect for Indigenous knowledge systems. Indigenous astronomy is deeply embedded in oral traditions that have survived for millennia, and there is a legitimate concern that engaging with international institutions could lead to the exploitation of Indigenous knowledge rather than its protection. As Ruggles emphasizes, "[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). The international forum of UNCOPUOS could serve as a platform for such dialogue, but only if it is structured in a way that ensures Indigenous voices are heard and respected.

c) Challenges in Engaging with International Space Law

Despite the potential for dialogue within international space law frameworks, Indigenous communities may be hesitant to engage with institutions that have historically overlooked or disregarded their rights. As Venkatesan observes, "[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).

This history of marginalization suggests that the burden of initiating change should not fall solely on Indigenous communities. Rather, spacefaring states and private entities must take proactive steps to invite Indigenous participation in discussions about the future of outer space governance. These actors should recognize that the principles enshrined in the *Outer Space Treaty*—particularly the idea that outer space is the "province of all mankind"—obligate them to ensure that all of humanity, including Indigenous Peoples, benefits from and has a voice in space-related decision-making.

d) Domestic-Level Engagement and Alternative Avenues

While change at the international level would have the broadest impact, domestic engagement with national space agencies could also offer a pathway for Indigenous inclusion. National initiatives may be better suited to address the specific concerns of Indigenous communities within individual countries.

One example of such an initiative is NASA's Indigenous Peoples Pilot (NASA 2019), which fosters dialogue and provides training on Earth observation technologies. This program demonstrates how satellite data can be used to support Indigenous communities in areas such as natural resource management. Given that NASA already facilitates discussions about satellite applications with Indigenous groups, this existing framework could be expanded to include discussions on the impact of satellite mega-constellations on Indigenous astronomy.

Ultimately, there are multiple avenues—both international and domestic—that could facilitate the inclusion of Indigenous perspectives in space governance. However, the urgency of this issue demands that these conversations begin now, before the rapid increase in satellite numbers further disrupts Indigenous astronomical traditions.

MOVING FORWARD: ENSURING INDIGENOUS VOICES SHAPE THE FUTURE OF SPACE ACTIVITY

The rapid expansion of satellite mega-constellations presents both opportunities and challenges for humankind. While these constellations offer clear benefits—such as expanding internet access—they also raise pressing concerns about their impact on Indigenous astronomy and cultural heritage.

As highlighted throughout this article, the *Outer Space Treaty* was intended to ensure that space activities benefit all of humanity. Yet, as the current situation demonstrates, these benefits have not been equitably distributed. The increasing presence of satellites is already obstructing astronomical research, and emerging studies indicate that the disruption extends to Indigenous knowledge systems and spiritual traditions.

Despite the fundamental role Indigenous astronomy plays in many cultures, no regulatory framework exists to address this issue. This article has therefore proposed opening a dialogue—whether at the international or domestic level—to ensure

Indigenous voices are included in discussions about the present and future of satellite mega-constellations.

While technological advancements, such as SpaceX's VisorSat, have been introduced to mitigate satellite visibility, these efforts do not resolve the broader issue: the need for Indigenous astronomy to be recognized as a legitimate and protected form of knowledge. As noted in Section 5.3, research on the peoples Indigenous to Bawaka Country suggests that the encroachment of satellites into space is not merely an inconvenience—it is perceived as a modern iteration of colonization. These concerns cannot be addressed through technology alone; they require meaningful dialogue and policy action.

Among the potential avenues for such dialogue, a collaboration between the IAU and Indigenous representatives, leading to formal discussions within UNCOPUOS, appears particularly promising. The IAU has already acknowledged the issue, and UNCOPUOS has demonstrated its willingness to consider concerns about satellite proliferation. However, any such collaboration must be driven by Indigenous voices and structured to ensure their perspectives are respected and protected.

Ultimately, meaningful inclusion of Indigenous perspectives in space governance is not just a matter of cultural preservation—it is a matter of justice. Ensuring that Indigenous voices are heard in discussions about the future of space is essential to upholding the principles of fairness, sustainability, and shared responsibility that should guide humanity's relationship with the cosmos.

CONCLUSION

The rapid expansion of satellite mega-constellations has brought both opportunities and challenges, reshaping the landscape of space activities while raising critical ethical and cultural concerns. While these technological advancements have the potential to bridge digital divides and create new opportunities for many communities, they also threaten to disrupt Indigenous astronomical traditions that have been practiced for millennia. The increasing number of satellites obstructing the night sky is not merely a technical issue; it is an existential challenge to Indigenous knowledge systems, cultural identities, and spiritual connections to the cosmos.

Despite some progress, including the IAU's recognition of Indigenous star names and its *Dark and Quiet Skies* report, there remains a significant gap in ensuring that Indigenous voices are meaningfully included in decision-making processes related to space governance. As outlined, several avenues exist to facilitate this inclusion, from international forums such as UNCOPUOS to domestic-level engagement with national space agencies. However, for any of these initiatives to be effective, they must be based on mutual respect and a commitment to preserving Indigenous knowledge without exploitation.

Moreover, the historical context of colonization and broken treaties underscores the need for spacefaring nations and private actors to take responsibility for initiating this dialogue. The *Outer Space Treaty* asserts that space is the "province of all mankind,"

but this principle remains unfulfilled as long as Indigenous perspectives are sidelined. The recognition and protection of Indigenous astronomy should not be seen as an obstacle to progress but as an essential component of ethical and sustainable space development.

Ultimately, this article argues that the most effective way to balance the benefits of satellite mega-constellations with the rights of Indigenous Peoples is through an open and ongoing dialogue. Whether through collaboration with the IAU, engagement with UNCOPUOS, or domestic-level initiatives, the time to act is now. If these conversations do not take place before satellite numbers escalate further, the consequences will be irreversible—not only for Indigenous astronomy but for humanity's collective relationship with the night sky.

Ensuring that Indigenous voices are heard and respected in space governance is not just a question of cultural preservation; it is a fundamental issue of justice, equity, and shared responsibility. By integrating Indigenous perspectives into space policy and planning, humanity has an opportunity to approach space exploration in a way that is not only technologically advanced but also ethically and culturally inclusive.

REFERENCES

American Astronomical Society. (2020). *Impact of satellite constellations on optical astronomy and recommendations toward mitigation (SATCON 1)*. Retrieved March 9, 2022, from https://aas.org/sites/default/files/2020-08/SATCON1-Report.pdf

Anaya, S. J. (2013). The human rights of Indigenous peoples: United Nations developments. *University of Hawai'i Law Review, 35*, 983.

Barelli, M. (2009). The role 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.

Bawaka Country, Mitchell, A., Wright, S., Suchet-Pearson, S., Lloyd, K., Burarrwanga, L., Ganambarr, R., Ganambarr-Stubbs, M., Ganambarr, B., Maymuru, D., & Rrawun, D. (2020). Dukarr lakarama: Listening to Guwak, talking back to space colonization. *Political Geography, 81*, 102218.

Bhathal, R. (2006). Astronomy in Aboriginal culture. *Astronomy & Geophysics: The Journal of the Royal Astronomical Society, 47*, 27.

Bhathal, R. (2016, October 13). How astronomy paved the way for *terra nullius*, and helped to get rid of it too. *The Conversation*. Retrieved March 9, 2022, from https://theconversation.com/how-astronomy-paved-the-way-for-terra-nullius-and-helped-to-get-rid-of-it-too-66703

Bielicki, D. M. (2020). Legal aspects of satellite constellations. *Air & Space Law, 45*, 245.

Boley, A. C., & Byres, M. (2021). Satellite mega-constellations create risks in low Earth orbit, the atmosphere and on Earth. *Scientific Reports, 11*. Retrieved January 30, 2022, from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8137964/

Buente, W., Baybayan, C. K., Hajibayova, L., McCorkhill, M., & Panchyshyn, R. (2020). Exploring the renaissance of wayfinding and voyaging through the lens of

knowledge, representation, organization, and discovery systems. *Journal of Documentation, 76*, 1279.

Cajete, G. A. (2000). *Native science: Natural laws of interdependence*. Clear Light Publisher.

Code of Federal Regulations. (2022). *Title 47: Telecommunication*. Retrieved March 9, 2022, from https://www.ecfr.gov/current/title-47/chapter-I

Cropper, S., Kemp, C., Little, D. R., & Hamacher, D. W. (2019, August 16). Why do different cultures see such similar meanings in the constellations? *The Conversation*. Retrieved January 30, 2022, from https://theconversation.com/why-do-different-cultures-see-such-similar-meanings-in-the-constellations-121981

Drahos, P. (2014). *Intellectual property, Indigenous peoples, and their knowledge*. Cambridge University Press.

Feinberg, R., Dymon, U. J., Paiaki, P., Rangituteki, P., Nukuriaki, P., & Rollins, M. (2003). 'Drawing the coral heads': Mental mapping and its physical representation in a Polynesian community. *The Cartographic Journal, 40*, 243.

Freeland, S. (2015). The laws of war in Outer Space. In K.-U. Schrogl, P. L. Hays, J. Robinson, D. Moura, & C. Giannopapa (Eds.), *Handbook of space security*. Springer Science & Business Media.

Hamacher, D. W. (2014, November 30). Stories from the sky: Astronomy in Indigenous knowledge. *The Conversation*. Retrieved January 30, 2022, from https://theconversation.com/stories-from-the-sky-astronomy-in-indigenous-knowledge-33140

Hecht, J. (2021). Will satellites cripple ground-based astronomy? *Optics & Photonics News*. Retrieved January 31, 2022, from https://www.optica-opn.org/home/articles/volume_32/may_2021/features/will_satellites_cripple_ground-based_astronomy/

Hollabaugh, M. (2017). *The spirit and the sky: Lakota visions of the cosmos*. University of Nebraska Press.

International Astronomical Union. (2017, December 11). IAU approves 86 new star names from around the world. Retrieved January 30, 2022, from https://www.iau.org/news/pressreleases/detail/iau1707/

International Astronomical Union. (2019, June 3). IAU statement on satellite constellations. Retrieved January 30, 2022, from https://www.iau.org/news/announcements/detail/ann19035/

International Astronomical Union. (2022, January 12). *Dark and quiet skies II for science and society work group reports published*. Retrieved March 9, 2022, from https://www.iau.org/news/announcements/detail/ann22002/

Koch, J. S. (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.

NASA. (2019). *Indigenous peoples pilot: Connecting knowledge and strengthening communities*. Retrieved January 31, 2022, from https://appliedsciences.nasa.gov/indigenous-peoples-pilot

NASA. (2020). *The Artemis accords*. Retrieved March 9, 2022, from https://www.nasa.gov/specials/artemis-accords/img/Artemis-Accords-signed-13Oct2020.pdf

United Nations General Assembly. (2021). *Report of the Committee on the Peaceful Uses of Outer Space* (UNCOPUOS Sixty-Fourth Session, August 25–September 3, 2021, A/76/20). Retrieved March 18, 2022, from https://www.unoosa.org/res/oosadoc/data/documents/2021/a/a7620_0_html/A_76_20E.pdf